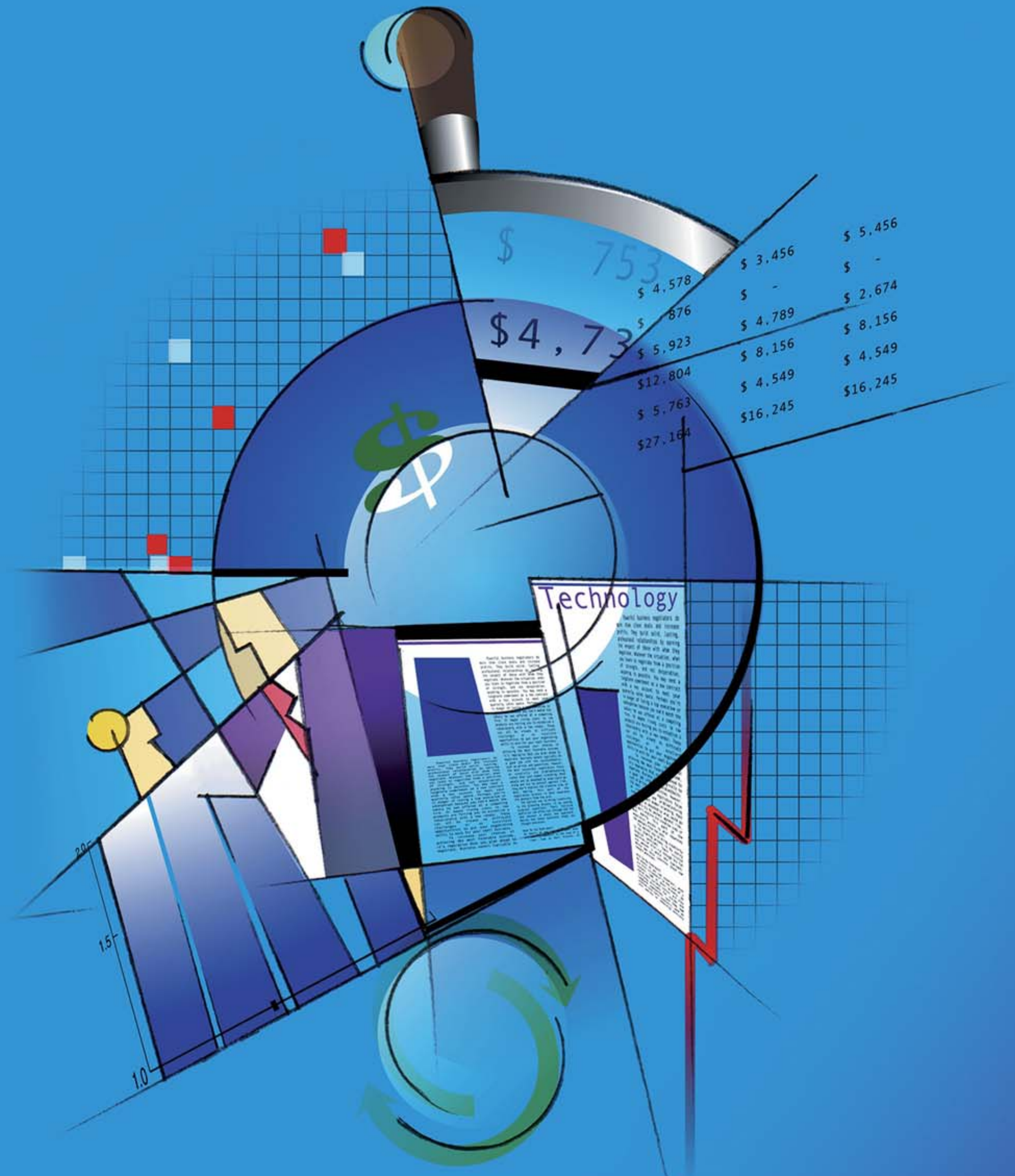

VIEW CONTENTS

STRATEGIC ALLIANCE to Advance Technological Education through Enhanced Mathematics, Science, Technology, and English Education at the Secondary Level

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Several administrators, Diane Kuehl of Rock Valley College, codirector of the project and acting dean of academics, along with the following Northern Illinois University administrators, strongly backed the project: Promod Vohra and Ramuldas Kasuba, deans of the College of Engineering and Engineering Technology and professors of technology and mechanical engineering, respectively; Frederick Kitterle, dean of the College of Liberal Arts and Sciences and professor of psychology; Cliff Mirman and Dennis Stoia, professors of technology, who chaired the Department of Technology. When funding ran out, the Provost’s Office of Northern Illinois University carried us through and enabled us to meet our requirements.

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Most of all, we owe thanks to our families, who hardly saw us for so many nights, weekends, and holidays. To them, we say thank you for supporting us in serving the region’s schools and living our passion to “make a difference.”

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Executive Summary

The information presented here makes accessible to a broader readership the philosophy, strategies, models, processes, program content, tools, research, and evaluation outcomes of "*Strategic Alliance to Advance Technological Education through Enhanced Mathematics, Science, Technology, and English Education at the Secondary Level,*" a major project funded by the National Science Foundation. The report's direct, yet reflective, approach provides evidence and analysis about a formal learning community and its effect on the teaching and learning of mathematics, science, technology, and English at the secondary level. The information spirals in depth, beginning with a general introduction, moving to a presentation of definitions, philosophies and models, then concluding with broad program content. Most of the program leaders present chapters in their individual voices with references and appendixes, making it possible for those interested in the intellectual merit or replication to clearly understand what concepts and principles were presented, what processes were used, and what tools were developed, as well as to build upon our work and reduce the learning curve or eliminate problems and issues that might occur. The processes and tools evolved over time, through several initiatives and by working with a variety of partners, including those mentioned herein; thus many have contributed to what is reported and found here. Access to all results, outcomes, and products is possible through a website, www.strategicalliance.niu.edu, which presents complete research data and information about related projects. The project contributes to the bodies of knowledge on building learning communities, staff development, teaching and learning, partnership building, evaluation, and research with the primary purpose of improving mathematics and science education at the secondary level to prepare students for higher education and technical careers.

"*Strategic Alliance to Advance Technological Education through Enhanced Mathematics, Science, Technology, and English Education at the Secondary Level*" was a collaborative partnership involving the Rockford Public Schools (RPS), Rock Valley College (RVC), and Northern Illinois University (NIU), in Illinois, that sought to motivate and prepare high school students for technical careers requiring a solid foundation in mathematics, science, technology, and English (MSTE). The primary goal was to improve secondary MSTE, ultimately student achievement, especially for nonmajority students and young women. The project began as an alliance between the Rockford Public School District, NIU, and 300 local business, industry, and community organizations.

The following objectives provided the operational framework for accomplishing the goals.

1. Provide in-service education, training, and technical assistance to secondary teachers.
2. Provide in-service education to district school administrators and counselors on change, reform leadership, and strategic planning, as well as exposure to the teacher-development program.
3. Partner with local business, industry, and community organizations to provide teachers (and ultimately students) with exposure to the real world of MSTE problems

and applications, authentic contexts, careers requiring MSTE foundations, and information about the higher-education pathways and MSTE requirements to realize access to career clusters.

4. Evaluate all project activities, monitor progress, and determine the merit and broader impact of the initiative.
5. Produce a systemic reform model for improving MSTE education at the secondary level through business, industry, educational, and community partnerships.
6. Develop teacher knowledge and skills in the use of computer technology for teaching and learning.
7. Develop teacher and counselor knowledge and skills in strategies to assist students to develop postsecondary educational and career plans.
8. Develop a plan for long-term sustainability and continuous improvement.

The project achieved most of its goals. Rockford's approximately 32,000 K-12 public school students are representative of the national profile, consisting of inner-city, urban, suburban, and rural students with approximately 42% nonmajority (approximately 29% African American, 10% Hispanic, and 3% Asian).

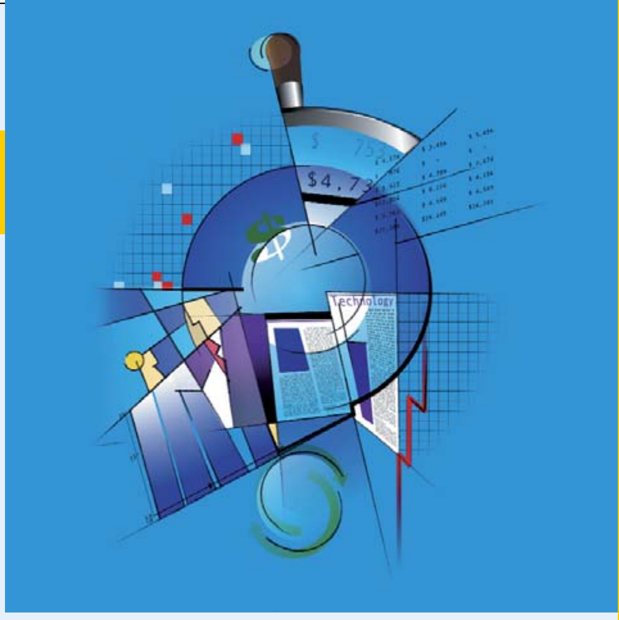
This report has three main sections that present the project's basic principles and aims, its methods for addressing the aims, and reflections on research methods and evaluation.

Part I. Overview. After an introductory chapter that describes the nature and aims of the project and provides background and context, Chapter 2, *Learning – What Does It Mean?,* defines our goals and strategies. Chapter 3, *Partners in Change*, establishes the leadership foundation for our work with the schools; the next chapter, *Organizational Learnings*, offers reflections from the perspective of leadership strategies, techniques, processes, and outcomes. Chapter 5, *Operating Philosophy and Project Strategies*, along with the succeeding chapters, *Operational Models* and *Program Scope, Content, and Sequence,* completes the foundational discussion and establishes the framework and belief system for the project. Finally, Chapter 8, *Challenges and Lessons Learned,* describes the major difficulties and offers lessons learned for the benefit of those who may want to replicate all or part of what was accomplished

Part II. Program. The first six chapters describe core elements of the program, such as articulation (Chapter 9), interdisciplinary teaming (Chapter 10), interdisciplinary curriculum (Chapter 11), and student performance assessment (Chapter 12), teaching models (Chapter 13), and instructional technology (Chapter 14). Chapters 15-30, written mainly by program leaders, focus on discipline-specific program elements, covering content, strategies, outcomes, opinions about experiences, and in some cases recommendations for replication. Several chapters focus on elements of the program that were multi- and interdisciplinary in nature and represent a fusion of content and delivery. Chapter 31 discusses the role and importance of school counselors.

Part III. Research Data and Evaluation. These chapters review the basis for the classroom pilots, present the methodology, and discuss the research limitations.

The full report, including research data and evaluations, is accessible at http://www.strategicalliance.niu.edu.



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STRATEGIC ALLIANCE
TO
Advance Technological Education
THROUGH
Enhanced Mathematics, Science,Technology, and English Education
AT THE
Secondary Level

PART I. Overview

1. Introduction

Jule Dee Scarborough

“Strategic Alliance to Advance Technological Education through Enhanced Mathematics, Science, Technology, and English Education at the Secondary Level” was designed to motivate and prepare students for technical careers requiring a solid foundation in secondary mathematics, sciences, technology, and English (MSTE). We were especially concerned to reach out to nonmajority students and young women. The initiative involved a collaborative partnership between the Rockford Public Schools (RPS) in Illinois, Rock Valley College (RVC), and Northern Illinois University (NIU). The project began as an alliance of the Rockford Public School District, Northern Illinois University, and 300 local business, industry, and community (BIC) organizations. Rock Valley College, a community college, became a partner after the pilot years.

Objectives

“Strategic Alliance” had eight objectives:

1. Provide in-service education, training, and technical assistance to secondary teachers.
2. Provide in-service education to district school administrators and counselors on change, reform leadership, and strategic planning, as well as exposure to the teacher development program.
3. Partner with local BIC organizations to provide teachers (and ultimately students) with exposure to the real world of MSTE problems and applications, authentic contexts, careers requiring MSTE foundations, and information about higher-education pathways and MSTE requirements to realize career access.
4. Evaluate all project activities, monitor progress, and determine the merit and broader impact of the initiative.
5. Produce a systemic reform model for improving MSTE education at the secondary level through business, industry, educational, and community partnerships.
6. Develop teacher knowledge and skills in the use of computer technology for teaching and learning.
7. Develop teacher and counselor knowledge and skills in strategies to assist students to develop postsecondary educational and career plans.
8. Develop a plan for long-term sustainability and continuous improvement.

Participants included all middle and high school teachers in the Rockford Public Schools who taught mathematics, the sciences, technology, and English. The results of a concurrent regional initiative pilot are also mentioned in this review.

Rationale

The initiative addressed fundamental issues of workforce preparation raised by various researchers on the basis of numerous national indicators, such as the Science and Engineering (S&E) Indicators (National Science Board, 2002). These indicators suggest that the U.S. workforce needs more people with appropriate degrees as retirements increase. Figures noting the high percentages of foreign-born science and engineering degree-holders – a result of little or no growth in domestic Ph.D. production – provide an incentive to increase the number of students following through to higher degrees in S&E.

The National Science Foundation (NSF) provides much evidence of learning gaps, which can be closed only by establishing stronger mathematics and science (MS) preparation at all levels of education. For example, at the secondary level, females score more than one year higher in reading, but boys continue to score higher in mathematics and science by approximately one year's difference. The gaps among whites, African Americans, and Hispanics remain significant and widen between entering school and high school. African Americans learn less in high school than whites and Hispanics.

Furthermore, although NSF data reveal that mathematics scores have increased and some progress is being made toward achievement of the National Council for Teaching Mathematics (NCTM) standards, few students scored as proficient or advanced, and more than 30% scored below the basic level. Again, boys outscored girls, and whites and Asians outscored African Americans, Native Americans, and Hispanics. The 1996 Third International Mathematics Science Study (TIMSS) study (Johnson, 1998) revealed that U.S. students score lower than those from other nations in mathematics at the eighth-grade level. For science, the U.S. students score lower at the fourth-grade level. And finally, students in the United States seem to decrease in mathematics and science competence as they progress to the secondary level.

Concerns remain about the lack of focus and depth of MS coursework. Standards and assessments have been implemented by most states, which now often require more courses for graduation, and there seems to be an indication that more students are enrolling in more courses (National Education Commission on Time and Learning, 1994). Females have course-taking patterns similar to males, with some differences (e.g., less likely to take physics), and their achievement is similar. However, the percentage of females is lower in the science, technology, engineering, and mathematics (STEM) pipeline. Nonmajority students also take more advanced courses, although African Americans and Hispanics lag behind whites and Asians. Lower socioeconomic students are more likely to be assigned to lower-level curricula, even though their ability may be the same.

There is insufficient evidence to determine if increased course requirements, quality of courses, standards, and assessments have improved student learning. Some studies suggest that requiring more courses has resulted in more failures, especially for non-majority students. Additionally, opinions differ about course quality, especially for lower-achieving students; some feel the courses lack integrity (National Science Board, 2002).

There is also the question of whether the state standards and assessments are closely linked. Do the measures have integrity? Or do they focus too much on facts rather than complex inquiry? Are the standards too vague to provide guidance? There is clearly a need for "a fully developed standards-based system that links quality standards to tests, curriculum, and accountability measures," given that tests are often based upon weak standards or not directly aligned with standards (National Science Board, 2002, pp. 1-29). Additionally, the curriculum is not adequate, and beyond that, tests for promotion are not always aligned with standards.

Enrollment in higher education for S&E degrees is also an issue of focus by the National Science Board (2002). In 1997, Johnson reported that by seventh grade, only 11% of a pool of 7 million students will express an interest in MS or technical fields, dropping to 5% by college age. Also in 1997, Hendley reported that 50% of all college freshmen, and even higher proportions of women and minorities, begin their college careers at community colleges, untapped sources of student recruits for technical degrees at the bachelor's level. Therefore, universities, especially those offering bachelor's degrees, should articulate more closely and work together to move students into bachelor's programs.

To tie that to the improvement of teaching, Wenglinski (2000) identifies the overwhelming importance of teacher development in student achievement in science, technology, engineering, mathematics, and English (STEME), the foundations for S&E. He found achievement to be higher when teachers receive professional development in different disciplines (107% ahead of grade level), higher-order skills (40% ahead of grade level), lab skills (44% ahead of grade level), and classroom management (37% ahead of grade level). When students are exposed to hands-on learning weekly rather than monthly, they are 72% ahead of grade level in mathematics and 40% ahead in science. When frequently exposed to critical thinking, they are 39% ahead of grade level in mathematics, and when exposed to ongoing, authentic assessment, they achieve ahead of those less frequently exposed to point-in-time tests.

Overall, Wenglinksi reveals the importance of teacher development on teaching and learning strategies, student achievement, and success in mathematics and science. Lynch (2000) reports on common denominators across outstanding high schools, including high standards, rigorous core curriculum, authentic assessment, and work-based learning – all foci of the work reported here.

The failure to take teacher development seriously is closely linked to professionalism (Bracey, 1997; Stigler, 2001). Good teaching matters. Students who have good teachers make dramatic gains (Traiman, 2000). Research indicates that one of the most important factors for student achievement is the teacher's disciplinary expertise (Darling-Hammond, 2000). Strong verbal and mathematical skills are essential for teaching lower-performing students. Ambach (2000), Chase (2000), and Feldman (2000) advocate the need to increase funding for effective professional development, employ a peer evaluation process, and professionalize the teaching and learning environment. Houston (2000) suggests that a university-school partnership can improve teaching and learning in schools. Bryant (2000) comments that these types of programs need to be increased, enhanced, and held to high standards. Langenberg (2000) praises the reform movements occurring through school, university, and industry partnerships, stressing that student learning improves when more attention is paid to the teacher's professional development.

Dozier (2000) supports results-driven professional development and rigorous evaluation of its effectiveness. Thurston (1999) reports that direct and deliberate leadership support is needed to ensure the success of collaborative teaching and that teachers have the same planning times and appropriate professional development and visibility of results. Adams and Hamm

(1990) and Lord (1994) find 12 distinct benefits to cooperative learning among students, ranging from improved achievement to increased empathy and student retention. Wenglinski (2000) adds that applying concepts in context increases critical thinking and improves mathematics performance. Basili and Sanford (1991) and Watson (1991) demonstrate the benefits of collaborative learning in specific disciplines, while Pedersen and Digby (1995) provide the necessary theory behind the success of cooperative learning.

Content and Pedagogical Strategies

"Strategic Alliance" also addressed important content and pedagogical issues that remain centers of debate among educators. The National Science Board (2002) reports there is still a debate over "drill and practice," conceptual understanding, and skill application as instructional practices. Whole-group instruction and a reliance on worksheets are still common, although most teachers do report using small-group instruction. (In my experience with secondary education, small-group instruction needs to be more formally structured, and teachers need to learn how to plan, lead, direct, and assess learning through small-group activities.) NSF also reports, based on the TIMSS study, that using the more engaging techniques advocated by NCTM is somewhat superficial (pp.1-30), and data about the success of these approaches is still thin.

The standards movement has resulted in a new vision for the teaching of mathematics (and science), but there seems to be little action. Schmidt, McKnight, and Raizen (1997) suggest that the U.S. approach covers more topics than international counterparts; teachers typically complete one topic before beginning another and deepen the study of the topic at each more advanced grade level. U.S. educators use a "spiral" approach, elaborating and extending topics over time, resulting in redundancy and limiting depth. The goals, in the United States, are to: (a) increase the depth of concepts and principles at each level; (b) expand and further explore careers and educational paths at each level; (c) increase field experiences at each level, extending their content, purpose and depth; and (d) engage teachers and students in changing the visions and goals for themselves at each level, modifying their portfolios as they grow and change.

Although science curricula have improved, textbooks still have inadequate depth and development of topics, challenging expectations, repetition, and new information (Flanders, 1987). This perspective is reinforced in a 1999 study by the American Association for the Advancement of Science (AAAS). Science literacy is also poorly addressed or achieved, often reducing the concept to "technical terms."

"Strategic Alliance" provides a multilevel approach for progressive teacher growth, each level reinforcing and extending the previous one. We offered many opportunities to perform through observed pilots in the classroom, using a strong and closed-loop feedback system to learn from what occurred, and then a networking model to share across teachers, groups, and schools. Our teachers were more likely to understand the learning theory underlying the teaching standards; our improvements were more likely to persist beyond the grant period. Teachers became comfortable using technology as a learning and teaching tool.

Previous Research and Development in Illinois

"Strategic Alliance" was built on more than a decade of research and development in northern Illinois. Our effort was a "culminating" initiative and was designed and developed based upon several complex projects, many of whose models, practices, strategies, techniques, and processes were either adopted or extended by us. They enabled us to provide yet another layer of possibilities in the process of working with schools to improve mathematics, science, technology (MST), and ultimately to include English (E) education at the secondary level in Illinois (MSTE).

Many of these projects anticipated trends in professional development, in that they provided integrated, interdisciplinary, multileveled programs that followed teachers into the classrooms to pilot. They were also strong in feedback, met individual and district needs, and usually provided the teachers with technology and other tools required for professional development. Interdisciplinary since 1983, they always included mathematics, sciences (especially physics), and a variety of technology or vocational disciplines, usually including chemistry and English (since 1994), and recently geology and environmental science. We worked with each discipline as individual knowledge taxonomy and also as a vehicle for learning or applying the other disciplines or interdisciplinary concepts and principles; thus each participating discipline had two purposes for being included.

It is helpful to understand the line of progression, for in working with educational reform or improvement, clearly there is an evolution of models and strategies, and of contexts across which those models and strategies become useful. Our study, it is hoped, will enlighten others about that progression as well as the models, strategies, results, and outcomes.

Our work began with a major statewide initiative (1984-1988), which had eight schools develop, design, and pilot new technological curricula across areas of importance at the time (e.g., computer-aided drafting, healthcare, electronics). An additional initiative included the area of manufacturing technology. The products and models developed were an attempt to provide articulated Illinois secondary schools and community colleges with well-developed, industry-validated, and MSTE-based curriculum products that could be easily adapted or directly adopted. The strategies for development involved secondary teachers with community college, university, and industry experts. Schools then field-tested the curricula and revised them based upon the results; the state published the materials for dissemination. There has rarely, if ever, been such an in-depth and widespread attempt at dissemination and staff development in Illinois, possibly in the nation.

Once the curriculum products were revised (based upon the pilot data) and published, there were approximately two years where staff development occurred regionally statewide. Project teams delivered workshops throughout Illinois on seven new curricula. All staff development involved participants using new technology and software in conjunction with the new curricula.

The results were positive for three reasons: the curriculum was validated by industry and endorsed by the state; it was delivered through hands-on activities with the new technology and software (with purchasing information accessible for administrators); and the participants' response was favorable because the workshops brought them not only the published curricula products but also the technical experts who developed the software and applications, industrial representatives, and the vendors through which it could be purchased. The curricula were generic in the technology and software requirements, an attempt to make them time-future in nature rather than quickly dated. This occurred through special funding, legislated as Education for

Technology Employment (ETE); the manufacturing technology (MT) projects were funded through the Illinois State Board of Education.

There were no "student learning standards" at the time nor any focus on integrated interdisciplinary curriculum. The curriculum products were a first attempt to lead MSTE teams into an analysis that went beyond the technological content and desired requirements to identify and align the inherent MSTE content and then build the curriculum in such a way as to acknowledge and include it. As with "Strategic Alliance," these efforts acknowledged the importance of the MSE content alongside the T content if students were to become technologically and scientifically literate, equally capable in their MSE knowledge and skills, and move on to higher education (especially into technical programs requiring higher levels of MS) and then to technical careers.

Articulation and industrial partnerships were also critical components of that first initiative. The curriculum products were either grades 11-12 and aligned with 13-14, or were directly 11-14 in content and application. Industrial partnerships were critical in the curriculum-content identification, validation, and dissemination aspects. Those developing the products were brought to campus or a central site for the intense curriculum development aspect, and then validation occurred. Development and field testing occurred statewide, data were reviewed and revisions made, documents were published, and dissemination was taken statewide. The ETE project focused on six technical areas, and the follow-up project added MT from a systems perspective.

These products, probably still useful because they are generic, are still available through the Illinois Office of Education Services at 800-252-4822.

In continuing our work, the next project, PHYS-MA-TECH (1989-1992), was a direct result of the ETE and MT projects and focused on the development of an integrated mathematics, physics, and technology curriculum using somewhat different models. Its curriculum and research results are still viable today and discussed at length in Chapter 32. From that point forward to the Rockford project (1992-1995), a variety of smaller activities occurred with small and rural regional schools. Those results, although not included here, did confirm the positive directions of the PHYS-MA-TECH project. The MSTE teaching teams came from a wide variety of districts and schools. For four years, teacher teams from small and rural schools came to campus for three or four weeks during the summer, developed their educational products and processes, and then returned to pilot them the following school year.

Some of the foci mentioned below were inherent in the PHYS-MA-TECH initiative, but the most recent projects made a more in-depth and aggressive attempt to engage teachers in complex changes beyond the integrated curriculum, team teaching, and interdisciplinary instructional delivery. They focused equally on teaching models, additional delivery strategies, metacognitive processes and skills, learning styles, multiple intelligences, and more formal performance-based assessment. Simultaneously (1992-1997), the Chicago Public Schools (CPS) participated in a wide variety of staff development activities focused primarily on the improvement of mathematics and science education linked with vocational education. From those activities, a more formal, five-year initiative grew through federal Perkins grants for Chicago.

The collaboration with 36 Chicago public schools concentrated on broadly improving MSTE education, with special emphasis on 21 of the schools. Evaluation of the work accomplished in the first year of the Perkins-funded initiatives showed good efforts but great gaps between goals and accomplishments. Using that as a needs assessment, we analyzed what was required to move the schools forward to accomplish the Perkins goals and worked with central administration to design, deliver, and pilot a staff development program for approximately 150-200 teachers in MSTE teaching teams for each of five years.

The accomplishments of those teams, in spite of a strike, late school-year start, massive retirements and teacher transition across schools, and administrative changes were quite remarkable. A great deal was accomplished and documented through in-depth evaluation reports. The 21 evaluations included pretest and posttest results of student achievement; qualitative student and teacher data; and interview data from each school's local school council, industry advisory boards, administrative personnel and counselors, teachers and students, and school portfolios. After that first year, the portfolios improved greatly. Once the "new" staff development program was put into place, goals were more clearly established and expectations became more focused.

A broad and deep evaluation included many data types. Significant positive indicators suggested that integrated curricula, interdisciplinary teaching teams, block scheduling, and teaching and learning strategies could increase urban and underprivileged student learning of MSTE and actually improve school attendance. However, administrative transitions prevented the possibility of collecting a second data set, nor was publication possible.

There were some unique and successful staff development and evaluation models designed for working with such a large group of teachers in a complex district at a time when there was change each and every year. It was a privilege to work with the CPS teachers; they were a dedicated, respectful, and engaging group who truly wanted to improve teaching and learning.

The Rockford Project

When PHYS-MA-TECH ended, as well as our work in Chicago, we had a desire to continue our work in a complex urban community with similar issues. The PI contacted the Rockford Public Schools (RPS). Rockford's approximately 27,000 K-12 public school students are representative of the nation: inner-city, urban, suburban, and rural students with roughly 42% nonmajority (approximately 29% African American, 10% Hispanic, and 3% Asian). Few enroll in MS classes beyond those required for graduation. Only 14% of the eligible pool continue into higher-level courses, decreasing the number even more. Our goal was to improve MS success rates and increase the rate of enrollment into higher level MS courses for all students, especially for young women and other under-represented groups. In a politically charged district, at times this was a challenge. However, we believe that our responsibility is to partner with districts in need to help rebuild trust and improve education.

Concurrent with the NSF-funded initiative, "Strategic Alliance," two regional projects comprised of teams from regional districts were also ongoing. One round of their pilots is reported here.

Importance of Long-Term Effort

It takes many initiatives and much dedicated effort to accomplish educational improvements of any kind in a complex scenario across very different educational entities. Further, the best change occurs when the effort happens through true partnerships. It is a primary responsibility and mission of higher education to initiate and help lead change in K-12 districts, since that is where the research and practice take place. The combination of theoretical experts with experts in practice can engender phenomenal results.

Social science or experimental studies in schools are very complex contexts for controlled studies. There are many limitations, extraneous variables, and contextual issues with which to contend. Human and organizational characteristics make them challenging to accomplish, yet also much more interesting, necessary, and rewarding. It is very unlike setting up experiments in more easily controlled laboratories. This is not meant to dismiss our work as lacking value, but merely to acknowledge its limitations.

It is important to note that with many of the initiatives, there was an agreement not to publish any results other than those aspects required by funding agencies. This was a trust issue; therefore, much less was published than should have been. However, we attempt here to present the context, chronology, and general perspective. That does not directly address the need for empirical evidence for evaluation purposes. However, the mixture of what can now be published with the "confirmation" of positive implications over the span of 23 years may have meaning, if only to confirm the need for more tightly controlled empirical studies.

Some of the most important outcomes of the work discussed here lie in teacher renewal, changed attitudes, revived enthusiasm, sharpened vision, rededication to mission, and more. While acknowledging the great need for empirical results, we must also give adequate attention to the more qualitative. Developing practices based upon significant research would clearly tell the educational world that it must better attend to building relationships and partnerships, renew energy and dedication, add breadth and depth of disciplinary and interdisciplinary knowledge and skills, and build more friendly learning and teaching environments.

Therefore, we would encourage those who would find and identify faults, limitations, or missing elements in the research and development presented here as opportunities to further the work with greater controls. Identifying what needs to be done beyond the work presented here and following through to accomplish that work would be a reward for my colleagues and me.

Organization of This Report

This report on "Strategic Alliance" has three main sections that present the initiative's basic principles and goals, the methods to accomplish the goals, program leaders' perspectives, research methods and results, and reflections about the external evaluation.

Part I. Overview. After an introductory chapter that describes the nature and aims of the project and provides background and context, Chapter 2, *Learning – What Does It Mean?*, defines our goals and strategies. Chapter 3, *Partners in Change*, establishes the leadership foundation for our work with the schools; the next chapter, *Organizational Learnings*, offers reflections from the perspective of leadership strategies, techniques, processes, and outcomes. Chapter 5, *Operating Philosophy and Project Strategies*, along with the succeeding chapters, *Operational Models* and *Program Scope, Content, and Sequence*, complete the foundational discussion and establish the framework and belief system for the project. Finally, Chapter 8, *Challenges and Lessons Learned*, describes the major difficulties and offers lessons learned for the benefit of those who may want to replicate all or part of what we did.

Part II. Program. The first six chapters describe core elements of the program, such as articulation (Chapter 9), interdisciplinary teaching (Chapter10), interdisciplinary curriculum (Chapter 11), and student performance assessment (Chapter 12), teaching models (Chapter 13), and instructional technology (Chapter 14). Then chapters 15-30, written mainly by program leaders, focus on discipline-specific program elements, covering content, strategies, outcomes, opinions about experiences, and in some cases recommendations for replication. Three chapters focus on elements of the program that were multi- and interdisciplinary in nature and represent a fusion of content and delivery. Chapter 31 describes the roles and importance of counselors.

Part III. Research and Evaluation. Chapter 32 presents the original basis for the research in this project, revealing the results of the PHYS-MA-TECH study. Chapter 33 reviews the results of the Rockford classroom pilots, presents the methodology, and discusses the research limitations. In Chapter 34, the external evaluator discusses evaluative aspects, accomplishments, and outcomes. Finally, Chapter 35 presents what the teachers had to say.

The full report, including research data and evaluations, is accessible at www.strategicalliance.niu.edu.

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2. Learning – What Does It Mean?

Jule Dee Scarborough

Until 1990 I struggled with defining what learning meant and how I would know it had been accomplished by my students. Courses were designed to be outcomes driven, it is true, but largely because the technology field has an inherent bias toward inquiry and action rather than any intention on my part. Discovering Senge's (1990) *The Fifth Discipline* made it clear that the teacher is a participant learner, as well as a coach and designer. Senge believes "deep down, we are all learners … infants are intrinsically inquisitive, masterful learners who learn.... all on their own … it is our nature to learn … we love to learn" (p. 4). This definition had real meaning for me, and from that point forward, my teaching and student learning were organized around it and established it as the basis for designing teacher professional development.

Senge (1990) describes learning with a term from Classical Greece, *metanoia*, a fundamental shift of mind. Learning is not only the "taking in of information," as is commonly thought today, but involves a re-creation of ourselves. Real learning gets to the heart of what it means to be human. *Through learning we re-create ourselves…we become able to do something we never were able to do...*we *extend our capacity to create, to be part of the generative process of life.* Our hunger for this type of learning is "as fundamental to human beings as the sex drive" (p. 207).

A learning person continually discovers how they create their own reality and how they can change it. Therefore, the learning, "shift of mind," leads us away from seeing ourselves "as separate from the world" to "connected to the world" to "transforming the world" and, finally, to "creating the world" (Senge, 2000, pp. 206-209). This fits with our use of Bloom's and the revised Bloom's Taxonomy, as the ultimate learning level on the revised Bloom's is "create" (Anderson & Krathwohl, 2001).

Senge extends his thoughts to include a discussion on a transformative pedagogy that leads to deeper learning. His "generative model" coaches learners through a process of inquiry, exploration, and discovery of the subject. The model encompasses various theories and methods, including constructivism and collaborative learning (p. 206). Using this model, teachers (or staff development leaders) provide learning experiences where "learners create knowledge by building on their own experiences and by interacting with the subject matter(s) and other people" (p. 206). Knowledge is created in layers. As students (or teachers) learn more, what they learned previously develops to deeper and extended meanings. Each time learning occurs, the information previously learned changes and gains greater meaning.

The generative model of teaching and learning is about content *and* process, rather than just content. By extending active learning beyond the classroom into the world, providing the opportunity to more critically consider the world, a more significant change can take place. This synchronizes well when the result is learning communities that can provide a broader learning environment to deepen learning by extending the classroom and types of learning experiences.

Transformative pedagogy results in transformative learning that "grants learners the power to relate to the subject matter…builds upon existing knowledge…constructs new knowledge…and empowers one to create their desired future" (p. 211). "Transmission pedagogy takes power away from the learners…and the teacher. Generative pedagogy grants teachers and learners the power to relate to the subject matter and build on their knowledge…providing a functional literacy to fit into the world. Transformative pedagogy, however, provides learners with a functional literacy and provides teachers and learners with a social literacy...and systems literacy…to create their desired future" (p. 211). This is actually the basic meaning of a learning organization, "an organization that is continually expanding its capacity to create its future" (Senge, 1990, pp. 14-15).

One other concept that particularly draws attention is "creative tension." Senge quotes Martin Luther King, Jr.: "Just as Socrates felt that it was necessary to create a tension in the mind," said King, "so that individuals could rise from the bondage of myths and half truths…so must we…create the kind of tension in society that will help men rise from the dark depths of prejudice and racism" (pp. 52-53). King was talking about the *creative tension* of personal mastery, generated by holding a vision and telling the truth about the current reality relative to that vision. According to Senge, those who master creative tension gain a profoundly different view of reality: "People literally start to see more and more aspects of reality as something they, collectively, can influence…[and] are subject to being influenced by creative tension…[a] shift of view or metanioa" (p. 357). Creative tension is necessary for closing the gap between the current reality and a vision. The "gap" is the source of creative energy – creative tension.

Senge (2000) says that we can structure tension so that we will seek a solution. This all comes into play as we work with teachers on what they want to change and how they will go about making the change happen. The professional development described below provides real cases of what Senge is describing.

Schools as Learning Organizations

In another of his books, *Schools That Learn* (Senge et al., 2000), Senge writes that one of his most difficult challenges with teachers is to get them to understand that there are others in the classroom, that they are teaching students *and* the subject. Fields of knowledge do not exist separately from each other or from the people who study them. The processes through which people create knowledge "are living systems made up of often-invisible networks and interrelationships…all learners construct knowledge from an inner scaffolding of their individual and social experiences, emotions, will, aptitudes, beliefs, values, self-awareness, purpose, and more. …Disconnecting them weakens the scaffolding and, consequently, the knowledge" (pp. 21-22).

Our strategy has been to have the teachers understand their own purpose and goals for participating in our initiatives by envisioning something different (or more) for themselves and their students. We help them to build a vision, first individually and then together as an interdisciplinary team, of what they want to accomplish and what they want their students to be able to accomplish. We have set up our initiatives for interdisciplinary teams of mathematics, science, technology, and English teachers to formalize and learn more deeply that they should not disconnect the disciplines if they want to bring students to the transformation that takes place when real learning occurs.

To Extend This Conversation

According to Senge, “we need to design assessments for learning, not for blaming, ranking, and certifying. This requires deep *shifts of attitude* about testing and learning” (p.188). He describes the qualities of assessment for learning: timeliness, honesty, reflection, constructive guidance, focus. This ties into the 1996 Third International Mathematics and Science Study (TIMSS) report (Johnson, 1998; Stigler, 1997), which addresses the value of reflection by teachers participating in “lesson study.” Tests as assessments serve merely as “indicators of potential performance ability…” (Wolf & Reardon, 1996, p. 19). I have always been suspicious of traditional tests and test results as indicators of learning. My assessment focus has always been on assessment through projects that typically require a range of products, performances, and behaviors. It is important that students provide evidence of learning by demonstrating the application of knowledge: “the ability to transfer knowledge into action, even in situations that are less than routine” (Senge, 2000, p. 187).

The ultimate assessment goal should be to more authentically assess learning using Senge’s three types of learning: (1) formal, (2) applicable, and (3) longitudinal. In other words, (1) can students provide evidence of learning the academic content, for example, principles, facts, information? (2) Can they then provide evidence that they know something by demonstrating the application of that knowledge to solve a problem, design a solution? (3) Finally, can they demonstrate that they have sustained the capability to use knowledge over time and across contexts; that is, can they use the new knowledge and skills in their major senior capstone course? This discussion needs to include assessment as an integral part of learning, especially the more authentic and performance-based version.

Learning and providing evidence of learning should be intertwined rather than separated. For example, while learning about teams, students or any other group (e.g., teachers) could begin to function and perform as teams. Students who are learning to design and build an electronic circuit, using the underlying physics and mathematics inherent to circuitry, could be simultaneously assessed on how well they learn physics principles, mathematics concepts, and electronic concepts. No separation between learning and assessment has to occur.

To move to professional development for teachers, it has always worked for us to structure most learning as product or process development with culminating performances. In learning to develop integrated MSTE curricula, teachers design and develop an integrated module. In learning to use more teaching strategies, they incorporate them into the module to use during their pilots with students, after first trying them out with each other. Learning has always been doing, at least to us, and assessment has usually occurred while learning takes place.

After piloting new curricula, teachers engaged in small groups to network and reflect on what worked, what did not work, and what could be changed to enhance teaching and further learning. Teachers reported that group “lesson study” was very valuable. We tried to use this approach in a small way throughout the pilot experiences; and throughout the development, we tried to get teachers individually and as teams to reflect on what they were really teaching and what students were really learning. Is teaching tied to what is assessed? (Stigler & Hiebert,1997).

Literacies

We are all familiar with the traditional literacies of reading, writing, and speaking, but, as Senge (2000) remarks, literacy now describes multiple skills: computer, cultural, environmental, financial, and technological, to name only a few. The National Academy of Engineering of the National Research Council (NRC) formed a Committee on Technological Literacy, which published *Technically Speaking* (National Academy of Engineering, 2002). The authors of this report complained that "the issue of technological literacy is virtually invisible on the national agenda" (p. viii). Few educators grasp the basic concepts of today's technological society. To address this deficiency, the International Technology Association (2000) developed *Standards for Technological Literacy, Content for the Study of Technology,* followed by its companion guide advancing excellence in technological literacy: student assessment, professional development, and program standards (2003), and the International Society for Technology in Education (1998) produced the *National Educational Technology Standards, Standards for All Students.*

We have interwoven "technology" throughout our professional program – as disciplinary knowledge, as process for teaching and learning, and as tools and infrastructural requirements. Far more is needed, but we did help the teachers build confidence in themselves and create a comfort zone with "not knowing," thus stimulating them to seek the answers and exciting them about the possibility of knowing more.

The National Academy of Engineering of the NRC (National Council of Engineering, 2000) recommends that "NSF, DoEd, and teacher education accrediting bodies should provide incentives for institutions of higher education to transform the preparation of all teachers to better equip them to teach about technology throughout the curriculum" (p. 9). Those institutions or agencies, one might argue, should continue professional development, thus making it easily accessible for continued learning and professional growth. For some reason, it seems difficult for people to grasp that *accessible and continued* opportunities for learning are what ultimately help teachers to develop depth of knowledge and the ability to design and develop broader learning contexts for their students.

One aspect of learning that perhaps fits into technological literacy is "growing up digital." The teaching and learning dynamics between students who grow up with digital literacy and their teachers, many of whom did not, can be quite a mess, or it can work, depending upon the teacher's comfort zone with the new environment where student learning takes place. Brown (2000) reports a Xerox, Inc. study in which 15-year-olds were hired to join researchers. They were given two jobs: design the "workscape" of the future – one they would want to work in – and design the school or "learningscape" of the future, also where they would want to be. What occurred really "shook up" the Xerox people. The 15-year-olds operated the same as top executives in a fast changing context and "were always multiprocessing," for example, listening to music, talking on the cell phone, and using the computer; their attention span ranged between 30 seconds and 5 minutes. Brown (p. 14) describes a set of dimensions and shifts:

> (1) "Literacy today involves not only text, but also image and screen literacy…to read multimedia texts and feel comfortable with multiple-media genres…[T]he new literacy is

beyond text and image…. [I]t is one of information navigation, the ability to be your own reference librarian – to know how to navigate through complex information spaces and feel comfortable."

(2) Gone is, or should be, the lecture-with authority-based formal learning. It should be replaced with learning that is discovery based, enabling us to discover new things as we browse through digital libraries. Surfing "fuses learning and entertainment," to create "infotainment."

(3) Infotainment combines with different "forms of reasoning," not the classical deductive and abstract. Rather, the method is a form of "bricolage," a concept that anthropologist Claude Levi-Strauss related to "the concrete…abilities to find something, an object, tool, document, a piece of code – and to use it to build something you deem important. Judgment is inherently critical to becoming an effective digital bricoleur…Web-smart kids learn to become bricoleurs."

(4) The final dimension is "a bias toward action." Older generations want to know everything about something before they try it. Today's young people want to "muck around, and see what works…link, lurk, and watch how other people are doing things, then try it themselves…[This] brings us back into the same loop in which navigation, discovery, and judgment all come into play *in situ*.…[L]earning becomes situated in action…as much social as cognitive…concrete rather than abstract…and intertwined with judgment and exploration…[T]he Web becomes not only an informational and social resource but a learning medium where understandings are socially constructed and shared…[L]earning becomes a part of action and knowledge creation."

We have sought to deepen our teachers' understanding of their own disciplines, broaden that understanding into interdisciplinary knowledge relationships, and establish in them a comfort zone where they are willing to explore the use of technology for teaching and learning purposes and build their repertoire of teaching strategies, models, processes, and procedures. Too often teachers feel that their product is the student. Ultimately, we hope they realize that "their product" is their choice of academic content, educational products, and teaching and learning processes.

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3. Partners in Change

Jule Dee Scarborough

It is important to expand the learning experiences beyond the individual middle and secondary schools. The most effective method is to create partnerships with representatives from higher education, business, industry, and community organizations and to seek support from the administration – primarily the building principals. These partners in change help to create exciting opportunities for both the participating teachers and their students.

Leadership: A Moral Responsibility of Higher Education

According to Burns (1978), *transforming leadership* engages leaders and followers in a mutual relationship that raises both to higher moral and ethical levels. Manz and Sims (1989) define *superleadership* as that process through which leaders develop others to be leaders.

The university has a moral responsibility to collaborate with and support, or lead where necessary, the ongoing development of K-12 teachers, administrators, programs, and educational processes. Many would argue that partnerships are already in place between universities and schools or districts. Some might even question that this kind of leadership role is a moral responsibility, especially those in higher education who consider themselves content-discipline specialists or those instructors and professors of departments not directly linked to colleges of education.

The morality of the issue lies in a code of behavior inherent in our mission: using our knowledge, skills, and capabilities to build, strengthen, and question the educational aspect of the community within which we serve. However, a review of government reports and the literature suggests that most community service historically has consisted of working with business, industry, municipalities, and community-health and other non-educational organizations – with which the universities feel discipline or field-specific ties.

Possibly that is because we are segregated by disciplines with very narrow departmental missions and definitions of our responsibility; we have no rewards or immediate gains from working with schools, and we do not really understand that by working with schools we might be able to prepare students better for our own classrooms at the university. In working with teachers, we begin to understand the learning contexts from which our students come, gain insight about them and what they know, and influence what they learn. We also gain exposure to ideas about teaching and learning, areas in which most faculty have little formal background. Finally, the ultimate purpose for working with schools, especially in mathematics, science, technology, and engineering, is that most disciplinary departments offer general education courses that all students must successfully complete before entering their major degrees. Two-year technical programs require general education preparatory courses before the major courses or program can be completed. These factors alone should motivate us to work with schools.

A solid K-12 educational program that evolves with our highly technological society is vital if the nation is to maintain its global leadership, research status, and technological advancement. But we are struggling, except for some pockets of quality K-12 education. After 23 years of working intensely with schools to develop curricula and implement best practices and new strategies to improve student achievement in mathematics and science, it is my conclusion that all of us, across all disciplines, must collaborate with schools to sustain high-quality K-12 education.

Communities of Practice: Business, Industry, and Community[*]

It is critical to provide learning experiences that make academic knowledge and skills come alive; to provide more authentic exposure to the concepts, principles, facts, and theories in action in the workplace and in communities of practice and across career contexts. Although most partnerships have the goal of improving education for students, teachers also benefit. Learning outside of the classroom extends teachers' knowledge across contexts and moves it beyond theory, principles, or concepts.

Teachers have repeatedly asked us for real-world learning experiences first, before the students, so that they gain exposure and a base from which to build broader and deeper learning experiences and curricula. Teachers have let us know, too, that they need continuous or ongoing opportunities to do research and learn how MSTE is used across fields in communities of practice and that what they learn deepens and begins to make more sense with repeated exposure. A program of external exposure is the best way to deepen and extend learning. (The term Community of Practice Quest, CPQuest, refers to a teacher's or student's search for standards-focused learning in a real-world environment or community of practice. See the appendix at the end of this chapter for details.)

A few events can create awareness, but a program of ongoing events with BIC partners deepens learning while providing authentic contexts and engaging with those in the communities of practice. Most businesses and organizations desire to be good corporate citizens and assist educators in any way that they can, but they are limited in what they can do by personnel and financial constraints. Educators have to make it easy for companies to say yes to participation by spreading the load equitably among BIC partners. Rotate the events across sectors and organizations, if necessary, and tap each partner only once every two years or so.

Begin with a few events and expand a few events into a program where teachers and students can engage with those in communities of practice on a regular basis, using the CPQuests as an ongoing method to make learning real. Keep the process simple, yet formal. Make it someone's job to keep the program going and growing. Prepare the partners, teachers, and students for the CPQuests so everyone is ready to learn or to provide what is being sought. The partnership program, as a component of the ongoing teaching and learning professional development, will go far to develop exceptional teachers who motivate students to achieve at higher levels; more importantly, this exposure will extend their self-perceptions and help students realize career potential previously not explored.

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[*] Vicki Benson served as our industrial liaison and created exceptional opportunities for teachers in communities of practice.

Principals in Partnership – Leading Change

School principals are possibly the most critical partners when working on change with teachers in formal educational settings. It is hard to maintain sustainability without their visible, active, and continued leadership toward the goals of any grant or initiative.

One of the principal's most important tasks – removing barriers to performance – has attracted our particular attention because our initiatives focus primarily on teacher performance as a way of improving student learning. Many of the barriers are easily removed, and when removed, markedly increase what teachers are able to accomplish. Often, when we engage in a project, we acquire responsibility for identifying barriers and assisting in their elimination, mainly because we are external to the school district and can discuss things teachers sometimes do not feel comfortable broaching or bringing to the principal's attention.

Burns (1978, p. 19) defines *transforming leaders* as those who truly believe that "leadership is inseparable from follower's needs and goals." The essence of the leader-follower relationship is

> the interaction of persons with different levels of motivations and of power potential, including skill, in pursuit of a common or at least joint purpose.…Power is utilized to realize common goals and purposes and not for purposes of exploitation or manipulation. A unique aspect of transforming leadership theory is its moralistic or ethical component.

Principals who believe in transforming leadership realize that it is not all about them; the greater good is to develop students to their highest possible potential. They understand that, although they lead the teachers, they also work *for* the teachers by creating an environment and climate where learning by all is the expectation and context of operation.

Enlightened principals intuitively put into practice the superleadership theory (Manz & Sims, 1989), where they lead others to lead themselves; they empower others to demonstrate superleadership by actually engaging in leadership. They provide a working environment where teachers can develop a culture of functioning independently *and* through teams and where students also begin to engage in self-leadership.

In a world where we automatically function primarily within the "transactional" leadership construct, through which individuals make exchanges such as salary for teaching, the focus can be very different. Transactional leadership focuses on the self-interest of both parties in an exchange that is mutually beneficial (Burns, 1978).

Transforming leadership is about something else. In our initiatives, we apply the transforming leadership philosophy, using the superleadership model as well, while striving to develop teachers as leaders of learning. This is sometimes difficult, as most teachers really operate in a more transactional environment, especially districts in turmoil or crisis. That is, however, exactly when transforming leadership can reap the greatest results.

The following sources are valuable references when considering the context within which principals are administrators and leaders. It is a complex and turbulent context, where the challenges are great and the rewards few.

Senge et al.'s (2000) *Schools That Learn* helps us to understand what a school can or should be as a learning organization. It is an insightful resource from which to draw questions, seek analysis, and identify strategies and solutions. His definition of learning, which helped me to crystallize my own vision and goals for teaching and learning, when combined with a transforming leadership philosophy using the superleadership theory while modeling good leadership behavior, can set the stage for exciting and sustainable change.

Shumaker and Sommers (2001) illustrate how to bring about change by involving others through stories. They make the point that in learning something, we have to admit that we need to know, or do not know, something. That is an important issue when we work with teachers during the teaming component. I would ask them to stop a moment, clear their minds, and then give themselves the freedom to admit when they wanted to learn about something they "did not know." Once they did that, they worked so much more effectively. They moved quickly into a comfort zone with each other where posturing disappeared, honesty with each other became an openly practiced value, and even the know-it-alls began to act more positively.

Admitting that we do not know or that we need to know something runs contrary to what we as educators stand for. Teachers have been conditioned to hide what they do not know rather than openly seeking to learn more. This is counterproductive to a learning culture; in fact, there cannot be a learning culture where this is true. Principals are the ones who must change this type of environment or climate. Shumaker and Sommers (2001) show others how to make changes that move the culture to a higher level, leading through modeling. They encourage extending the classroom to other learning places, to group activities in nontraditional ways: encouraging interdisciplinary curricula, teaching teams, learning through multiple intelligences, authentic assessment, use of portfolios, and much more.

Modeling goes far to bring about change. Shumaker and Sommers (2001) offer change models and use mental maps as some of their strategies. They address sources of problems by mentioning a workshop by Phil Schlechty, who identifies the basic behaviors exhibited by teachers when confronted with change – "trailblazers, pioneers, settlers, stay-at-homes, and saboteurs" (p. 81). His descriptions fit perfectly with what we have observed as well, and are an informal but direct way of discussing change and roles with teachers. Shumaker and Sommers's model for continuous growth through feedback spirals also has a direct fit with the process we used throughout our initiatives (p. 136). The principal's involvement and modeling are critical to the kinds of change we are leading. The core personnel and program leaders, intuitively or intentionally, modeled best teaching and learning practices, leading by example.

Tonnsen (2000) examines instructional leadership and concludes that the research is clear about the requirement of the principals being knowledgeable, and "that the principal's authority is derived from their knowledge competence" (p. 10). We always included a principal's program of development that ran concurrently and addressed role, leadership for change, and best practices. Sometimes we were able to engage them, and sometimes not. For example, it was difficult to engage the Rockford principals as a group; some participated individually, when invited, and did support their teachers. The principals for both regional endeavors, however, were active and visible in their support, making accommodations for what teachers needed to accomplish, providing full support to help them achieve their visions and missions, and following them into the classrooms to observe during the pilots.

Drake and Roe (1999) address the social context of schools and describe the principal as a person and a professional: job description versus reality; the school communities; the theory, research and principles upon which action should or could be based; views of the organization; and major tasks for the individual learner. They consider assessment of performance and discuss staff development, society-related problems, management, and, of course, leadership. They list factors conspiring against instructional leadership and, as a solution, urge schools to employ a manager or services coordinator who can relieve the principal of particular management duties. Their chapter on creating "appropriate structures to improve learning" (p. 195) provides a list of what we do, now, often in spite of what we know.

In the sessions with teachers, we mentioned that what they were going to learn was not necessarily new but were successful practices that had been discontinued. Our initiative was as much about bringing back good practices and behaviors as introducing teachers to new ones. By this, I meant issues such as Drake and Roe (1999, p. 207) cite:

- We do not teach as well as we know how.
- We have not generally developed school environments that provide the best kinds of learning situations.
- We still teach the textbook and subject matter instead of the child.
- We structure for groups instead of individuals.
- We still operate schools as if all teachers are the same and all children learn the same things at the same rate in the same way.
- We still teach as if the school is the only place a child can learn.
- We still teach as if children can learn only from adults, and certified adults at that.

Drake and Roe further discuss a variety of models and strategies, making the point that plans exist for softening the inflexibility of school structures. In other words, we have viable options. Drake and Roe pose a question, "As principal, will you have enough leadership ability and creativity to structure a school so that teaching and learning are improved?" (p. 223).

Leadership, according to Drake and Roe, is where you find it: teacher, student, staff member, parent, board member, or other (p. 131). They consider the principal's primary task one of developing, nurturing, and reinforcing leadership wherever it may be found. This seems to be transforming leadership, using the inherent superleadership model: one that develops others to be leaders (p. 469).

Drake and Rose also have a fairly analytical chapter on staff development, following through with their strategy of identifying issues and alternatives or solutions, also focusing on the principal as an expert. They confirm the role that this university has played, especially those involved in this initiative. In discussing leadership, they quickly admit that old patterns of behavior will not work if principals are to meet today's needs or opportunities for leading. They review literature and theory on leadership, and although they do not mention "transforming leadership" (Bass, 1978) as we discuss above, their list of outcomes for leadership as "a deliberate process that results in the following outcomes for all in the school community" (p. 31) works for us:

1. Working collaboratively toward an ever-expanding vision of excellence in the achievement of organizational and personal/professional goals and objectives.
2. Creating a threat-free environment for growth so that the creative talents and skills of each person are maximized.
3. Encouraging and building working relationships that are individually and organizationally satisfying, unifying, and strengthening in the realization of mutually determined goals and objectives. Such relationships result in effectives group problems solving.
4. Optimizing available human and material resources. (p. 131)

Webster (1994, p. 4) discusses learner-centered principals, or the principal as teacher of teachers. He addresses how to use authority appropriately to achieve effective learning climates, maximize learner growth, and direct an organization of instruction and evaluation. He offers five premises that contradict conventional management-oriented principalship:

1. Effective principalship is a means to the end of maximum learner growth.
2. Effective principalships are principal teachers, teachers of teachers.
3. Effective principalship is both eclectic and pragmatic.
4. Effective principalship is an experience-derived art.
5. The skills of discourse are the most important ones in education because discourse is the "master switchboard" directing all content, learning and teaching.

Kaiser (1995) is one of many who include a discussion of Deming's 14 points to educational administration. In our particular case, many of us are from the industrial side of education and practice. As a college of engineering and technology, with partners from mathematics and science, we are immersed in industrial concepts, philosophies, and practices, especially related to quality. Therefore, Deming makes points easily used by us or interpreted and used in our work with schools, teachers, and administrators. Some of my favorite Deming points for our context here are: "break down barriers; remove barriers that rob people of pride of workmanship…eliminate the annual rating and merit system; institute a vigorous program of education and self-improvement for everyone…put everyone to work to accomplish the transformation…adopt and institute leadership" (p. 387). Possibly a business analogy will fit as well. Rather than focus on increasing the profit margin, if one focuses on improving the quality, conditions, processes, and education, the outcome will be improved profit margin. Rather than focus on teacher evaluation, we might get better results by working with teachers to self-assess, identifying strengths and areas to grow, and providing ongoing opportunity and support to learn.

In summary, principals are absolutely critical when engaging in complex programs of staff development for targeted change. Without their direct, active, and visible participation, the process can be much more difficult and the accomplished changes have less potential to be sustained.

Conclusion

It has been my mission to initiate and lead partnerships across campus with faculty in many different departments or fields, extending to other institutions of higher education, specialty schools, and community colleges, as well as with a great variety of business, industry, and community organizations for the purpose of supporting advancement in secondary MSTE education. Those from non-education fields or disciplines add depth, broader contexts, understanding of knowledge and applications, and different perspectives that can greatly enhance teachers' knowledge, skills, and ability to build more relevant and deeper learning experiences. The richness of knowledge and applications, the level of depth, and the variety of contexts for mathematics and science are much greater when we involve the broader community. Also many of these individuals are engaged in research that generates new knowledge, so their research skills and work with partners, such as national laboratories or the scientific community, add to what they bring the teachers.

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Appendix

1. *Initiating the business, industry, and community (BIC) partnership for standards-based CPQuests (Community of Practice Quests)*

   Very often a partnership would be initiated, but after the one or two visits, things seemed to fall apart. Schools generally did not follow through. It was usually left up to individual teachers to decide on the level of effort to expend in sustaining contact. In all fairness to teachers, unless they had release time, they could not make their phone calls until after the end of the business day, and no one could be reached then. Industry, too, is experiencing great difficulty in today's competitive and turbulent environment and could not always dedicate an employee to sustain the partnership. It is important to "make it someone's job" to sustain contact, but this does not have to require extended effort. It is all about how those engaged design the partnership and connection process.

2. *Developing the BIC partnership process*

   Partnership can operate in several different ways. The optimal method is to have a coordinator, whether for a grant providing teacher professional development or for a school, district or several schools working together. Alternatively, assign responsibility to a volunteer at a school. The administration needs to provide release time for a teaching professional or an administrative person. Another viable choice is to have a responsible parent volunteer for a year at a time for this. Many parents have their own networks within the community. Another alternative is a team of parents, with each member or subcommittee of the overall team serving to coordinate different BIC sectors.

   Once the method is chosen, begin with written agreements. BIC partners need to know exactly what is needed or desired. They have to assign the activity to someone, which is difficult to do if the request is unclear. For example, if you want a field trip for your students, tell them the date and time, what you want them to discuss, what type of experience is desired for students, and to what careers or personnel processes to expose students. If it is for teachers, the same holds true. One good method is to generate a list of questions to be addressed. Without direct and detailed requests, the result will be a general tour and question/answer session, which could be beneficial, but may be more awareness-oriented rather than addressing specifics at a preferred depth. Another example: when asking for financial support, be sure to create a budget, explaining each item in detail, which learning activities the request will support, the expected outcomes, and even what standards are going to be achieved.

3. *The agreement*

   It is important to generate a vision for partnership activities, determine which organizations have the capability of helping achieve the teacher development or curricular mission for each school year, and create an introduction with the vision and year's mission clearly stated, as well as a one-page summary of all requested experiences for the entire year and a one page form for each request. The summary form and each individual event form should have approval sign-offs. Thus, it is easy to determine if something will occur or is not possible.

Table 3.1 Partnership Introduction, Example

Partnership Vision:	To build teacher and student knowledge about technical careers requiring an MST foundation
Mission 2003-04:	To expose teachers and students to the manufacturing sector careers
School:	Name of School
Partnership Manager:	Contact Name and Information
(Teacher, parent, etc.)	
Principal:	Name of Principal
Summary 2003-2004 School Year	
Event 1:	Date, attached form #, focus; sign-off
Event 2:	
Event 3:	
Event 4:	

Table 3.2 CPQuest Event Form, Example

CPQuest Event Form
***(Business, Industry and Community Partnership Community of Practice Quest*)**
Event Agreement Form 2004
(Example)

Number of Teachers:	**Disciplines:**	**Teaching level:**
Number of Students:	**Student ages:**	**Student grade:**
Student Learning Standard(s):	**Related to Course(s):**	

Math
Science
Technology
English
Others

Student assessment or expected evidence of learning:
Project: (describe)
Paper: (describe)
Others: (name and describe)

Suggested Learning Activity:
Plant Tour
Q/A session with the following career partners:

Engineer	Scientist
Human Resource Manager	Publications Director

Shadowing: Name career track or specific person
Interview(s): Name career track or specific people
Others:

Requested Date: Priority Date — **Alternative Date:** Second Date

BIC Preference Date: Or, the BIC partner can suggest one of his/her own preferences here.

Requested Time(s): — **Alternative Time(s):**

School Contact: **Name, Email, Phone**

BIC Contact: **Name, Email, Phone**

School Approved: **Signature** — **BIC Approved:** **Signature**

Confirmation Fax/Email to be sent to BIC partner on:____ (put date here)
BIC Partner Fax/Email OKAY to School partner on:____ (put date here)

4. *Preparing partners for teachers and students*

Once the agreement is signed, someone has to be responsible for follow-up. We have found it best that the school send, email, or fax the partnership introduction form (Figure 3.1) approximately two weeks before the event with a confirmation, or we have used a simple follow-up form confirming the previously agreed upon event. The fewer forms, the better.

In addition, any information that can be sent ahead of time will assist the BIC partners in designing a more complete experience. For example, we have provided the BIC partners with all teaching and learning standards in a binder so that they will have them when we refer to them. They also have copies of information on performance tasks, rubrics, team visions and missions, and other materials, providing them insight into what teachers or students want to learn about.

5. *Preparing teachers or students for partners*

a. Choose learning standards
   - i. Mathematics
   - ii. Science
   - iii. Technology
   - iv. English (Communications)

b. Plan research focus of teachers or students

   Teachers –
   - i. Curriculum context for student learning
   - ii. Real-world performance tasks for student assessments
   - iii. Careers and educational requirements
   - iv. Others

   Students –
   - i. Research community waste from the manufacturing sector
   - ii. Career(s)
   - iii. Research properties of materials (chemistry problem)
   - iv. Others

c. Selecting BIC individual(s) as teaching and learning partners
   - i. Research options for best alternatives for purpose
   - ii. Determine which sector(s) are most appropriate
   - iii. Make Contact

d. Preorganize learning – Design the CPQuest
   - i. Gather information on organization
   - ii. Study the information
   - iii. Determine the learning and research pathway options, e.g., departments, personnel
   - iv. Select pathway(s)
   - v. Generate specific questions, issues; describe specific problems
   - vi. Identify best type of expert to accommodate learning

vii. Create information-gathering organization plan and process (forms, etc.) for visit

e. Target learning experience(s)
   i. Determine how many visits to request to complete the CPQuest
   ii. Describe each visit's purpose

f. Share CPQuest Plans
   i. Network across teachers or students and share CPQuest plans
   ii. Engage in peer cross-questioning to provide constructive criticism
   iii. Make desired modifications based upon peer feedback

It is important that teachers and students participate in preparation activities. They must have a focus, individual or group goals, target questions, specific operations they desire to observe, individuals to shadow, and career requirements about which they are seeking information. In other words, they must design a partnership research or learning plan or quest (CPQuest), much along the lines of a WebQuest. They should study the organization from Internet websites or materials from the organization to ensure that they understand as much as possible about the organization. This will save the organization personnel a great deal of time. The planning is a great way to deepen learning and achieve greater gains through a CPQuest; in addition, many standards can be achieved through the planning and requesting process. It is important that teachers and students do this planning and initial research themselves. The pre-CPQuest plan sharing and constructive feedback is a way to strengthen the CPQuest plan, and sharing the CPQuest results will build knowledge across individuals and groups. The feedback will result in more substantial and better organized CPQuests.

6. *Engaging in CPQuest learning activities at BIC sites*

a. Gather information
b. Perform research
c. Participate in learning activities

7. *Participating in post-Quest networking*

a. Complete feedback questionnaire about learning opportunities
b. Evaluate quality of learning experience(s)
c. Network with others; share CPQuest results, determine what was learned

8. *Finalizing product required as evidence of learning*

Teachers – Infuse information and BIC learning experiences into the curriculum:

a. Build curriculum
b. Design performance tasks
c. Develop career quest guidelines
d. Create virtual tour

Students –

a. Analyze data or information gathered
b. Design solution to problem
c. Draw conclusions about issue
d. Assess learning
e. Create virtual tours and websites/paper of results
f. Share and network across student groups and classes

4. Organizational Learnings: Reflections of a Superintendent

Ellen V. Bueschel

Secondary teachers in the Rockford Public School (RPS) district had the opportunity to participate in dynamic professional development experiences for seven years. These experiences evolved over time but always centered on the goal of improving student achievement in secondary mathematics, the sciences, technology, and more recently English (MSTE) education. A collaborative partnership including the RPS, Northern Illinois University (NIU), and Rock Valley College (RVC) drove the professional development project, but over the years it included scores of teachers and hundreds of business partners. For four of the seven years, I was an observer and participant, as deputy or interim superintendent, and witnessed the many and varied outcomes.

As I reflect on the outcomes, I am compelled to discuss the project in terms of my dual roles and have framed my reflections from the perspective of a student of organizational leadership strategies, techniques, processes, and outcomes.

Theoretical Lenses and Reflective Process

I have selected four models to frame my personal and professional reflections. The central model is derived from Senge's (1990) seminal work, *The Fifth Discipline*. However, as I continue reflecting on the outcomes and learning from the MSTE initiative, I also find meaningful connections with the work of Heifetz (1994), related to leadership and problem solving; Morgan (1998), related to organizational metaphors; and Hall and Hord's (2001) system for understanding the process of change.

The interconnections among these theoretical constructs became obvious as I shifted my reflection from leadership to change to organizations to systems thinking and ultimately to where I started – leadership. The interconnections provided coherence to my reflections about this initiative. Senge et al.'s (2002) discussion of the Industrial Age of Education resonates with Morgan's (1998) machine metaphor. Morgan's brain metaphor resonates with Heifetz's (1994) adaptive model of problem solving, and Hall and Hord's (2001) principles of change are woven throughout the writings of Senge, Heifetz, and Morgan.

The Learning Organization and Systems Theory

Senge's (1990) *The Fifth Discipline* and the subsequent *Schools That Learn* (Senge et al., 2000) have guided the professional development work of the RPS administrators and provided the opportunity to reflect on MSTE in terms of the tenets of a learning organization and our applications of the tenets. I have framed my analysis of the learning organization on Senge's five disciplines: Personal Mastery, Mental Models, Shared Vision, Team Learning, and Systems Thinking.

Discipline 1: Personal Mastery

A premise of the MSTE initiative was that teachers cannot teach students what they do not know themselves. According to Senge (1990, p. 140), "organizations learn only through individuals who learn. Individual learning does not guarantee organizational learning. But without it no organizational learning occurs."

Personal mastery for the secondary teacher in the 21st century necessitates the use of technology to extend knowledge and skills in mathematics, science, and English. But personal mastery also requires that educators clarify what is important and assess the current reality. In the MSTE initiative, the inclusion of English in the discipline mix brought to light curricular voids in technical writing for mathematics, science, and technology, while promoting acquisition of vocabulary specific to career paths and the use of technology in the teaching, assessment, and extension of language skill. The integration of disciplines increased the opportunities for students not only to apply and articulate their knowledge but to see the interconnections.

Senge (1990) argues that the juxtaposition of values and reality results in "creative tension," and that learning ensues as we seek resolution of the tension: "People with a high level of Personal Mastery live in a continual learning mode" (142). The MSTE initiative provided equipment, training, and a safe place to risk learning new ways to present the traditional bodies of knowledge as well as develop new skills and knowledge.

Often the involved teachers were learning at warp speed, even though the gaps in their training and education made it appear that they were running in place. They came to the project with a wide range of skills and competencies both in the content areas that they represented and in the pedagogical processes. The MSTE staff took these differences into account and modeled teaching strategies that could be replicated in K-12 classrooms. The assessment of current reality was based on individual situations and also indicated significant differences across participants. However, the teaming processes that will be discussed in a later section provide some assistance in managing this wide range of differences and in resolving the creative tension generated in examining values against the current reality. In Rockford, this examination often led to tensions around student achievement in the content areas, the expectations and role of the teachers in the learning process, the differences between teaching and learning, the definition of leadership, and the responsibility for lifelong learning.

As teachers pursued personal mastery in the development of new knowledge and skills, they also developed confidence in their own abilities and a capacity to bring their current reality into line with their personal and professional values. This capacity for leadership became crucial in the implementation phases of the process and a significant factor in assessing the role of leadership in the change process.

Discipline 2: Mental Models

In an analysis of why some of the best ideas fail, Senge (1990) suggests that the "slip 'twixt cup and lip' often stems from our own mental models" (p. 174). The development of this discipline was evident in the MSTE initiative. A significant part of the project was the interaction with more than 300 business, industry, and community (BIC) partners. During the years of the project, there were significant technological advancements in most of the BIC environments. The teachers who engaged in on-site learning with these partners learned from and contributed to this generation of new information. They would not have been privy to the current requirements and methodology had they not developed these important relationships with practitioners.

The relationships played out in a variety of ways. Without the BIC and higher-education visits, teachers would have had little opportunity to identify and challenge the mental models they held about important concepts and skills. They gained opportunities to shadow practitioners whose work depended on a current application of mathematical, scientific, or technological advances. Shadowing revealed curricular and instructional voids (particularly in medical technology, engineering, and mathematical applications) and enhanced the development of new mental models. It became clear to the teachers that the fieldwork required a different knowledge base and skill level than had been part of their own preparation and teaching repertoire. The requirements of this new knowledge base led to the hosting of "discipline update" workshops by the professors and BIC partners.

The Rockford teachers also benefited by learning from models, while simultaneously serving as models. The opportunity for the teachers to be the experts in teaching pedagogy and methodology, when interacting with the BIC and higher-education partners, shifted their mental models about the complexity and requirements of their own profession and helped them see that the ability to stimulate learning was not to be taken for granted. These two-way collaborations enabled them to connect with the Personal Mastery dimension and develop it concurrently with the shifting of their own Mental Models.

Discipline 3: Shared Vision

According to Senge (1990, p. 206), shared vision "is vital for the learning organization because it provides the focus and energy for learning…. A shared vision is a vision that many people are truly committed to because it reflects their personal vision." Further, "the discipline of shared vision is the set of tools and techniques for bringing disparate aspirations into alignment around the things people have in common" (Senge et al., 2000, p. 72).

As the initiative played out in Rockford, the power of shared vision became apparent and was the glue that held participants together during some of the rough times of implementation. The vision was developed by capitalizing on the learning related to the disciplines of Personal Mastery and Mental Models and was extended throughout the informal organizations created during implementation. The work of the teachers often built upon the work of teachers in previous cohorts as teams shifted and were reconfigured. Many teachers came back year after year and encouraged others to join them, expanding the benefits throughout the district. The ability of the project staff to model interdisciplinary teaching, provide learning experiences for varied learning styles, and create and share tools and techniques enhanced the development of shared vision at the content, grade, school, and district levels. The initiative provided a space for intervention to support the teachers in a less than accommodating environment. Many players owned the vision and gained power in a setting usually known for the isolation of the professional staff. The vision could be articulated at any level of the district where opposition occurred.

Even more significant, the educational modules developed by the teachers required sharing visions across disciplines to create coherence in the learning activities and strategies. As the teachers discovered connections between content areas and created opportunities to take advantage of the connections, they also developed a shared vision of learning for their students. The project director and team listened carefully to the participants and found connections when the participants could not. The participants came to realize that in a shared organizational life, we all have something to learn and to teach. Finding a shared vision became the tipping point in creating learning organizations in the schools.

Discipline 4: Team Learning

Senge's (1990) work informs the concept of team learning and helps participants to use the power of the team to enhance the effectiveness of teaching and the efficiency of learning. According to Senge (1990, p. 234): "When a team becomes more aligned, a commonality of direction emerges, and individuals' energies harmonize. There is less wasted energy. In fact, a resonance or synergy develops, like the coherent light of the laser rather than the incoherent and scattered light of the light bulb. There is a commonality of purpose, a shared vision and understanding of how to complement one another's efforts."

Team learning brought out the connections that developed in the shared visions for enhanced student learning. The teams also learned how and when to engage in dialogue and discussion, even in difficult or defensive situations.

Senge (1990) has identified three critical dimensions of team learning: a need to think insightfully about complex issues, a need for innovative and coordinated action, and a recognition that members of one team have a role on other teams. An individual cannot master the discipline of team learning. There were formal and informal teams at every level of the MSTE initiative: classroom teaching teams, university professor teams, business partnership teams, subject matter teams, teaching and learning strategies teams, grade level teams, building teams, and district teams. They tackled the three dimensions on every level of their work together by sorting through the complex issues of development and implementation of the products and their own learning.

The first dimension, thinking insightfully about complex issues, goes right to the heart of the MSTE initiative. Changing the content and delivery of instruction is a very complex issue. Reflection often leads to the painful conclusion that it is necessary to give up long-held beliefs that shape our professional persona. This kind of thinking is best done in a team context, and during the MSTE initiative, the team learning brought reflection to a much deeper level. Learning begat learning, and questioning begat questioning, as well as the generation of new answers. Thinking is synergistic in nature, which brings us to the next dimension of team learning.

The need for innovative and coordinated action brought out the strengths and weaknesses of the Rockford leadership team. There was no way to include all of the teachers in the project at the same time, and this generated an insider/outsider complex. Some staff members were working diligently to effect the learnings of the initiative, while others were working just as diligently to end the project. In buildings and departments where professionalism was evident in the work of the teachers and administrators, innovative and coordinated action was demonstrated. Conversely, in those where power was held at the administrator level and not distributed to other staff members, roadblocks to implementation were clearly evident.

The third dimension speaks to the role that the members of one team serve on other teams. This dimension was demonstrated throughout the project. When participants had the opportunity to interact across team structures and serve on teams with different foci and mission, they significantly increased their learning and the ability to implement the desired changes.

Discipline 5: Systems Thinking

The project served as a microcosm of Senge's fifth discipline (1990, p. 68):

> Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots." It is a set of general principles....It is also a set of specific tools and techniques....

Discipline 5 has synergistic interrelationships with the other four disciplines – among professors in varied schools, departments, and academic disciplines; between theoreticians and practitioners; and between classroom teaching and student learning. Of Senge's (1990) 11 laws of the fifth discipline, three seem closely connected to the implementation of the initiative in the Rockford schools. Examples of the second law (p. 58), "The harder you push, the harder the system pushes back," were common throughout the project and often compromised implementation of the interdisciplinary modules. The fourth law, "The easy way out usually leads back in," will be discussed later in the section on adaptive leadership. The eleventh law, "There is no blame" (p. 67), shaped both the framework of the initiative and the successful implementation efforts in the schools. Senge discusses this law in the context of the impossibility of disconnecting ourselves from the outside forces that we often blame for our problems and emphasizes that we are all a part of the system that creates the problems that we encounter.

Evident throughout the project were structures of balancing and reinforcing feedback loops, principles of leverage, double-loop learning, and the language of systems thinking. Our first cohorts predated Senge's work, but our outcomes certainly support his ideas. The whole was surely greater than the sum of the parts, and patterns of change became clear, at least when seen through the lens of leadership.

Technical vs. Adaptive Leadership

The second theoretical lens I applied to my reflections is Heifetz's (1994) problem-solving model. In *Leadership without Easy Answers* (1994) and *Leadership on the Line* (Heifetz & Linsky, 2002), Heifetz defines two types of problem-solving challenges that require completely different approaches. Technical, or Type I, problems are those that we have the knowledge and skill to define and solve. However, many problems require more than technical expertise to solve. Heifetz offers two definitions for these adaptive problems. The first is the Type II Adaptive Problem, for which we have the knowledge and skill to define but no obvious solution. The solution requires new learning. The most complex problem is the Type III Adaptive Problem, which requires new learning both to define and solve.

This differentiation of strategies has focused my thinking on many levels. Our initiative had many adaptive challenges, and the missteps in the school system could often be traced to situations where a Type I technical solution was applied to an adaptive problem that required a Type II or Type III approach. For example, it was critical that teacher teams have enough time to plan together and deliver instruction in nontraditional scheduling formats. In those cases when the building principal supported the project and was willing to take on a Type II or III adaptive approach, the problem of flexible teacher time was resolved. However, when the principal framed the building schedule as a Type I technical problem, the flexibility was impossible to achieve. There really is no technical solution for an adaptive problem, and the narrow approach to the time issue set up barriers to implementation; the inability or unwillingness of the principal to think creatively added frustration for many of the teacher participants.

A significant learning from this experience is that a leader who has a ready solution in his/her repertoire that has been applied to similar situations may decide not to risk doing something different. An additional learning is that the use of technical solutions often supports Senge's fourth law of the fifth discipline and provides the easy solution that often leads right back into the problem.

Further reflection on the successes of the MSTE initiative led me to conclude that the entire project exemplified adaptive leadership. Type II adaptive problems were abundant in the project, and the many alternatives generated during the years attest to the leadership within the project itself. The problems that the school district encountered with implementation seemed to relate to its inability to understand or solve Type II and Type III problems. Too often, the organization lacked the capacity or language to articulate or deal with the problem. Those participating educators grounded in theory (as described in Senge, Heifetz, and Morgan) were generally better able to avoid attacking complex adaptive problems in a linear and simplistic manner.

Images of Organizations

The challenge of organizational capacity leads to the third model that shapes my essay. Morgan's (1998) *Images of Organizations* identifies eight "metaphors" to help understand organizations. He defines metaphor as "a primal force through which humans create meaning by using one element of experience to understand another" (p. 4). Table 1 (Cambron-McCabe et al., in press) stimulates my own reflections, especially in terms of moving an organization like the public school system from old images to emerging ones. The two images that capture our journey are the machine metaphor in the "old" category and the brain metaphor as the emerging image. The brain metaphor also connects with Senge's (1990) learning organization and Heifetz's (1994) adaptive leadership.

Table 4.1 Imagining Your School District (Adapted from Morgan, 1998)

Image	Nature	Strengths/Weaknesses
Old Images		
Machine	Goals and objectives predominate; rational structure; organizational charts; people interchangeable within the system.	Works well where machines work well. Creates a mindless bureaucracy.
Political System	Management as political process; identify different styles of government; view politicization as nearly inevitable and accept conflict as normal; study power and learn how best to use it.	Puts power and conflict center stage while emphasizing the interest-based nature of organization. Breeds more politics and can understate gross inequalities in power and influence.
Psychic Prison	Psychic forces encourage or block innovation; frozen mindsets and unconscious forces hinder change; irrational things take on power and significance; imprisoned by own way of thinking.	Challenges basic assumptions, puts the "irrational" in new perspective, and encourages the management of tension. A focus on the unconscious may deflect attention from other forces of control.
Instrument of Domination	Power dominates organizational activity; workaholism, occupational accidents, and social and mental stress common; exploitation of employees and customers taken for granted.	Indicates that rationality can be a mode of domination and brings ethical concerns to forefront. Metaphor is so extreme it can polarize discussion.
Emerging Images		
Culture	Organization as unique mini-society that reflects people; accepts idea that some cultures are uniform, others fragmented.	Emphasizes symbolic significance and interdependence of management and labor in everything. Can manipulate and ignore some dimensions of culture.
Organism	Focuses on open systems; organizational health, life cycles, and development considered important; adapting to environment encouraged; relationships of species to ecology explored.	Contributes to organizational development. Easily becomes ideology and overstates cohesion.
Brain	Examines organizational intelligence; interest in learning organizations; uses technology to decentralize and distribute intelligence.	Recognizes importance of paradox and provides clear guidelines for learning organizations. May be naïve if conflicts arise over learning and realities of power.
Flux and Transformation	Tries to understand fundamental nature of change; looks "around the corner"; analyzes systemic forces encouraging change; tries to encourage organization to shift from one pattern of operation to another.	Leaders get powerful new perspective on role in encouraging change. May imply that leaders and managers have to "go along for the ride" and are powerless to do much about change.

The Machine Metaphor

Morgan's (1998) description of the machine metaphor is consistent with ideas presented by Senge et al. (2000) in "The Industrial Age of Education." Both trace the factory system of production that characterized the Industrial Revolution to the mechanistic military organization attributed to Frederick the Great of Prussia during the 18th century. Mechanistic organization led to the principles of classical management theory and scientific management that defined organizations during much of the 20th century and still define many school districts today. Morgan's machine metaphor uses many of the same terms that we associate with the factory model of education: decentralization of work, centralized control, specialization, efficiency, production, precision, dehumanization, consistency, narrowly defined goals and objectives, and bureaucratic principles and processes. Morgan describes the strengths and limitations of the machine metaphor in terms of the types of organizations served. Organizations that require precision, consistent application, and strong measures of accountability are able to thrive under the bureaucratic practices that are consistent with the machine metaphor. However, the very characteristics that define success in these organizations also set up a barrier when the organization needs to change.

As we look at the MSTE initiative, we can understand some of the resistance and barriers encountered as we faced down many of the bureaucratic processes. The school district was often responsible for many of the barriers through policies and procedures consistent with a top-down organizational structure.

Participation and change might be mandated by the administration but not followed up with the necessary support, including scheduling and feedback. Often the principal set the tone for an individual school building and influenced not only actual participation but also the effectiveness of the module pilots and evaluation and implementation. Additionally, union regulations limited the times and conditions of teacher participation. Reviewing Morgan's (1998) metaphors and Hall and Hord's (2001) change principles might have helped project leaders and ultimately the districts to anticipate and address these issues.

The Brain Metaphor

Morgan's (1998) brain metaphor is based on the notion of learning organizations, which by definition have the capacity to be flexible and innovative in meeting challenges. This metaphor is consistent with Senge's (1990) definition of a learning organization and Heifetz's (1994) adaptive model of problem solving. The paradoxical images described by Morgan include holographic and specialized, random and coherent, and redundant and efficient.

Morgan lists five principles that can help to create contexts for holographic self-organization. These principles, which are consistent with Senge's systems theory, are: (1) build the whole into all the "parts," (2) redundancy is important, (3) ensure requisite variety, (4) define minimum specifications, and (5) learn to learn. The first and fifth tie directly to Senge's shared vision and team-learning disciplines.

Morgan describes the strengths and limitations of this metaphor in terms of the organizations of the future, in contrast to the machine metaphor, which capitalized on historical premises. The brain metaphor provides clear guidelines for creating learning organizations and using information technology to support intelligent evolution. It also lays out the challenges facing traditional organizations, supports the creation of new kinds of leadership and management models, and recognizes the importance of dealing with paradox. The metaphor does have significant weaknesses, notably in dealing with the realities of organizational life, especially those that concern power and control – two constructs that often shape the status quo. Employment of the brain metaphor can set up an intense resistance to change. The idea of resistance to change leads to the next lens for reflection.

Principles of Change

Hall and Hord (2001) provide a useful framework for examining the change process from the leadership perspective. Their 12 principles applied to our initiative and are also identified in the writings of Senge (1990), Heifetz (1994), and Morgan (1998). The sources used to shape these reflections include *Implementing Change: Patterns, Principles, and Potholes* by Hall and Hord and a chapter in *The Superintendent's Fieldbook* (Cambron-McCabe et al., in press) entitled "Nature of the Change Process." (The *Superintendent's Fieldbook* presents the learnings of the Danforth project, which involved superintendents across the country dealing with the realities of making change in their organizations. The concepts of Senge, Heifetz, Morgan, and Hall and Hord are embedded in the presentation.)

Change Principle 1: Change is a process not an event.

This principle was reinforced over and over throughout the seven years of the project. At no time could the participants say that the change was complete and then move on to something else. The participants were changing both in the persons involved and in the knowledge and skills achieved.

Hall and Wallace (Cambron-McCabe et al., in press) note that as people and organizations move through change, they begin to understand and use new ways of thinking and doing. These new ways of thinking and doing require new systems of implementation that spawn newer ways of thinking and doing, and so on. To revert to Heifetz's (1994) model of leadership, if change were an event, technical solutions could make it happen according to plan with no need to adapt. That clearly was not the case with our initiative in Rockford. As the project grew in numbers and complexity, the implementation processes often required new thinking and different arenas for implementation. Senge et al. (2000) define these phenomena as a reinforcing process, "a form of feedback that leads to exponential growth or decline – either in nature or in human affairs" (p. 84). They caution that underestimating the power of reinforcing processes often leads to linear thinking, which in turn leads to trouble.

Linear thinking is a technical process used when we know what the problem is and can apply known solutions to the problem. In Rockford, the underestimation of the power of reinforcing processes was clearly evident in the early years of the project. Single-loop thinking prevailed, and the question of whether the curricula and instruction in our secondary schools were relevant to the needs of the workplace or foundational to higher-education requirements did not emerge. Linear thinking sufficed for the purpose of instruction, when the process was isolated from the needs of the workplace and the knowledge and skill requirements of higher education. Do I hear echoes of Heifetz?

Change Principle 2: *There are significant differences in what's involved in developing an innovation and implementing it.*

Earlier I referred to the role of the principal in the implementation of the products generated by the participants of our initiative. Hall and Wallace (2004) describe development and implementation as two sides of the same coin but remind us that the style of the change agent for implementation needs to be significantly different from the style of the change agent for development.

An early problem that we encountered was the communication gap between the teacher-developers and the administrator-implementers. We recognized that there were gaps in the knowledge and skills between those who were engaged in developing the modules and those who would have to put the structures in place to implement the modules. But we incorporated a technical solution into the problem by trying to educate the implementers about the power of the modules in effecting change, rather than understanding that their contribution to the success had to do with a completely different skill set and organizational context. I understand now that it would have been helpful to have built the capacity of the administrator-implementers to effect changes at the same time as the teacher-developers were creating the impetus for it. When those processes overlapped and all the participants in the project understood the different roles and expectations for developers and implementers, the change process went more smoothly.

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Change Principle 3: *An organization does not change until the individuals in it change.*

This principle is consistent with the disciplines of Personal Mastery and Mental Models as Senge (1990) describes them. He makes this principle the spirit of the learning organization. The initiative supported individual change on many fronts. Two supporting mechanisms that contributed to the success of our initiative are not common approaches to staff development, at least in my experience. The first is the modeling embedded in the staff development opportunities. Modeling occurred in many ways throughout the project, but two techniques were significant in providing for change in individual participants. Those who led the workshops were trained to incorporate the desired teaching strategies into their own planning and presentations; the BIC partners provided models for the new knowledge base required for assuring relevance of the teaching modules. These two techniques facilitated change in the mental models teachers held about content and effective teaching. The second mechanism was even more powerful in effecting individual change: personnel actually went to the classrooms to help teachers pilot or test their modules. In a profession known for isolation, this exhibition of support let the teachers know that they were not out there by themselves. They had a safety net and could take the risks inherent in learning something new.

Change Principle 4: Innovations come in different sizes.

This principle certainly held true in our initiative. Innovations occurred on many fronts and in many forms and formats. The underlying philosophy was itself an innovation consisting of many components:

- Writing across content areas
- Interdisciplinary development teams and team teaching, portfolio assessment
- Interdisciplinary learning and integrated MSTE curricula
- Rubric development and scoring with authentic performance-based assessment
- Teaching and learning styles
- Multicultural sensitivity in the selection and creation of materials
- Distance learning
- Internships
- Use of technology as an infrastructure and for teaching and learning

In addition to the innovations in pedagogy, we used many innovations in technology to enhance the teaching and learning process. Whatever the innovation – collaborative software for critical interaction, a PowerPoint presentation, creation of a website, Web-based learning, or a simulation representing a scientific process – it became a source of changed behavior. The size of the innovation did not matter. It only mattered that everyone was engaged in learning.

A major learning related to this principle is that the principles of change cannot be ignored, whatever the scope and impact of the innovation.

Change Principle 5: Interventions are actions and events that are key to the success of the change process.

Hall and Wallace (Cambron-McCabe et al., in press) have emphasized that leaders often neglect the very interventions that can shape the process of change. Leaders can become so consumed with the innovation that they ignore the day-to-day opportunities to question, provide help when needed, and support the developers and change makers. Leaders are often so busy planning the big events related to the change that they forget to manage the individual components and support the people who are affected by it.

As superintendent, I was guilty of ignoring this principle, especially when developers were not getting the needed support in their buildings. While full-scale mandates can be detrimental to success, especially if you are unsure of the audience's potential reaction, I know now that there were places where I needed to be more "hands on," even to the extent of intervening to gain support for the teacher teams' work.

Even if administrators are not inclined to actively support the teachers' participation and change efforts, they should be directed to avoid negating the process. My own reluctance to intervene at the individual, department, and building levels undoubtedly slowed the process in some buildings and halted it in others. However, in hindsight, I know that supportive informal conversations I held with some of the participants, usually by chance, were important far beyond my expectation.

Change Principle 6: Although both top-down and bottom-up approaches can work, a horizontal perspective is best.

Both top-down and bottom-up are descriptors associated with bureaucratic organizations, and we have learned that change-making within bureaucracies is challenging at best. Developing horizontal approaches to change signals a new model, but it also comes with new and often daunting challenges. The most significant in our project was the development of trust.

In a horizontal structure, the trappings of formal power and control give way to collaboration and cooperation. All participants contribute, and all benefit. However, everybody must be trusted to do their part. In our initiative, trust issues ran the gamut from very significant concerns around creating a safe place to take risks or expose weaknesses in skills or gaps in knowledge to providing the pastries for an early morning session.

We learned that trust builds very slowly in troubled organizations and is always fragile and tenuous. Unfortunately, the climate in Rockford contributed to significant trust issues. Earlier in this report, Scarborough writes about the lost opportunities for publishing discussions about our initiative owing to lack of trust by the public school participants. This is a clear example of some of the real costs to the higher-education participants and the tradeoffs required to create an adaptive solution. However, the attention paid to issues of trust helped to create a horizontal organization that built leadership capacity and could sustain innovation in the absence of formal authority.

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Change Principle 7: Administrator leadership is essential to long-term and successful change.

As I initially confronted this principle of change, I concluded that it was too obvious and even questioned its inclusion in this model. I have changed my mind and believe that it was my own narrow conception of administrator leadership that challenged serious reflection of this principle. It makes sense to me now to apply my reflections about a different model of administrator leadership.

Schools are noted for embracing change for change's sake, and yet very little innovation is actually institutionalized. Too often change comes about because of external factors. Administrators leave the district. A school board election results in a different philosophical approach. The message of a dynamic speaker motivates the staff to explore a new concept. The pendulum is continuously swinging back and forth, never stopping long enough to establish a firmly centered position.

When I analyze this principle through the works of Senge, Heifetz, and Morgan, my conception of leadership shifts in fundamental ways, and it is within this view that I see the power of this principle. If we are seeking long-term and successful change, we must look at a different concept of leader, one that does not incorporate the more traditional and bureaucratic idea of administrator. The most important work of the administrator in this context is to develop leadership in others, a task requiring a different skill set and certainly a different approach to power relationships. If we look at Senge's learning organization, we find no place for static knowledge. Rather, everyone in the organization must become a learner, with all the inherent risks. When all are learners, it follows that all can also be leaders.

In Rockford it was sometimes necessary for teacher-leaders to develop or implement the initiative, and it was certainly easier when the administrator was willing to support or at least allow the development of leadership in others. My own impression is that this willingness is correlated with an administrator's personal concept of the strength and effectiveness of their own leadership abilities. The least secure seemed to be the least likely to build capacity in others.

Change Principle 8: Mandates can work.

As a superintendent who believes that a mandate from on high should not be necessary (if you believe that people, given the opportunity, will do the right thing), this principle is difficult. However, I learned the hard way in our initiative that sometimes it is necessary to mandate the change if you want it implemented. Too many innovations bloom for a short time and disappear without a mandate, or at least intervention, to support the implementation. Mandates can provide impetus, resources (sometimes!), and legitimacy to the need for change. I learned that some people respond to a mandate because it removes accountability and responsibility from them; they are doing "it" because "the superintendent made me do it" or "the grant required it."

Also, we experienced the power of an oppositional mandate. If the principal, the central office staff, other teachers, or the union opposed the processes required for development or implementation, the levels of resistance often required a return to the hierarchical model of management to counteract the resisting forces. A mandate could provide cover for those who genuinely wanted to participate fully in the benefits of the project. Mandates also provided a means to limit participants to those who were willing to take on the challenge of learning and implementing new techniques.

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Change Principle 9: The school is the primary unit for change.

In our initiative, the successes and the failures of implementation confirmed this principle. Even when identical modules were used in different schools, the results varied according to the ability of the participants to implement changes at the site.

A major learning is that the superintendent must work with the building's leadership to effect implementation according to the school's need for change and its capacity to sustain it. This relates back to Principle 7 and requires different approaches from district leaders. The approaches are rooted in creating capacity for leadership at the building level and providing a safety net for those principals who are advocating for change. The superintendent must minimize the personal and professional risks for the building's administrator, while supporting development and implementation that can clearly be interpreted as top-down management. The superintendent must employ the tenets of both a bureaucratic and a learning-organization form of leadership, without appearing schizophrenic or two-faced.

The theoretical models and vocabulary described above were invaluable to me as I reflected on this particular slippery slope and sorted through the events to understand when and why some things worked very well, while others were dismal failures at the building level. This principle and Principle 12 both operated in the district and had significant impact on the success of implementation.

Change Principle 10: *Facilitating change is a team effort.*

This principle refers to the fourth discipline of a learning organization, team learning. No one person can manage all that needs to be done in a change effort. Different skills, competencies, perspectives, knowledge bases, processes, and products enhance the change effort. However, there must be coherence or alignment of the effort or chaos will result. Alignment needs to be incorporated into the district's mission and supported throughout the organization for optimal implementation.

Senge (1990) writes: "Individuals learn all of the time and yet there is no organizational learning. But if teams learn, they become a microcosm for learning throughout the organization" (p. 236). The teaching and learning teams surely facilitated change in RPS, especially in the deepening of content knowledge and the acceptance of integrated learning models and innovative teaching strategies at the secondary level. A review of the participants and the modules confirms the effectiveness that can be achieved when teams are supported. Early in my experience with this initiative, a new principal was appointed at one of our high schools. She bought into the inherent MSTE team structure early in her administrative career and supported the efforts at that school from the outset. Eventually, most of the staff was involved in project work either directly or indirectly, and the culture of the building now reflects respect for teachers and students, risk-taking in teaching, high levels of student achievement, and participation in the activities of the school and the community.

Change Principle 11: *Appropriate interventions reduce the challenges of change.*

This principle follows from Principle 5. Harvey (2004) describes the leap of faith that is often required to move from "today's ugly realities to tomorrow's beautiful possibilities" (as cited in Cambron-McCabe et al., in press, p. 304). He also provides a bridging strategy to assure that when we take the leap, we can arrive at the other side.

This bridging strategy was very useful to my reflection about leadership. Harvey has suggested that we need to find out where the people are in relation to the leap of faith and lead them from there. His "bridge" is adapted from Hall's seven Levels of Concern (Hall et al., 1979, p. 309):

- Little awareness of innovation – Needs general information
- General awareness of innovation – Needs substantive information
- Concerned/anxious about innovation – Needs financial or status information
- Worried about processes or tools – Needs information about time demands, efficiency
- Interested in impact on students – Needs data on performance/competencies
- Interested in cooperation – Needs support and encouragement
- Refocuses and explores innovation – Needs to be cheered

I used Hall's framework for assessing the implementation of programs during the late 1980s and early 1990s, but had not considered it in examining the learnings of our program until

I stumbled upon it again in referencing Hall's later work. It amazed me to discover its applicability to the MSTE initiative, especially in managing appropriate interventions. The team was always right there, meeting the participants' levels of concern with the information and the strategies needed to permit them to take the leap of faith.

An example of this attention to the levels of concern is the innovative approach of following the participants into their own classrooms and observing the implementation of the pilot projects. This approach was unheard of in the public school setting, and concern was expressed from so many perspectives – ranging from fear of the experts observing mistakes to the place of this activity in the district evaluative process to the perceived lack of understanding the university faculty would have for the challenges of the contemporary K-12 classroom in an urban setting. The project team listened to the concerns, adapted the process when appropriate, provided tools, shared information related to content and data collection, interceded for the participants when necessary, and served as cheerleaders. I learned the importance of dealing with all of these levels of concern in a systematic and systemic fashion when attempting to institute change at any level of the organization.

Change Principle 12: The context of the school influences the process of change.

Bennis's (1983) classic, *On Becoming a Leader,* describes the importance of mastering the context. It was apparent throughout the development and implementation stages of our initiative that the context of the school was usually the most significant factor in effecting change in the teaching and learning environment. The complexities of the context included the training and development of the teachers, the expectations for student achievement, the treatment of diversity, the expectation that all would be engaged in learning, the material support for learning, and the support of the principal.

If the school is the primary unit for change (Principle 9), the context of the school has far-reaching consequences on the superintendent's ability to effect change throughout the system. In Chapter 5, Scarborough describes the project's pull-versus-push approach, which is relevant to the superintendent's need to effect change at the building level while understanding when to push and when to pull. When we examined the influence of school context, we found an unexpected phenomenon. Those schools and teachers that were openly struggling with student achievement issues were willing to take the risks necessary to learn new content and strategies for teaching. A result of their efforts was that student achievement, as measured on both district and project indicators, exceeded the achievement in schools that had previously been considered better. We speculate that a reputation for being a good school may, in some cases, inhibit the possibility of becoming a true learning organization.

Recommendations

In reflecting on the RPS initiative, I am convinced that there are several general keys to overall success. Understand that even when the following are practiced, as with this initiative, challenges may still occur.

1. Actively involve representatives from the school district in the grant-writing process because they can judge which may be the best options. It is counterproductive to write a proposal that will not be possible.
2. Ground the project in theory to give leaders, teachers, and administrators a language to articulate the changes and programmatic needs.
3. Remember that a project grows and is modified as needed. It will require adaptive leadership, cooperation, and patience.
4. Have the building principals buy into the change process. The principal often sets the tone in a school, but it is possible to modify an attitude through cooperative interaction of a critical mass of the staff.
5. Select a core of teachers to become the leaders in each building. They should possess a strong curriculum focus and be willing to learn. They should also be team players who are willing to serve as models.
6. Treat the teachers as professionals and important contributors to the educational process. Remember that burned out does not mean bad; it simply means something has happened to cause a change of attitude or diminished enthusiasm. Since poor or burned-out teachers hurt everyone, it is crucial to have teachers reflect about why they originally became teachers and regenerate the enthusiasm.
7. Identify and deal with personality conflicts that can harm or derail the project. Focus on what is being done rather than on who is doing it. (The skilled leaders from Northern Illinois University helped overcome these challenges, but it was often three steps forward and two steps back.)
8. Use mandates carefully to avoid giving teachers the excuse that compulsion was the reason for their failure to participate in or support the activities and changes.
9. Remember that change occurs one person at a time; with a core of support, it is possible to keep going in difficult situations.
10. Organize ongoing formal discussions about the project, beyond the informal discussions at lunch and during sessions. These forums might be support groups for the teacher participants, and they could exercise quality control for the overall program. Eventually student input could be added through focus groups.

Conclusion

Heifetz and Linsky (2002) tell us that "leadership would be a safe undertaking if…organizations and communities only faced problems for which they already knew the solutions" (p. 13). They caution about the proportionate relationship between risk and adaptive change. When facing the dangers of tackling adaptive problems in organizations, one strategy is to distribute leadership. This distribution is different, however, from the specialized leadership that is prevalent in organizations characterized by the machine metaphor. It is more like the holographic description in the brain metaphor, which implies a distributed form of intelligence with the whole built into all its parts.

If we believe that teaching and learning are central to the mission and organization of schools, it follows that developing leadership capacity in teachers should improve the odds that teacher-generated innovation will overcome organizational inertia. I would rewrite Principle 7 to read, “Administrator and teacher leadership are essential to long-term and successful change,” and expand the notion of leadership to encompass the real leaders in a learning organization, the teachers and the learners.

We have learned that there are no shortcuts to the process. Building leadership capacity in others takes more time, effort, and skill than merely doing the job yourself. I liken the task to building supports for the organizational structure at the same time that you attempt to turn it upside down.

My own mental model or metaphor is an inverted triangle representing the traditional bureaucratic organization in flux and trying to maintain stability while tottering on its peak. Building leadership capacity creates supporting structures and strength throughout the organization, enabling it to maintain equilibrium during the process of change. That equilibrium is clearly dependent on the style of leadership, methods for approaching and solving problems, organizational images, and an understanding of the challenges of making substantive change. Building leadership capacity in others requires that everyone participate in the learning and results in everyone being changed by it. In Chapter 2, Scarborough uses Senge’s (1990) concept of *metanoia*, a shift of mind, to frame the meanings that are applicable to our initiative. There is no doubt that significant mind-shifting occurred in all the participants who were willing to let go of preconceived notions and recapture the joy of learning. Our initiative evolved to develop a true representation of Senge’s learning organization, and the Rockford Public Schools were forever changed by the process.

> We shall never cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time.
> – T.S. Eliot

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5. Operating Philosophy and Project Strategies

Jule Dee Scarborough

Holistic Programming

Teachers have often told us that they find staff development to be disjointed and not necessarily relevant to their professional life. Most grants for supporting staff development provide for the costs of the development, but fewer pay for the extended time to support classroom pilots or implementation, and hardly any allow for multiple levels of programming and pilots.

All of our grant-supported work with schools contained a "program" of development, beginning with an initial needs assessment through administrators and followed by a needs assessment by the teachers. The program of development occurred actively: teachers performed while learning, and then they were supported while planning their pilots; they were observed and offered feedback during the pilots, and then they participated in pilot wrap-up sessions. Our program evolved to include many levels of programming and pilots. Teachers could participate in extended opportunities to learn, develop, and continue to pilot again. This greatly enhanced sustainability. Teachers were reassured that what they were doing was worthwhile, and, if the data showed student achievement, they were more likely to continue once the project ended.

The holistic nature and complexity of our endeavors made us more a "center" of activities than a single grant program. Our initial aim was to identify districts in need and offer to seek support for their reform needs. Therefore, over the years, as teachers or district leaders learned about our programs, they asked us to seek grants to support the program offerings or similar initiatives in their districts. We have found it challenging to sustain our focus while building interdisciplinary teaching teams at middle and high school levels, unless particular conditions are in place. Networking has remained a key strategy. In all initiatives, we have tried to connect teachers with each other within districts, but also across districts and with external partners.

Although we have focused on secondary teachers, we have worked with both purely middle school groups and purely high school groups and have had them participate together. Some merged groups felt that it was fine to include teachers from grades 6-12 in the same professional development sessions; some did not. My opinion is that the high school teachers can learn a lot from the middle school teachers when it comes to engaging students. Also, as long as high school teachers are working directly with high school, and middle school with middle school, there does not seem to be any real problem working with them together. There is another invisible level to consider: those high school teachers who teach primarily the first-year and second-year classes and those who teach the third-year and fourth-year classes. Admittedly, what they teach and how they should or do teach can be quite different, but the third-year/fourth-year teachers can learn a lot from the others. We have also had a group called "transitions," the eighth and ninth grade teachers working together to develop transitional activities between the middle and high school levels for their students.

The Rockford project involved approximately 300 teachers over seven years; other projects have involved as many as 50, 75, or 150 per year. While we could work with larger numbers of teachers or teacher teams, our preference was to work with 40 to 50 at one time. Our strategy was truly engaged learning – doing and performing while learning. This degree of involvement made it possible to work successfully with larger numbers, but it required highly competent program leaders. Additional funding sources sometimes enabled us to work with teachers in very small groups, in which they received individual attention and were able to address individual concerns, brainstorm their ideas to a much deeper level, and learn more about knowledge with which they were less secure.

Integrated MSTE Curriculum

The culminating products were always integrated and interdisciplinary mathematics, science, technology, and English (MSTE) curriculum modules, three to eight weeks in duration, for each year of the teams or individuals participating. Some of the modules were a semester long and a few were year long.

The modules were far more than merely the curriculum content, knowledge, or skills to be learned. Embedded within them were the new strategies, techniques, procedures, or processes. For example, in trying to achieve learning at the higher levels of Bloom's Taxonomy, teachers used more engaged teaching and learning strategies and models, more authentic student performance assessment procedures, and so forth. These were also major components in the curriculum modules, making the whole much greater than its parts, both content and process. The major outcomes and deliverables went well beyond these curricula products. For the teachers, the module was the culminating product or deliverable, which included other nested products, processes, strategies, practices, and procedures.

We submitted copies of the modules to the Illinois Curriculum Center to share final products across teachers, schools, districts, and statewide. Advancements in electronic communications enabled us to share more easily, although we had some frustrations at first with incompatible software packages. The additional materials that teachers include (books, adapted materials, videos) are not available. (See www.strategicalliance.niu.edu.)

Pull versus Push

In teaching about a variety of pull-versus-push models in industrial management classes at Northern Illinois University, I had not originally considered that terminology in the context of professional development programs for teachers. Then one of our mathematics professors used it in describing the approach to working with the mathematics teachers in some of the discipline-update workshops. Once he used the phrase in this context, I found that it precisely described what our program is all about. Although we designed a program to match the identified needs, we were flexible with changes suggested by the teachers, such as more programming or extended time on topics. Our philosophy was to meet the needs of the teachers so that they could become more capable in moving students to higher levels of achievement, making their curriculum and learning activities more relevant and authentic, and improving their pedagogical and technological skills. We began with a clearly defined program and expected outcomes; then the teachers pulled and we did our best to respond. That was how we evolved to multiple levels of programming (Rusin, 2002). We are now more conscious of that philosophical goal.

Modeling

In our initiatives, those who led were expected to model that which they expected of teacher participants. For example, program leaders were required to use the engaged teaching models, not just tell teachers about them and ask them to use the models. Again, when we asked the teachers to develop student performance tasks with scoring rubrics establishing the standards of performance, we also used that approach ourselves. We provided teachers with a rubric establishing the standards and criteria for their module product. Not only did this make participants more inclined to try new strategies, but it built professional trust and set a firm foundation of professional exchange.

Relationships

It was important for program leaders to find common ground with the teachers; after all, they had similar teaching and learning issues, whether at the secondary or higher-education level. Relationships were built on trust, credibility, truthfulness, delivery of promises, and mutual respect – qualities that developed when the leaders created a safe learning climate in which all were comfortable owning up to what they did not know, where everyone was a resource, and where the leaders learned and acknowledged that they were also learning from the teachers. We had program leaders from the community college; the university; business, industry, and community organizations; and, most importantly, we had "peer leaders," practicing teachers who had been program leaders.

Building self-confidence, self-esteem, and self-efficacy

Many teachers had serious reservations about their own capabilities to learn or perform; they felt uncomfortable working in groups with predetermined criteria or standards to achieve, especially if some type of rubric, feedback process, or review of their accomplishments was involved. Some became defensive and began to have reservations about participating. Therefore, our first step was to work them through what they would be expected to deliver, how the process would take place, what rewards would be provided, how they would be held accountable, what would occur at various levels of performance, and, most importantly, what support they would have as they went through the program. If promises of support were made, they must be fulfilled as described.

We had very few teachers actually drop out because we showed them that they could succeed if they worked with us appropriately. If they were committed and followed through, sought help or confirmation that they were on track, used available feedback, and worked together, they could attain higher levels of performance and successfully complete their work with us.

Building trust

Trust can be broken by something very insignificant, but if teachers sense that leaders are genuine and trying their best to deliver, they stand behind them. How is trust built between secondary and higher-education collaborators? It is both complex and simple. The cultures are very different, and human dynamics make groups very complex. Typically, in the relationship between secondary and higher education professionals, the university is perceived as the driver. To build trust for productive and respectful collaboration requires defining how all parties can contribute and benefit. Genuinely participative decision making is crucial, along with an explanation of what is mandated, such as grant regulations.

For example, at the beginning of almost every endeavor, some teachers questioned our motives for working with them. They asked if they were being studied as part of someone's research or dissertation or if the data collected was going to serve someone's publication interests. Often they could not see that what they accomplished would be important to publish so other schools could gain access to the results. This concern caused us not to publish about most of our work with teachers. As a result the teachers trusted us, but it did limit our ability to disseminate the results of our work; indeed, the level of university faculty involvement in our projects may have been limited by the fact that we were able to publish relatively little about the processes and outcomes.

Continuous feedback

Our operating philosophy included providing feedback at each stage of development so that teachers understood where they were in their performance and product development. The feedback took place informally and formally. Formal feedback increased dramatically over the final years, and we began to use rubrics more often to document progress and feedback. Although we were careful about "evaluation," we did have to evaluate the final products or performances of the teachers. The more feedback that occurred throughout the program formally, the more successful the evaluations were, ending with celebrations rather than frustration.

Creating an exchange forum of ideas and strategies

We find it beneficial to be open about our difficulties in teaching and learning. Some teachers claim that our university working environment and students are very different from theirs, but most saw the common ground. When we worked closely for more extended periods, teachers began to appreciate that we tried some of their ideas in our own classrooms and were more willing to research something together or have our students work together across levels. Once collaboration began, it created endless opportunity for exchange.

Mentoring

The word mentoring gets a lot of use, but it is rarely implemented in a formal way, and therefore, we use the term carefully. Our goal was always to have mentoring going on between professionals, but we never had consistent, formal mentoring relationships where meetings were scheduled. Instead teachers and professors or other partners developed a comfort zone and felt confident that they could call, email, or visit one another. During the Rockford initiative, participants and leaders found a comfort zone that lasted beyond the formal grant period, largely because the leaders were approachable, responsive, and genuinely interested in the teachers. Also, the teachers were excited by the research, types of courses, and experiences of the professors. Only a few of the leaders were in education; rather most of them were practicing scientists, engineers, industrial technologists, or experts in fields such as aviation or nursing.

Teachers know a lot about what should occur in the classroom, but most of them lack experience outside of the classroom. Therefore, when teachers are partnered with professors who are active beyond college or university teaching or with representatives from business, industry, and community organizations, they are able to extend their disciplinary knowledge.

Joining Teachers in the Classroom

We went beyond offering in-service programs. We found it critical to follow teachers into the classrooms to pilot or field test their educational models, processes, strategies, techniques, procedures, and curricula. When we were present to lend support and observe, teachers felt more secure in trying something new and less anxious that they would be penalized if it did not go well. We set the program up so that teachers prepared for their pilots by clearly identifying what was new and what goals they desired to achieve. We did this as part of a preparation meeting, and then we joined them in the classroom to observe aspects of their pilots, but not the whole thing, as most pilots ranged from three to eight weeks. If a teacher team was involved, we visited each teacher during the pilot.

Immediately after the pilots, we engaged with the teachers in examining what worked, what did not, and what changes should be made. They appreciated this approach and evaluated it highly. This went far to ensure continued implementation after the grant period. An extension of this model, also very successful but not always possible, was to convene meetings twice a year to network on pilot outcomes, usually before Christmas break and at the end of the year. These depended upon external but relevant considerations, such as whether teachers had to be paid stipends for each hour of participation because of union regulations. Teachers enjoyed and benefited from these sessions, and many were willing to participate without direct rewards.

We also extended what might be perceived as the more traditional activities of the professors, as program leaders, to those of learner. In the Rockford project, we felt that our professors needed to better understand what teachers face in the classroom and local contexts. Therefore, all professors participated in classroom visitation and observation to become at least minimally familiar with the secondary teaching and learning context. Most were amazed. Many had not recently been in a school classroom, except for parent/teacher conferences about their own children. This contextual experience greatly helped them gain insight about what teachers face on a daily basis, which was expanded by conversing with teachers throughout the program.

We created yet another opportunity for the professors. We asked them to develop integrated interdisciplinary modules to deliver in the secondary classrooms. Most of the university faculty agreed, as did a few of the community college professors. The university faculty used the module format required for the teacher modules to varying degrees. We did not tie them rigorously to the format, but instead asked them to identify state standards and other curricular requirements. They then delivered the modules in the classrooms.

We created this opportunity for two reasons: (1) to give professors the opportunity to work directly with students and (2) to initiate a closer connection among teachers, students, and professors for ongoing visitation and joint lessons, so that secondary students would become familiar with professors and have the opportunity to ask questions and seek information about the discipline, particular lessons, or educational requirements for careers. This was very successful. The professors were open to continuing these activities should teachers continue to request them.

Leadership through Partnership

It was possible, using one lead person, to provide a program less complex than this one but similar in its foundation. My experience ranged from being sole lead person for an entire program, as well as evaluator and project administrator, to being the project investigator or director of a very complex and extended group of key personnel across one or more institutions with program delivery and evaluation responsibilities. The phrase "internal partners" meant across colleges and departments internal to Northern Illinois University; other educational partners were the school districts, community colleges, and regional education offices. Funding partners ranged from one (e.g., the National Science Foundation) to several simultaneously, including the Illinois State Board of Education and the Illinois Board of Higher Education, and local matches by the educational institutions and school districts. Partners also included master secondary teachers as peer leaders. And, very importantly, the business, industry, and community (BIC) partners engaged in communities of practices were invaluable to extend and deepen knowledge and understanding of MSTE contexts. Internal and external partners brought a wealth of knowledge and real-world contexts that one person could not deliver. Exposure helped teachers create more authentic lessons, assessments, and learning activities.

Our NSF grant funded one professor each from mathematics, physics, chemistry, biology, and English, and two from engineering technology from both the university and community college; one peer lead teacher; one educational specialist; the PI; and two co-directors with subcontracts, one to the school district and one to the community college partner. However, we had 23-30 NIU and 15 community college professors, plus others, active in this project because of success in obtaining additional funding. When able to match funds, we could involve a broader group with different perspectives, levels of creativity, special interests, and abilities and were better able to match professors with teachers. Also, the range of teachers included middle school and high school. Some professors had difficulty working at the middle school level, but by broadening our group, we were able to include those who could work successfully at each level.

Finally, we are discovering a new category of resources for teachers: the many professors who are taking their retirement, some of them at quite young ages. Many of them are interested in continuing their work with us and the teachers or are continuing as consultants to stay active in their fields and plan to keep an office on campus. Most are retiring locally, so it will be important to organize contact information and activities.

Professionalism

For teachers to be productive, they have to feel professional, be treated as professionals, and be in a space and environment conducive to getting work done. We find dramatic differences in the quality of work and the level of productivity according to the type of environment in which sessions or events are held.

Usually, schools were not the most appropriate professional development environments and had too many potential distractions. We tried to provide the professional development elsewhere, except for one case when the high school had a wing with full Internet hookups for laptops, a professional setting, and was conducive to small- or large-group work. Most of the time, we offered the development sessions at the community college, the university, or extension centers, and often at conference hotels.

Technology and Tools

Teachers expected to produce or perform must have easy access to the appropriate technology and tools. We led the way in providing teachers with laptop computers, printers, scanners, digital cameras, software generic for the whole group, and software or peripherals specific to individual or team endeavors. Once they learned how to use the technology, their sense of professionalism, and their productivity and product quality increased exponentially. Having a reason for using the technology encouraged them to learn more rapidly. They were required to use their technology in the classroom with the students, even if they had to rotate students. The technology was officially donated to the schools but permanently assigned to individual teachers if they followed through with participation. They could take their technology home and use it with their families as long as they also brought it back to the classroom. This worked well.

Extrinsic Rewards

Our philosophy was to reward teachers appropriately with summer stipends, graduate credit, or continuing professional development units (CPDUs). Teachers greatly appreciated a stipend of some kind or a mix of stipend, graduate credit, or CPDUs toward recertification. The teachers, and we, also considered the technology provided as a component of the reward structure, since it became theirs when they completed the program.

Intrinsic Rewards

In our attempt to provide intrinsically rewarding experiences that would result in the teachers' enthusiasm, excitement, and professional growth, we strove to ensure that the following did *not* occur (Sparks, 1997, p. 20; Killion, 2002, p. 64):

> For too many teachers, staff development is a demeaning, mind-numbing experience in which they passively "sit and get." As one observer put it, "I hope to die during an in-service session because the transition between life and death would be so subtle."
>
> The problem with staff development is that it is always done to us, as if we cannot be trusted. We are intelligent people who possess a desire to learn to improve our performance and that of our students. Frankly, we can be trusted to structure our own learning experiences if the administration would give us a chance. Most of us want to prepare for the next semester so we are ready when classes begin. Most of us want to know what is current in our fields. And most of us are tired of the administration telling

us what is important to learn. Why don't they ever ask teachers for their ideas or suggestions?

To further examine our staff development model, see Chapter 6.

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6. Operational Models

Jule Dee Scarborough

Staff Development

Our staff development philosophy is to move theory and best practice into the classroom. The fundamental concept involves needs assessment and teacher self-assessment as priorities (see Figure 1). We believe in a holistic program, rather than disjointed "sessions." And although we did structure events as workshops, workshop series, classes, or workshop clusters, they were learning action events, not stand-alone, and they ranged in types of activity. Our program provided a fabric of interwoven events.

We preferred leading others to lead themselves, rather than just serving as topical consultants. We believed in using "local" talent, knowledge, experience, and expertise whenever possible, especially when moving a grant-funded initiative toward sustainability. After self-assessment and needs assessment were concluded and compared, a program was confirmed and aligned, changed or built, based upon them. Teacher teams established their beliefs and values, created visions for themselves and their students, and identified their goals, basing them on what they perceived as current realities. They identified desired results; then together we analyzed the program and project to identify which program components could help them accomplish their goals. Their goals might relate to the development of interdisciplinary curricula, choice of new teaching models, development of assessment procedures and partnerships, and others. Teachers learned about new research and practices, and they then moved toward applying what they learned in the classroom.

The program, although usually already planned based upon the initial needs assessment, could be revised to accommodate what was learned in the self-assessments. Teachers were not passive participants in our process; they were involved in making content and process decisions, and they agreed to standards or criteria of involvement. The teachers and teacher teams engaged in individual and collective learning as well as leadership (Beavers, 2001; Collinson, 2000; Cozart & Gerstl-Pepin, 2002; Finch, 1999; Fuchs & Fuchs, 2001; Jones & Holder, 2001; Sanborn, 2002; Sparks, 1997; Terehoff, 2002).

All of our endeavors involved interdisciplinary teaching teams, which created an exciting context for sharing. Where it was not possible to continue a team or build a team, we supported individual teachers who desired to achieve the program goals. The ultimate goal was to have everyone involved in the program, so that when team members transitioned across schools within a district, all had been trained and members of teams and could, therefore, join existing teams in their new schools. To ensure the development of deeper and more meaningful relationships, we preferred to engage with schools, districts, or teaching teams for longer periods of time (Birman et al., 2000; Keifer-Barone & Ware, 2002; Peterson, 2002).

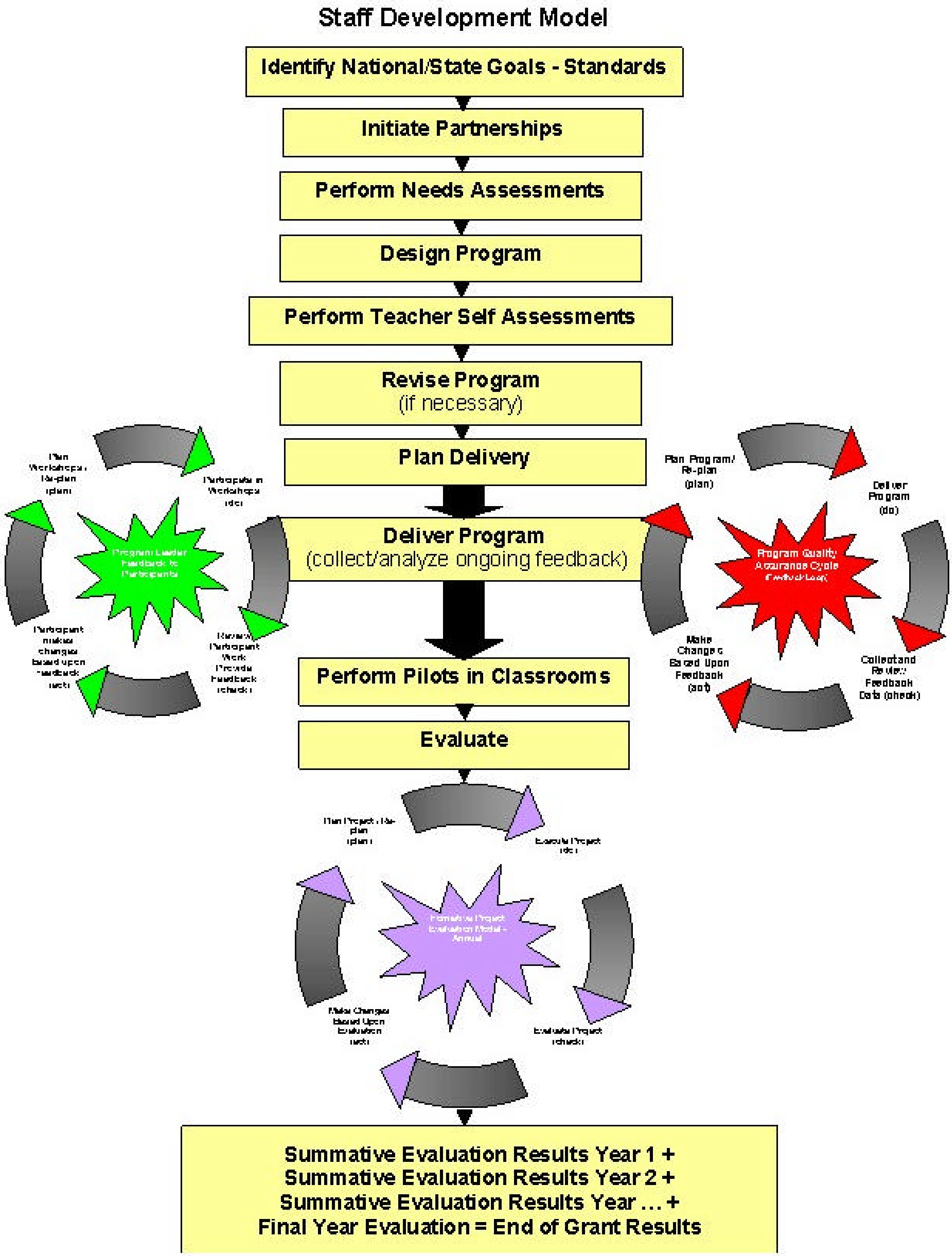

Figure 6.1 Staff Development Model

National Staff Development Standards

Our model has evolved since 1983, with fundamental components, processes, and philosophies that appeared "before their time." When we began our work, we had to justify why funding agencies should provide support beyond "program offerings," and why we wanted to follow teachers into the classroom to pilot their educational product or process. As national thinking about project evaluation began to change and include requiring classroom pilot and student achievement data upon which to base evaluation, we found it easier to seek funding. The action research movement has helped a great deal. Today, there is a plethora of literature upon which to base good staff development practice.

Our philosophies, strategies, and results support what is now regarded as best practice, addressing some of the critical questions in designing staff development programs. Readers should consult the National Staff Development Council's (NSDC) (2001) standards for staff development. The NSDC also provides a Standards Self Assessment to assist a district in determining staff development strengths and areas that need improvement.

Hirsh (2000, p. 50) elaborates the NSDC standards and lays out the following criteria for exemplary staff development, specifying: "results measurable in terms of student performance; a well-defined process that enables others to replicate learning; content-specific staff development designed to improve teachers' content knowledge and pedagogical skills; and, involvement of multiple schools, within or across districts, a state, or region." Hirsh (p. 51) poses important questions about the criteria:

1. *Content:* Is there evidence, in terms of student results, that proves an investment in this content will produce the desired results.… [H]ow well is the content aligned with standards for student learning? Is the program designed to improve teachers' content knowledge and pedagogical skills? Does the program embed the pedagogy in the content and enable teachers to make successful transitions into their daily practice?
2. *Process:* How well does the program address the national standards for professional development? Is enough information and support provided for the program to guide successful implementation? Does the program provide a means for collecting ongoing data to monitor its impact? Are there student measures of success to determine the impact of the program (e.g. student portfolios, pre-testing and post-testing, student writing samples)?
3. *Context:* Do the program developers or providers have evidence of its application in a school with similar demographics and needs? Will the program produce results similar to the results it has produced in other schools? Do you have the necessary resources, including time to ensure the program is implemented as recommended? Are the leaders sufficiently knowledgeable and invested in the successful implementation of the program?

The NSDC standards and Hirsh's questions appeared after we had almost completed our initiatives, but it is always important to benchmark one's endeavors against current standards. In doing so, we find that our programs and models measured up very well and that we met the three categories of professional development standards. In the following enumeration, italic type highlights those categories in which our programs excelled.

1. Content Standards – Staff development that improves the learning of all students:

- *Prepares educators to understand and appreciate all students; creates safe, orderly, and supportive learning environments; and holds high expectations for their academic achievement. (Equity)*
- *Deepens educators' content knowledge, provides them with research-based instructional strategies to assist students in meeting rigorous academic standards and prepares them to use various types of classroom assessments appropriately. (Quality Teaching)*
- Provides educators with knowledge and skills to involve families and other stakeholders appropriately. (Family Involvement) *(In our PHYS-MA-TECH initiative, we did seek approval from and inform parents about the goals of the initiative. Also, we surveyed parents about their children's reactions to the program. In the other initiatives, we were not involved with parents. However, we were very involved with business, industry, and community organizations as they delivered critical components of the program and then continued as partners during the modules.)*

2. Process Standards – Staff development that improves the learning of all students:

- *Uses disaggregated student data to determine adult learning priorities, monitors progress, and helps sustain continuous improvement. (Data-Driven)*
- *Prepares educators to apply research to decision making. (Research-Based)* (We engaged teachers in what today might be termed action research. They used pretests and posttests to determine student achievement. In our initiatives, these were formal, quasi-experimental pilots with researchers guiding the process. The tests were either adopted from national organizations or developed by teachers with the assistance of the project research associate. By engaging in the formal pilots, teachers began to see a direct connection between what they taught, how they taught, and how they designed learning opportunities, and they could understand that they must design carefully any assessment instrument, process, or procedure.)
- *Uses multiple sources of information to guide improvement and demonstrate its impact. (Evaluation)*
- *Uses learning strategies appropriate to the intended goal. (Design)*
- *Applies knowledge about human learning and change. (Learning)*
- *Provides educators with the knowledge and skills to collaborate. (Collaboration)*

3. Context Standards – Staff development that improves the learning of all students:

- *Organizes adults into learning communities whose goals are aligned with those of the school and district. (Learning Communities)*
- Requires skillful school and district leaders who guide continuous instructional improvement. (Leadership) (In some initiatives, we worked directly with principals

through workshops, discussion sessions, and opportunities for them to collaborate across schools about what their teachers are doing. This was possible in all of our initiatives, except Rockford.)

- *Requires resources to support adult learning and collaboration. (Resources)*

Additional literature supports our process. For example, Rhoton and Bowers (2001), in *Professional Development Leadership and the Diverse Learner: Issues in Science Education,* explore most of the major topics important to today's science education reform and can be used more broadly when considering staff development program and process issues. Since science is one of the critical disciplines to all of our initiatives, this source is quite valuable for reference. It confirms our approach to content and process. Also available is *Advancing Excellence in Technological Literacy* (2003) which presents staff development standards for technological literacy.

We asked similar questions when working with administrators and teachers and expected them to identify their individual and team goals for change. We engaged them in an assessment-oriented self-analysis in which they identified their strengths, growth goals, and areas where they wanted to learn more. This process focused on establishing the "reality" of where they were, a vision of where they wanted to be, and a plan for achieving their vision, using the components as part of their action plan.

Lipka and Brinthaupt (1999), in *The Role of Self in Teacher Development*, address teacher understanding and acceptance of self as critical. When teachers build their knowledge and skills, they gain in self-esteem and self-confidence as professionals, becoming personally more secure and more open to relationships with others in their learning community.

Hamachek (as cited in Lipka and Brinthaupt, 1999, pp. 207-208), identifies behavioral descriptors for good or effective teachers:

1. They are inclined to combine warm and friendly attitudes with firm, but reasonable, expectations.
2. They project an enthusiasm for their work that lends excitement to their teaching.
3. They are by no means perfect, in the sense of doing and saying just the right thing at all times.
4. Intellectually they are thoroughly grounded in their subject area, which, by virtue of a broad base of interests, they are able to connect to related areas of knowledge.
5. They are ready to assume responsibility for student outcomes, which they reflect in their efforts to make sure that all students have a chance to learn.
6. They make it a point to know their students as individuals and to respond to them as individuals; they go beyond simply seeing them as "students."
7. They provide definite study guidelines; they are as interested in getting their students prepared to know as they are in evaluating what they know.
8. They are able to challenge without being offensive and to encourage without being condescending; more importantly, they challenge when appropriate, and they encourage when needed. No behavior is indiscriminately practiced.

9. They give feedback that is personalized, an effect that makes the feedback more believable and powerful.
10. They take time to reflect about their work, their students, and themselves as teachers; they are, in a word, thoughtful.
11. They work on developing a positive rapport that serves as the interpersonal medium within which high, but reasonable, expectations and constructive, critical feedback can be transmitted.
12. They are able to be flexibly adaptive in terms of using direct or indirect methods of teaching to meet various student abilities and needs.

The individuals we selected to be program leaders usually exhibited these attitudes and behaviors as well as the knowledge and skills required. In our initiatives, caring was critical. We worked with large groups of teachers we might identify as insecure, lacking confidence, or uncomfortable in their roles or responsibilities. We "cared" about them as people first and then worked with them to build or strengthen their knowledge and skills, confidence, and self-esteem. Modeling went far to establish the expectations of a caring environment. It moved the group toward becoming a true "learning circle [community]," as discussed by Collay et al. (1998), in which six conditions begin to be realized: building community, constructing knowledge, supporting learning, documenting reflection, assessing expectations, and changing cultures (p. x). Ultimately, we wanted participants to find an environment where they realized that:

- There are a number of well-developed models of teaching and curriculum that generate substantially higher levels of student learning than do normative practices.
- The most effective curricular and teaching patterns induce students to construct knowledge – to inquire into subject areas intensively. The result is to increase student capacity to learn and work smarter.
- The most effective models of curriculum and teaching increase learning capacity for all students, greatly reducing the effects of gender, socioeconomic status, linguistic background, and learning styles as factors of student learning. (Hopkins et al., 2000, p. 5)

These authors, and others we could cite, discuss a framework for teaching and learning that revolves around behaviors, skills, relationships, and models. They confirm our content, strategies, and processes and further inform us for future endeavors. Also, they are in sync with *Models of Teaching* (Joyce & Weil, 1995), which we used as a primary resource for the teaching models component.

Objectives

One of our goals was to provide a holistic program with integrated deliverables, both product and process. Several objectives kept us focused on the quality of the program:

- Our *first objective* was to base our activities on the most recent research and information. In many cases, we were teaching new, or revisited, concepts, skills, and models before they became a national focus or best practice.

- Our *second objective* was to do as we asked others to do. We held ourselves accountable to formally model the best practices, models, techniques, procedures, and processes as workshop leaders. The lead team that worked with me for the longest period of time accomplished that very well. For example, our workshops set objectives and standards, and we used rubrics to inform the teachers about what was expected and to score what they developed. They scored their product (with incorporated processes), and then we scored it using the same rubrics.

- The *third objective* was to create an integrated program that was logically sequenced to accomplish the participants' learning and development goals. The program needed to be integrated in content and sequence, and also in how and when particular components of the products, performances, or processes were learned and developed or, in some cases, simply incorporated. Therefore, we usually chose an "umbrella" culminating product: the integrated, interdisciplinary curriculum module (IICM). The design and components for this module integrated new strategies, processes, procedures, models, and techniques that teachers were supposed to use during a formal pilot. The IICM promoted the integration of MSTE and also required the integration of new strategies, processes, models, techniques, and procedures. It was both content *and* process.

- A *fourth objective* supported piloting. We followed the teachers into the classrooms as they piloted the modules. We prepared them for data collection and feedback; a program leader helped the teachers set up their pilots, meaning that the teams established clearly what they wanted to learn as teachers. The modules provided the necessary information about the goals for students, but a critical piloting concept was that teachers themselves should have goals or identified targets of change. The teachers met with a program leader to identify their personal professional goals and what they were going to try that was new; after the pilots, they met with the same individual to debrief about the outcomes. They were observed at least once by an external observer, sometimes more often, and sometimes by a peer or several peers. Immediately after the observation, they met for feedback, and after the pilot, they met to determine what worked and what should be changed.

- Finally, a *fifth objective* was to set the stage for networking both within and across schools and across teachers and teacher teams. Networking reinforced and extended teacher learning, especially after pilots. For several years we were able to get teachers to meet mid-year and at the end of the year to review what they learned during their pilots. I cannot speak highly enough about the value of "group study" for enabling teachers to validate one another's experiences, reinforcing good results, and engaging together to determine what they should try next. Most of what worked is described in the workshop chapters (see Part II), and what did not work, usually, did not because the teachers lacked the infrastructure, leadership support, individual commitment, or simply did not follow through.

Facility

We tried to avoid working in school buildings, and sometimes even district staff development spaces, because we regarded them as less professional spaces that affected how teachers responded psychologically. We preferred space that was set up for professional conferencing and with technological capabilities because it transformed the "psyche" of the teachers and improved their motivation, productivity, and engagement. The "space" greatly affects their sense of value and professional.

Our views on space led us to use different models. When working with a district, as we were in Rockford, we had no choice but to go to Rockford. However, we tried to find a conference space, and in Rockford we held most meetings at a conference hotel and restaurant. Typically, this would have been too expensive, but the facility owner worked with us to keep within our budget. One might ask why we did not prefer a university or community college space. We did extend to the community college space and the university center located in Rockford. We also transported teachers from Rockford to the main university campus, about 40 minutes away. However, it is important to acknowledge the issues in accessing college or university space appropriate for conferences. Frankly, they have become profit centers and invariably give priority to outside clients rather than university-sponsored projects and events, and they are now expensive.

Time of year and day

Our teachers differed greatly in the time they devoted to our basic program, from as few as 19-20 days to more if they added electives. The advanced-level groups scheduled as many as 30+ days with us for a one-year cycle. To accommodate those choices and to give teachers a much needed and deserved break during the summer, we used various combinations:

a. weekday school holidays
b. weekdays, as a local in-kind school match, using substitute teachers for those days
c. local district institute or teacher work days
d. Saturdays
e. spring breaks
f. Christmas breaks
g. summer, after school ends and before it begins
h. evenings, after school
i. combinations of the above
j. on their own, a model that just does not work

The time of day has also varied:

a. 8:00 a.m.-5:00 p.m., a common model
b. 8:00 a.m.-4:00 p.m., a model we now use
c. 4:00 p.m.-9:00 p.m., after school, a model we have left behind
d. 8:00 a.m.-12:00 p.m., a model we do not use very often
e. on their own, a model that does not work

My preference was the 8:00-5:00 model, with an hour for lunch and breaks. However, many of my colleagues preferred the 8:00-4:00 model with an hour for lunch. Teachers were mixed about it as well. Although many were ready to end by 4:00 and admitted to being drained, some felt rushed and preferred 5:00, especially when working together and being supported. Teachers who are immersed in development and learning activities seldom realize what time it is. Though tired at the end of the day, they will be elated and enthusiastic about their accomplishments, especially when they are going to use their new products and strategies in the classroom.

A progressive program over the majority of the school year and into the summer, until approximately the end of June, worked best. It allowed "digestion" time between sessions, and many of the teachers actually worked on projects between sessions. It also allowed teachers to be free for vacations from July 1 to mid-August when school began. We preferred, however, to have them meet with us in mid-August to review the piloting strategies, data collection responsibilities, and meeting dates before they began piloting activities.

The best model was to meet with the teachers early in the fall semester for orientation and begin the first sessions no later than October, for an extended and holistic program.

Options for Place, Facility, and Time

On-campus extended conference (my favorite)

So far, only the "in-district" model of delivery has been discussed. Others were also successful. When working with a regional group of schools, teachers, or teacher teams, we had them come to campus for up to six weeks at a time, for the development activities, and housed them at the student center or a local hotel close to campus, the library, departmental laboratories, and computer access. This was probably the most exciting model. When teachers were on campus, away from their own contexts so they could not easily be disturbed or distracted, they immersed themselves in a very different way. Their enthusiasm, commitment, productivity, professional and personal growth, and interest in exploration and learning grew. When they stayed overnight, the learning, networking, and development lasted well into the evenings. We truly became the invisible support system and they began leading themselves, developing strong relationships with each other. Given the resources, most teachers who had a week with us on campus would choose this model over being located directly in the district. It also permitted frequent access to professorial support for shorter time periods because they could come and go as needed.

Alternative version of on-campus conference

In addition to the current program and the on-campus model for use when all teachers were engaged in the same program, there were others. The alternative version of the on-campus model was campus-based, of course, and could use some of the same program content, but it also provided for flexibility of participant concentration. For example, in working with some districts, most of the teacher teams focused on particular common goals (e.g., developing interdisciplinary teaching teams, learning to develop authentic or performance-based assessment, or adding alternative teaching models), but others had somewhat different goals or needs. In those situations, we organized programs so that the whole group of 80-150 teachers could engage in experiential learning together in the mornings and at the end of the day, but during the interim they engaged in experiences more directly related to interests or needs of their particular teams. This aspect of the program could differ by focusing on new teaching strategies that other teams might not feel the need for or by reinforcing or building skills where they did not feel as confident. Or each team might have different real-world needs and arrange its schedule to meet with separate industry representatives or visit different industries, laboratories, or community sites. Yet another variant was to schedule all participants together for half the day and then send them into their team-specific programs for the second half of the day.

These arrangements worked well, especially when teachers reconvened later in the day. The networking between groups often promoted interaction; the teams shared their experiences so that the others learned vicariously.

Teachers respond to. . .

Teachers actually worked more than the seven or eight hours a day discussed above, but there was never a discussion about hourly compensation in these settings. A key facility aspect of the on-campus model and its optional version is the importance of having particular rooms, labs, technology, and media available. Teachers need to be able to interrupt their work and go somewhere to try out a theory or technique. They need space to arrange particular types of shared resources and rooms for breakout groups, brainstorming, or videotaping themselves. Regardless of whether in-district or on campus overnight, teachers need to be in spaces where they could safely leave their work-in-progress and not have to unpack it each morning. Not having to lug things around each day and lose hours to packing and unpacking makes a major difference in their intellectual flow, productivity, level of engagement, enthusiasm, and excitement. When the environment, climate, and facility come together in the right configuration, teachers produce at amazing speed with extraordinary intellectual rigor and quality.

On their own (We refuse to do this ever again!)

This did not work for most teacher participants, regardless of ability. The few times that we tried letting teachers take a major piece of work home over the summer were not successful, in that most of them accomplished very little or work of less quality. A few exceptional individuals did finish high-quality products, even when they worked at home. However, they are the ones who put time and effort into their products, followed our guidelines, and called for assistance when they needed it.

One example of on-their-own lack of productivity occurred because the district and the local teachers union determined that teachers could only participate in additional work for two weeks after school was out and for two weeks before school began and that staff development over the summer was not to go beyond this time period without special approval. The district director convinced the project team to let teachers develop their modules at home between those times. The lead project team, against its better judgment, agreed. Some of the program occurred throughout the school year and for those two weeks after school ended and before school began. We did convince the district director, however, to let us offer several days when we would be available for teachers to seek in-person assistance.

When the teachers returned to us in August, most of the work was incomplete, even though the curriculum format and rubric were clear and detailed and had been explained to the teachers before they left for the summer. When the teachers realized that their work was not completed, they panicked and began to assume that they would not get their stipend (in fact, union regulations would have compelled us to give the stipend, and it is not our policy to withhold money as punishment or use it to motivate). The teachers refused to participate in the program planned for certain days because they wanted to finish their modules during that time. We managed to get each team to the completion point by changing the August program, but it was a difficult time. The lead team declared it would never again compromise the integrity of the approach by agreeing to the unsupported work by teachers "on their own." More importantly, we set the teachers up to perform less well than they would have with support, and frankly, they received two stipends for the same product. They also lost new program content, since they completed their modules during time planned for the new program components.

Development Based on Performance and Results

Our professional development program was based on performance and results. Teacher teams focused on creating or acquiring products, processes, models, strategies, and procedures that would lead to improved student learning and performance. The teachers only really began to grasp the concept of continuous improvement if they returned for additional program levels. As they advanced in the program – at each level designing, selecting, or developing new products or processes, and then piloting them in the classroom, while continuing the efforts that they had already piloted and modified – they began to realize how much they could accomplish when their efforts were continuous (Bernauer, 2002; Birman et al., 2000; Burke, 1997; Burke, 2000; Magestro & Stanford-Blair, 2000; Markowitz & Whittaker, 1999; O'Very, 1999).

Our philosophy requires experimentation in the classroom. Teachers have to commit to classroom pilots with observation and feedback for each level of program participation. They become very excited and return for more because we engage them in developing real products and processes to transfer directly into the classroom. When we were able to provide professional space, materials, technology, a "program" of learning, opportunity for collaboration, and multiple levels of learning, most teachers would engage in their own development, begin building their own bridges between sessions for their own purposes, and literally sign up for all or almost everything offered, all on their own. We considered ourselves only one factor in the resource formula (Gatlin, 2002; Grace, 1999; Hillkirk et al., 1997; McKenna, 1998).

Feedback

Feedback from the program leader and peer participants is vital for our staff development approach. Each teacher or team, and sometimes both individual team members and the team itself, received a great deal of feedback on products or processes (Figures 5, 6, and 7). Participants also provided ongoing feedback about the program content and process, and they evaluated it holistically at the end of each year.

Pilots

The key to success lay in our requirement of moving from the program into the classroom with direct observation and feedback because that requirement built application and practice into staff development. Many, if not most, traditional staff development models are involved primarily with the "imparting" of new information, knowledge, or skills and do not include classroom application or practice as an integral aspect. We, on the other hand, considered the pilot an integral part of staff development. Current research and best practice now encourage this approach, which we have been using since 1989.

Learning that resulted in the application of theory and piloting of new educational products and strategies in the classroom is the best type of staff development. Teams begin to need less time outside the classroom to prepare to do something new; they communicated, strategized briefly, and took action with the students. Optimally, the teacher team members and their students began to adopt a "let's try it" model of operation (Birman et al., 2000; Dufour, 2000; Hirsh, 2000a; Hirsh, 2000b; Senese, 2002).

Teaching Portfolios

Teaching portfolios work well for documenting professional growth and engaging teachers in ongoing self-assessment. We engaged teachers in informal portfolio development for particular clusters of learning events, using journaling for reflection. However, the interdisciplinary MSTE curriculum modules, content and process in nature, served as "formal" portfolios of a kind because they included the new models, strategies, procedures, and techniques. Therefore, although we did not label them portfolios per se, the modules could easily serve as documentation of what the teachers had learned and their piloting process. Finally, the teachers used them to assess where they were professionally and what they wanted to learn about and try next (Riggs & Sandlin, 2000).

Partnership Model

The partnership model (Figure 2) identifies both internal and external partners. Although our project was led by NIU's Department of Technology, various major contributions made it successful not only as a grant-funded project but as an initiative. NIU and Rock Valley College (RVC) provided personnel, matching funds, and in-kind services. RPS contributed matching funds and in-kind services and matched resources with computer technology and training for teachers. Some teachers had already been supplied with technology by the Illinois State Board of Education (ISBE) and Illinois Board of Higher Education (IBHE) partners in their support of the pilot grants prior to the NSF-funded project. Regional or state BIC organizations provided personnel, on-site development, and personnel partners to work in the classrooms, and some provided direct support of materials, supplies, or field trips for students. This initiative actively involved approximately 300 BIC organizations, more than 300 teachers, approximately 50 higher-education professors, and a variety of other individuals such as master secondary teachers, one master teacher leader from another district, and special consultants.

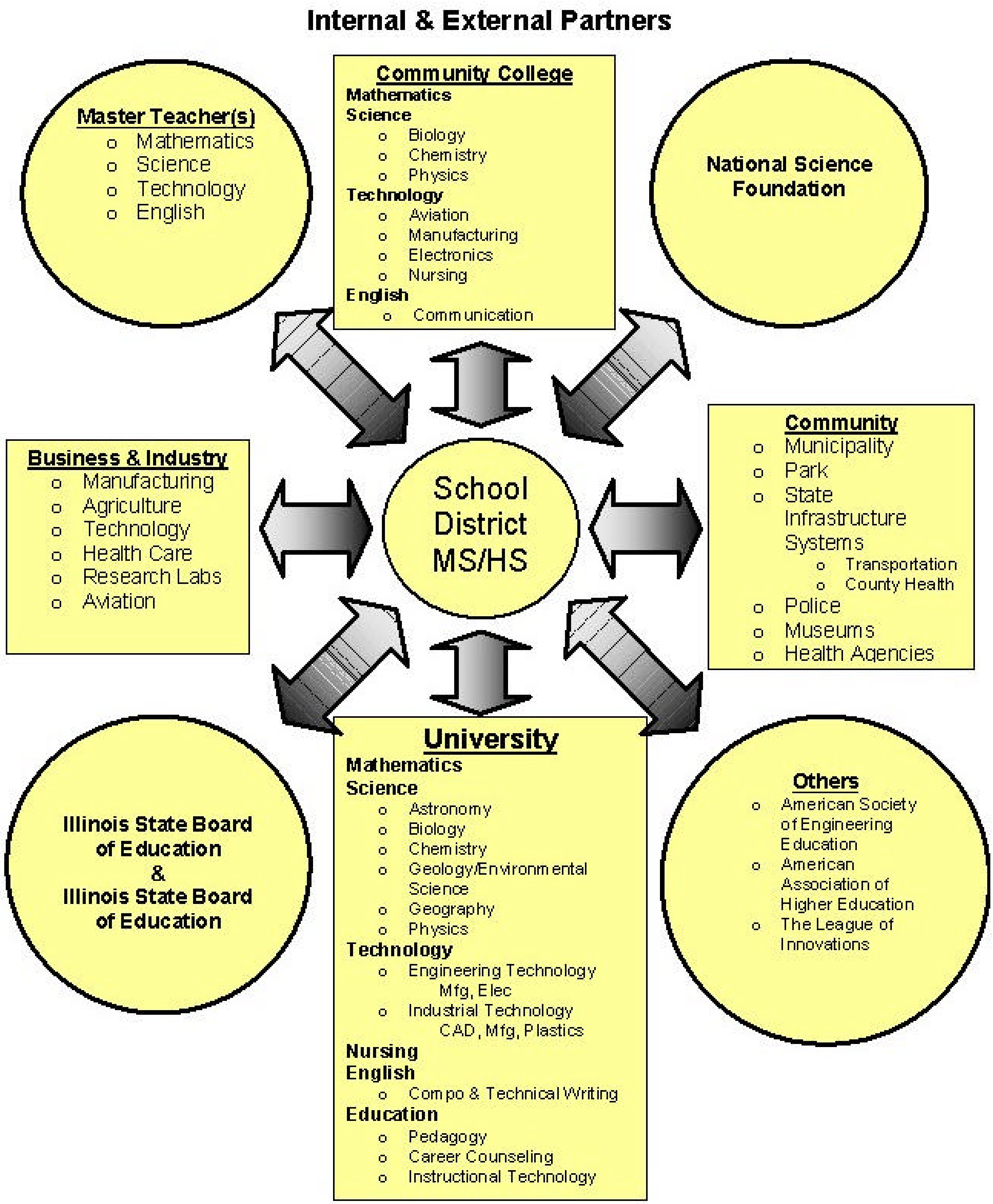

Figure 6.2 Internal and External Partners

Project Partners

Organizational Partners

Northern Illinois University; Rockford Public Schools; Rock Valley College; Illinois State Board of Education; National Science Foundation; Illinois Board of Higher Education; Private business and industry; Community, regional, or state organizations; Gray's Lake Community High; The League of Innovations; American Society for Engineering Education; American Association for Higher Education

Internal RVC Partners

Academics: Dean's Office, Mathematics, Science, English
Center for Technology: Director's Office, Electronics, Aviation, Health, Manufacturing

Internal NIU Partners

College of Engineering and Engineering Technology (lead organization): Dean's Office, Engineering, Engineering Technology, Industrial Technology
College of Liberal Arts and Sciences: Dean's Office, Mathematics, Biology, Chemistry, Physics, Geology/Environmental Sciences, Geography, English, University Writing Center
College of Education: Dean's Office, Instructional Technology, Kinesiology and Physical Education, Counseling
NIU: Vice President of Research and Dean of Graduate School's Office; Provost's Office; President's Office - Outreach Division
NIU Departments with Specialties: Sponsored Projects, Grants Fiscal Administration, Accounting and Procurement, Public Affairs

Program Model, Parts I and II

The Staff Development Model is discussed below, first with a brief description of program components and again graphically.

Figure 3 shows the basic program (Part I) and Figure 4 the advanced program (Part II). Most of the conceptual components transcend time. In other words, teachers would need to continue professional development on these topics regardless of what year it was or to what state the technology had evolved. There would always be a need to provide development on topics such as technology, articulation, communities of practice, partnership development, student performance strategies and procedures, and teaching models. (For more information on each workshop, read the general workshop component sections, starting with *Program Scope,* *Content, and Sequence*, in the next chapter, as well as the specific workshop descriptions in Part II, where particular program components are presented more fully.)

The program was offered in a variety of ways; however, the sequence presented is based upon what was successful most recently and also upon what we learned. It is suggested as a logical and somewhat constructivist approach to meeting teachers' needs and desires in the conceptual areas. Also important is the concurrency of the many learning activities. Because of the program's complexity, it was impossible to offer it as a pure sequence. The basic program is almost sequential, but when teachers choose to participate in elective offerings, they may be involved in activities concurrently, where one program component begins its series over four weeks and another one also has offerings during that time. The basic program had a set of requirements that anyone beginning with the initiative must complete and offered fewer elective options. The conceptual model will be briefly explained; for more information go to the full program description in Chapter 7.

Basic Program (Figure 3)

The basic program began with an *orientation* that described the program, requirements, schedule, expectations for the teachers, and reward structure. The second required session was training on *technology*, based upon individual needs. This training could be ongoing while participants began the first content session on *articulation*, which involved both community college and university faculty and focused on helping teachers understand the requirements for admission to college and university programs. There was usually a set of BIC panels, sometimes by sectors, sometimes mixed, so that teachers got a feel for what employers were expecting and what the educational requirements were for particular entrance points to jobs and careers. The program component included visits to community college and university campuses for discipline-specific workshops on *educational pathways to careers* that provided a more in-depth look at educational requirements or foundations for an array of careers.

Teachers were prepared to become *interdisciplinary MSTE teaching teams*, so they could understand what formal teaming entailed and also prepare their team organization and process. This was where they developed their vision for themselves as teachers. Participants were then ready to learn about their culminating product, the interdisciplinary and integrated curriculum module (IICM). They received the format and rubric and a full explanation to guide them throughout their entire program as they built the IICM. On their first day of *module development*, they reviewed Bloom's Taxonomy and Dale's Cone of Learning, chose standards upon which they wanted to base the module, made their BIC connections, and wrote the module introductions.

Next, participants spent a day on teaching foundations, focusing on brain research, multiple intelligences, learning styles, and teaching expectations and student achievement (TESA). They began their *BIC visitations* and participated in *discipline updates*. Once these updates and visitations took place, they worked with a program leader on *student performance assessment*: designing and developing more authentic performance tasks and rubrics and improving their traditional tests by developing a pretest and posttest for their module, with a new understanding that student assessments should be based upon standards and be developed before they completed the more contextual and instructional-related aspects of the module.

The module was much more than merely curriculum content; it also documented the teaching and learning process and the “how” and “to what levels” they were going to teach and students were to learn. Although we decided that instructional technology was probably best taught at the beginning, gradually progressing throughout the program as teachers developed the modules, we found that that strategy worked much better for the advanced program, where teachers already had the basic foundation. In the basic program, the instructional technology sessions occurred throughout, usually more toward the last half of the program, and the participants also learned about a variety of models that could broaden their repertoire. When the teachers *completed their modules,* during two days focused for that purpose at the very end of the basic program, they assessed the entire year’s *program* as a culminating *evaluation*.

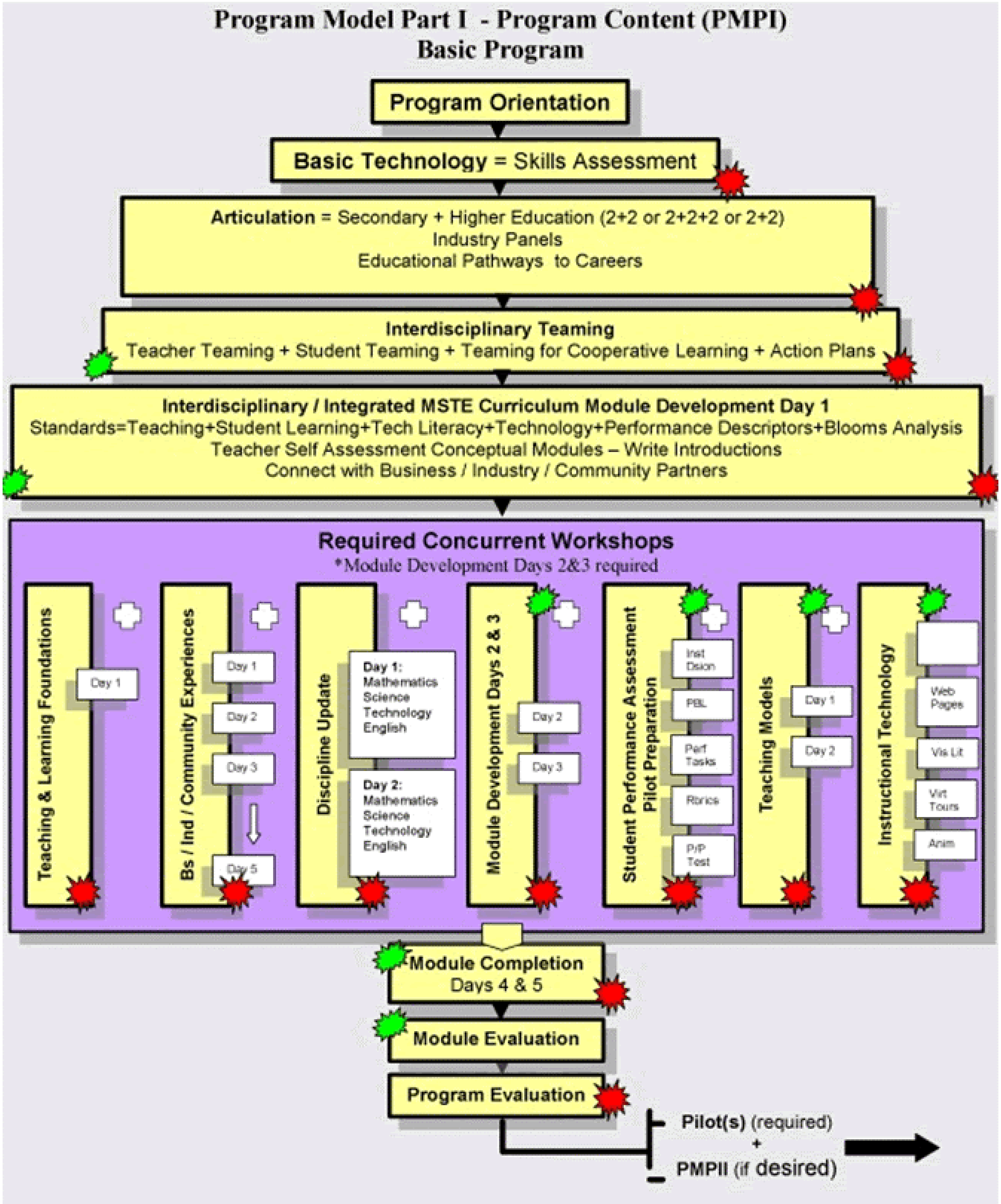

Figure 6.3 Program Model Part I – Program Content, Basic

Advanced Program (Figure 4)

The advanced program offered many more *concurrent* choices because participants had greatly expanded options and fewer required areas of learning. Participants attended an *orientation* where they concentrated briefly on the requirements, expectations, schedule, and options, as well as rewards, but then focused more on getting started, for it was presumed that they understood the demands of the program. They reviewed the interdisciplinary, integrated curriculum format, rubric, and explanations, Bloom's Taxonomy, and Dale's Cone of Learning, as well as technological literacy and technology standards, performance descriptors, Bloom's analysis, and the state's student learning standards.

Later, these teachers identified which program components they would select as part of their individual programs of study. The advanced program required *orientation*, *IIMD development days 1-5*, and *BIC visitations*, as well as the *module evaluation and program evaluation* activities. Participants chose among the *concurrent workshop options*, as many as they desired, and then built their modules based upon what they learned in each event. Their second required event was the *IIMD Day 1*, when they chose learning standards, developed the module introductions, and made their BIC connections. From that point they began participating in their chosen concurrent workshop options.

The *concurrent workshop* aspect of the program had embedded within it two levels of options: first, categorical options A, B, C, and D, and then options *within* each A, B, C, and D. Thus, within the concurrent workshops were: (A) discipline-update options, (B) advanced instructional technology options, (C) theme-based interdisciplinary, integrated MSTE options, and (D) other alternatives. The advanced program could actually occur within one school year or across several school years with a more gradual approach to learning by participants. They ended the year with *module evaluation and program evaluation, alongside those in the basic program.*

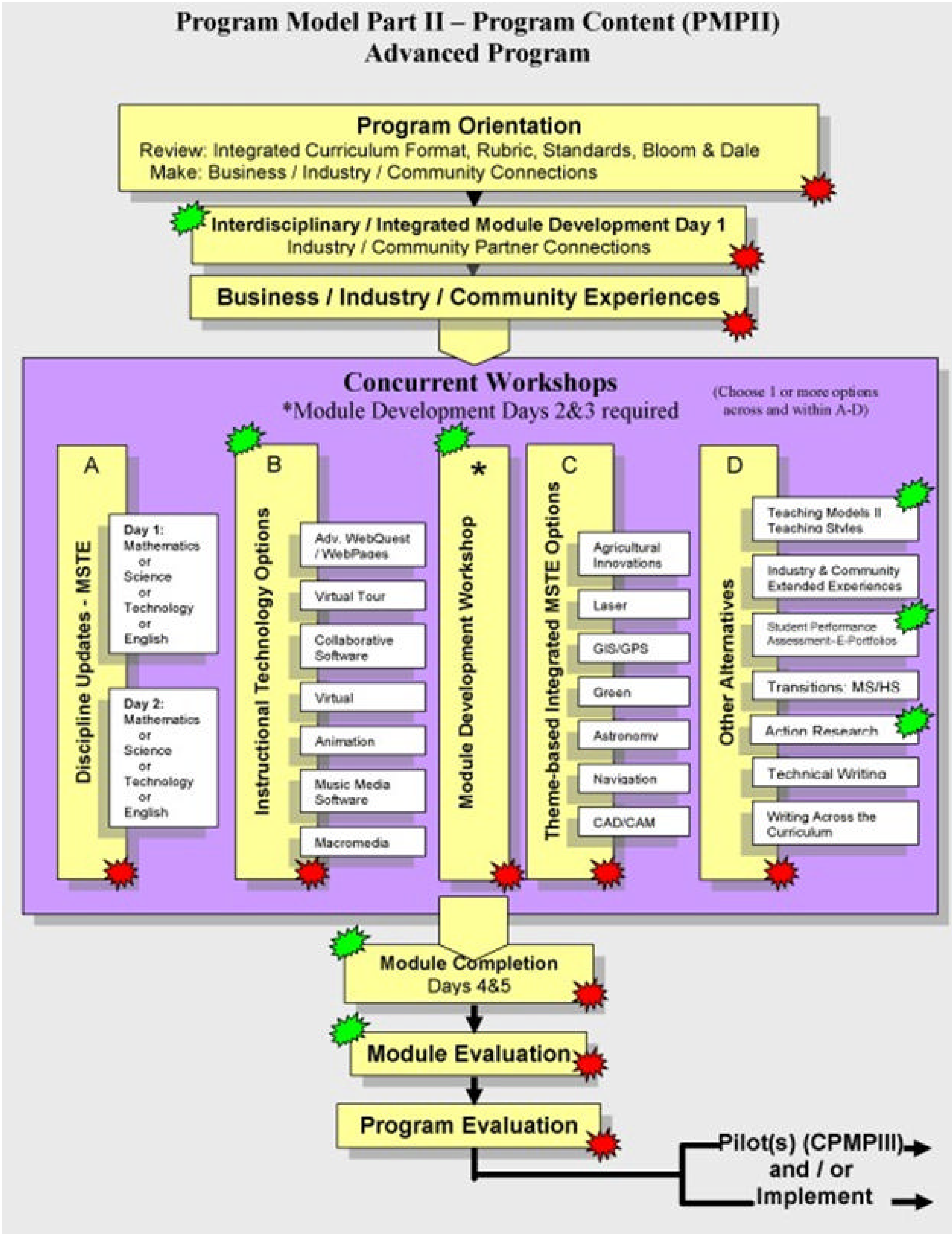

Figure 6.4 Program Model Part II – Program Content, Advanced

Program-Leaders-to-Participants Feedback (Figure 5)

Green "bursts" appear at various points throughout the model graphics in Figures 3, 4, 7. These are points where the participants receive *formal* feedback on their products, choices, or perspectives. Our process was based on intensive and regular formal and informal feedback. The green bursts denote times when the feedback was more *structured and formal*.

Feedback was structured using the general strategy established by Shewhart (1939) but often described as the Deming Cycle (1986), or the PDCA Cycle (plan, do, check, act). We modified it to fit our context, but it worked well here and also for program assurance. It was a closed-loop system where teachers designed, developed, selected, or tried something new; received direct feedback from the program leaders; revised their work; and advanced to the next stage (Figure 5).

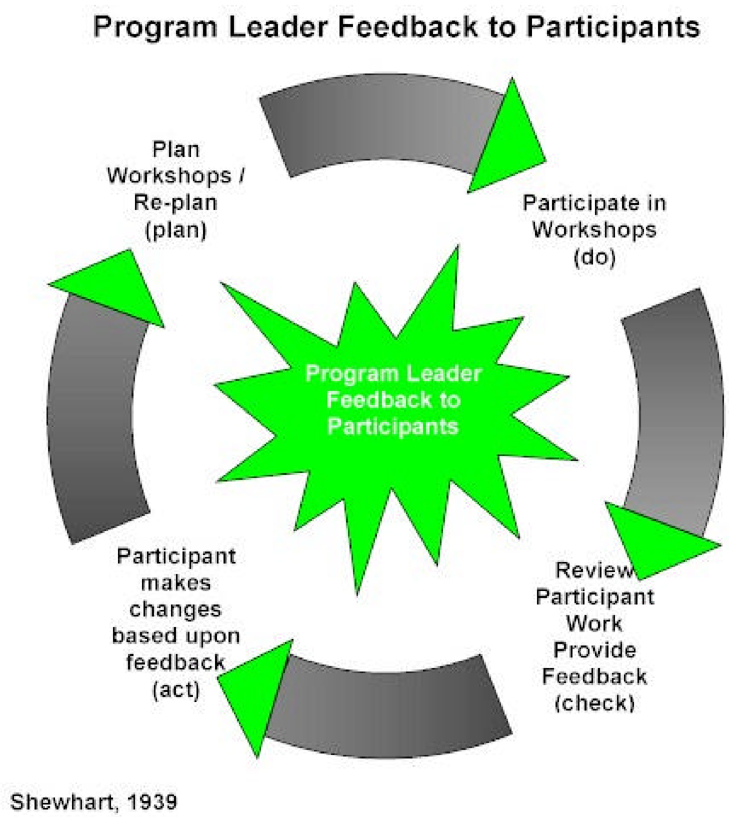

Figure 6.5 Program Leader Feedback *to* Participants

Program Quality Assurance (Figure 6)

In Figures 3, 4, and 7, red "bursts" appear at particular places, which denote points where *participants provided feedback* to the principal investigator or director, the co-directors, the program leaders, and external evaluator about *program content, process, environment, and climate.* The bursts also denote points where the external evaluator (EE) could choose to visit *unannounced***.** In addition to direct observation, the EE informally interviewed participants when observing many events to gain depth of insight into what they meant by their responses on the survey feedback forms completed at the end of each event.

The feedback model (Figure 6) used the general strategy established by Shewhart (1939) but often known as the Deming Cycle (1986). We modified it to fit our context. It was closed-loop in that it planned, executed, sought feedback, and used the feedback to make changes or take actions for improving the program.

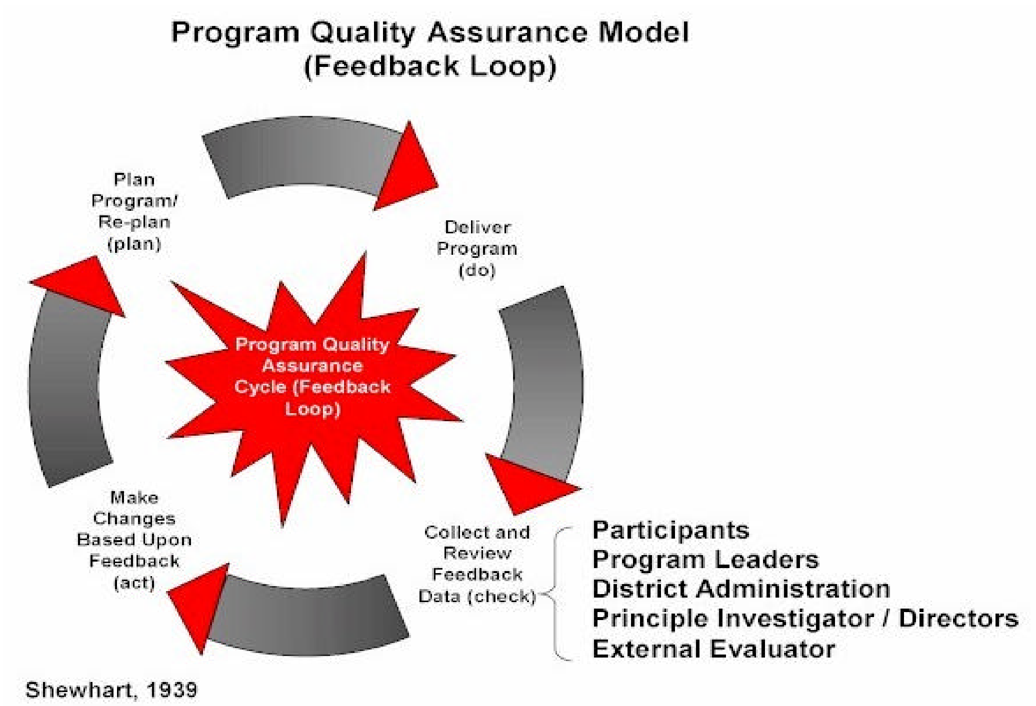

Figure 6.6 Program Quality Assurance Model (Feedback Loop)

Program Pilot (Figure 7)

All participants were required to pilot the IICMs. The model provided for a review of pilot requirements and process. Planning for the pilots began at the student assessment workshops, in which teachers developed or adapted the pretests and posttests to be used for the assessment of student achievement during the pilots. However, participants *reviewed their preparations* from the previous year to reacquaint themselves with the requirements and process. The pilot model began with that review; teachers then participated in a second session to review or reestablish their change goals. They piloted their modules as teams or individual teachers. During the pilots, they were *observed* at least once, more if needed. They received *feedback* after that visit if possible; at the end of the entire pilot, the teacher or the whole team received feedback.

Once the team *debriefed* with the observer, the teachers *identified changes* to their modules needed to complete the final version. Finally, participants joined in a *sharing and networking session* to explore what worked and to discuss teacher and student reactions across teams and schools. Teachers went back to their schools, *finalized the modules,* and submitted them to the district (and the PI and EE). At the end of the year, they *evaluated the program.*

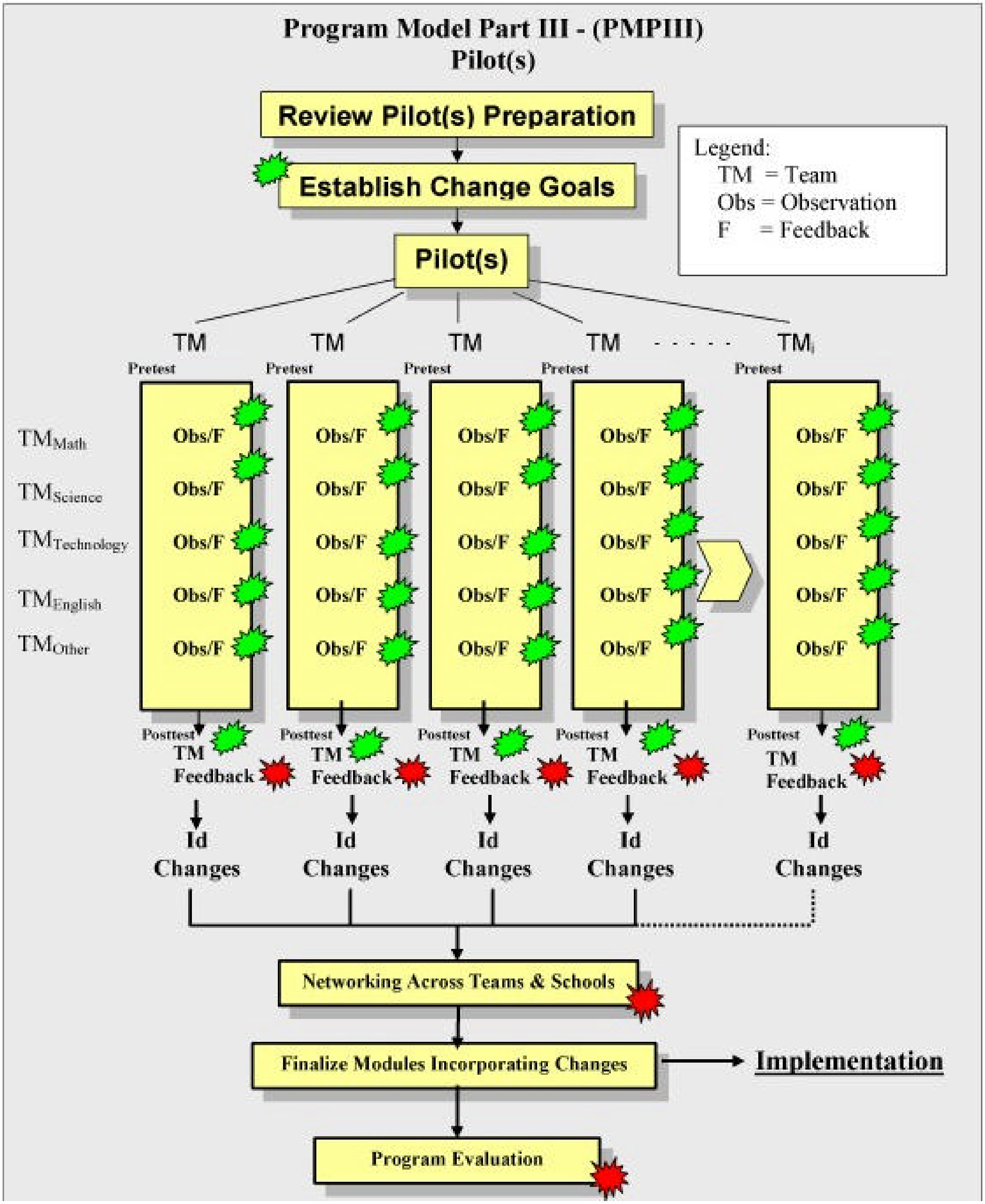

Figure 6.7 Program Model Part III – Pilot

Evaluation

Both formative and summative project evaluation occurred. Formative evaluation took place each year, and summative evaluation occurred at the end of the final year (year four). Summative also occurred at the end of the third NSF-funded year (prior pilot years were funded by the Illinois State Board of Education (ISBE) and Illinois Board of Higher Education (IBHE), ending the direct work with teachers. The project extended to include a fourth year for documentation and dissemination purposes.

Formative Evaluation (Figures 8 and 9)

During each year of the project, whether the prior pilot years were funded by the ISBE or the IBHE, the same Deming PDCA Cycle was adopted. The project was planned, evaluated, and changed if necessary. The cycle then began again. The component included the following types of evaluation:

1) Participant end-of-year evaluation; culminating reports from feedback were also used for evaluation purposes, in addition to the-end-of-year evaluation questionnaires/interviews
2) External evaluator end-of-year evaluation of all products, processes, and pilot results
3) PI/director end-of-year evaluation
4) Co-director(s) of RPS and RVC end-of-year evaluation
5) NSF evaluation at the end of the second NSF-funded year
6) Core project team end-of-year evaluation in the form of debriefing and recommendations for changes
7) BIC evaluation (not possible for every year)
8) Product evaluations
9) Pilots – student achievement results

The EE reviewed all products, data, and results, also using his own interview and observation data, and wrote a separate evaluation letter. The PI/Director summarized all data, product reviews, pilot results, feedback data, and other information, and wrote an end-of-year report; the EE reviewed and approved the report. The PI/Director and EE submitted a joint report summarizing what was accomplished, including supporting evidence. All goals and objectives were usually exceeded.

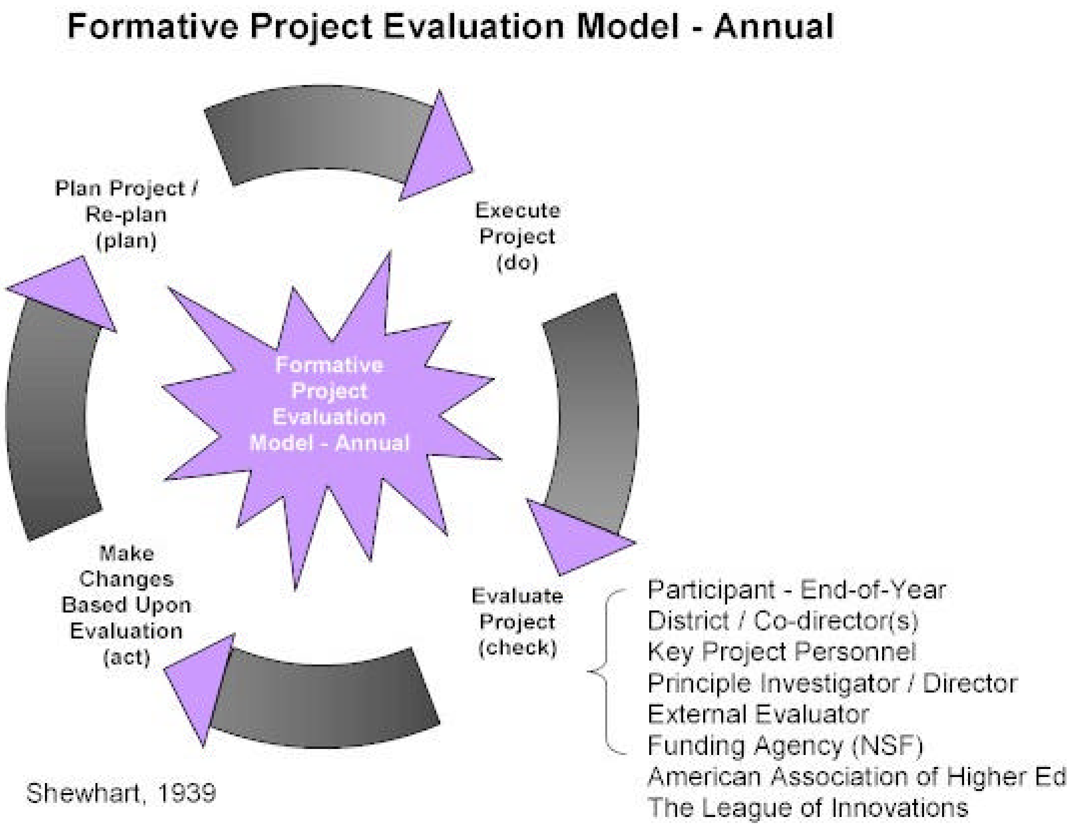

Figure 6.8 Formative Project Evaluation Model – Annual

Participants + Project Administration + Project Products + Research Results + External Evaluator = Formative Evaluation $_{Y1}$ … Final Year

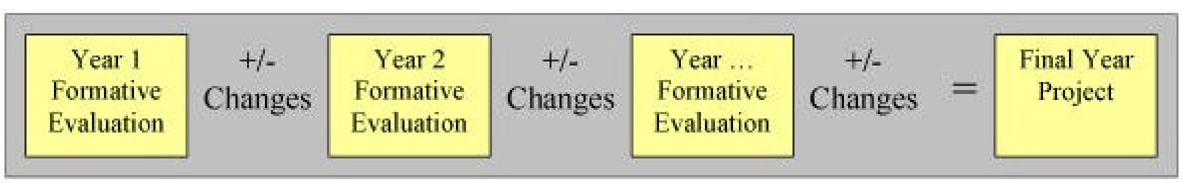

Figure 6.9 Formative Evaluation Flowchart

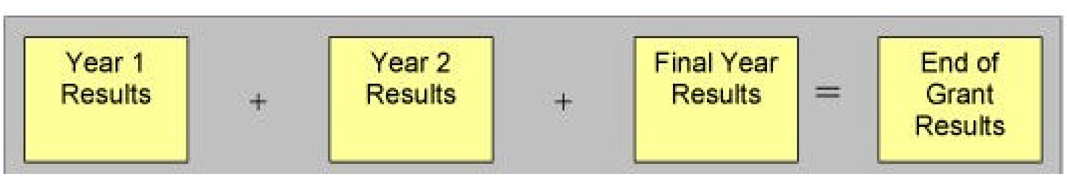

Figure 6.10 Summative Results

Summative Evaluation (Figure 10)

At the end of the project, the PI submitted all data, products, and results to the EE for review. The EE performed exit interviews with participants, wrote a separate letter of evaluation, and reviewed the report. The PI/Director wrote an end-of-grant report summarizing all data, results, product reviews, and external reviews (e.g., NSF visitation report). The EE approved the report. The PI/Director and EE submitted a joint report, which is accessible at www.strategicalliance.niu.edu.

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7. Program Scope, Content, and Sequence

Jule Dee Scarborough

Program Levels

Although the five core propositions of the National Board for Professional Teaching Standards (2003) were not available for the time period of the projects reported here, in retrospect they confirm and support our program to improve teaching. Level I of the basic program required teachers to become proficient using particular sets of knowledge and skills. They produced the same culminating product as the advanced levels, but at a beginning level. As teachers expanded their awareness and knowledge in their own and across related disciplines and began to acquire new skills, they began to request more learning opportunities. After they completed the basic program during year one and engaged in piloting during year two, they wanted to continue development of products and enhanced processes. That desire led us to reconfigure the program to incorporate additional levels that enabled teachers to continue as long as we could bring in funding to support their interests. Teachers wanted additional opportunities to "explore" more deeply into their disciplines, deepen their awareness about interconnectedness across MSTE and other disciplines, such as history, and extend into new areas of professional development.

Therefore, during the past 10 years, we managed to offer varying levels of programming, more recently up to Level IV, not including the pilots. With each advanced level of professional development, each teacher or team piloted its new products and processes. The additional levels are described below in the extended program description, now called advanced. Teachers could choose to take all of it in one extended year, part of it in Level II, and other parts in what might be called Level III or higher. We referred to the model as "spiral" in nature, offering advanced components as teachers sought to learn more, or "pull" the program.

The following describes various configurations of program scope, content, and sequence for the basic and advanced programs.

Basic Program Scope and Content (Figure 1)

The basic program included professional development sessions, usually 7- or 8-hour days, where teachers produced or performed while learning. Although each is labeled, Day 1 or 2, we arranged and rearranged the professional development sequence to reflect the best learning logic. The discussion here gives an idea of what content could be covered in a full-day format and the deliverables for each session. Most of these sessions are discussed in greater detail by the program leaders (see Part II).

Depending on the program and particular year, teachers were asked to design a growth plan in which they identified their most important areas of targeted growth. When they did this depended upon how the whole program was organized: after having been introduced to particular program aspects or following discussion with program leaders in the first few sessions. Most teachers had a lot to learn in each session, so the growth plans were usually easy to design and not intimidating. Their design was merely a strategy to encourage focus, self-analysis, and reflection. Depending upon the year and the group or the program leaders, this strategy was sometimes used very effectively and sometimes not at all. It was a good baseline motivation and a development and assessment tool.

We were bound by school calendars, and for the most part had to offer the program on weekends, holidays, or in summer, so the outcome was linear, but we also had concurrent offerings. We presented the basic program concurrently with the advanced program, and there were shared electives, with additional electives available to the advanced group. An additional type of concurrency was embedded within the program. For example, when a workshop was three days long, we usually did not offer it in its entirety for three consecutive workshop days, but rather over a longer span of time. Therefore, teachers might actually participate in several workshops concurrently over a period of time. A teacher might take one workshop that met for one day, each of three months, and also be enrolled in another three-day workshop that also met one day, each of three months; those months might overlap. There was concurrency within the linearity. The basic and advanced programs were offered concurrently, and multiple workshops within either of the programs might be concurrently offered over the same time period.

It is very difficult to say what might be considered a final program sequence because each year it changed, and our sequences were very successful across all of the arrangements. We looked at the content and then determined what sequence might work for a particular group.

The following sequence is one that we found balanced and effective. We have provided options in the descriptions. These descriptions provide information about content and process as it evolved over the past 12 years, and also about what worked in Rockford Public Schools, with initiatives involving regional groups of schools, and in Chicago Public Schools. The Rockford program evolved from others, as we progressed from pilot years to the NSF grant-funded program. In the beginning, the program was taught solely by me, including most of the basic program and other workshops not now incorporated but important to include in this discussion. However, in deciding to broaden the program to include other leaders, it became richer. After the leaders were trained, they took over program components. In other cases, ideas for new sessions came from me, from other program leaders, from the teachers, from district administration, or from the external evaluator. We then searched for competent leaders for the new program areas. Therefore, our descriptions of workshops offer a combination or range of times and strategies. The goal is to give a general idea of what was covered in content and the process used for working with the teachers.

Participants

We worked with interdisciplinary teams made up of at least one mathematics, one science, one technology, and, since 1995, one English teacher. The teams consisted of high school teachers, except for the Rockford project, where we added the middle school level. Some teams included history as a local match participant, and technology was extended to include the other disciplines as long as they could be integrated with the primary focus of mathematics and science.

General Process

The workshops employed an interactive process that used guided, supported, and discovery-through-action research (pilots) with informal immediate feedback, followed by very formal feedback for particular program components and support during sessions. Leaders responded after sessions on email or by phone; some visited teachers for follow-up. Almost all learning was designed to be active, engaging teachers in actual product development, process choices, and performances. We modeled best practices similar to what we were asking the teachers to use in the classroom (Wiggins, 1996-1997).

Orientation (1 day)

The orientation covered product and process development expectations and reward structure. Formats and rubrics were provided. It also provided state learning standards, integrated curriculum models, descriptions of the learning, performing, and product development processes, and feedback and support. Bloom's Taxonomy was set as a measure for higher-level learning, and other national standards were introduced, such as the technological literacy standards and the national technology standards. We might also provide professional skills standards for particular industrial fields.

Process: Teachers studied the student learning standards for their disciplines and reflected on which ones they thought they might achieve in their classes. This helped to set the stage for becoming focused on learning standards that should be achieved but were not. Teachers also studied learning standards in other disciplines across MSTE. They noted the overlaps: standards that seemed to be important to all disciplines, those that were specific to each discipline, and those that had the potential to be selected for integrated interdisciplinary curriculum modules.

Deliverables: Participants develop an awareness of products and tools to be used, as well as familiarity with requirements, standards, and expectations.

Peer teacher workshop (1-2 days)

An interdisciplinary team of master teachers in MSTE delivered an integrated and interdisciplinary curriculum module incorporating new teaching and assessment procedures to demonstrate what was expected of the participants as learners. Participants gained a clearer understanding of what they were striving to accomplish. Teachers talked to one another and performed for one another, which was an excellent way to begin when orchestrated with a partnership philosophy. We used this at the beginning of new initiatives and were usually able to keep one or two master teachers active as key personnel in each grant-supported endeavor.

Process: Peer-to-peer interactive learning while doing; new role models.

Deliverables: Teacher peer leaders; integrated and interdisciplinary MSTE modules that participants took with them after their own learning experience.

Participants: Vision, motivation, and initial notes on growth plans.

Interdisciplinary teacher team development (2-5 days)

It was important to foster formal team development by having participants organize appropriately and develop operational guidelines and processes. We had a whole sub-program that began with the participants developing a vision for themselves and their students, their operational goals and objectives, and the desired outcomes. The program required the development of an operational manual containing sections on issues such as conflict resolution, policies and procedures, and roles and responsibilities. Participants developed a team assessment inventory, a peer feedback inventory, a conflict assessment inventory, and more.

Process: Interactive and guided group development while producing a vision, mission, goals and objectives, and operating process.

Deliverables: Visions, goals, personal objectives, team operating manual, and assessment tools and process.

Student teaming

Participants discovered the process for transforming student groups into effective teams. The workshop's content worked equally well with teachers, students, business, industry, and community team development (and had the same deliverables). The process and deliverables were the same as for cooperative learning, discussed below.

Basic technology training (2-4 days)

We provided our groups with laptop computers, scanners, printers, and digital cameras, plus software, usually MS Office to begin with, and later module-specific software for student learning. We began doing this in 1994, before teachers had easy access to computers outside of school computer laboratories. We obtained the funds to buy a setup for each teacher and established with the schools that the hardware was donated to the schools but permanently assigned to individuals as long as they completed their commitment to the grant-supported initiative. If they left the school, the equipment could transfer with them to another school in the same district, but if they left the district, it stayed at their school and was to be reassigned if it was still viable technology.

Many teachers struggled even at a basic level. However, the good news was that districts finally began to provide laptops that could be taken off campus. Teachers learned more rapidly, adapted more readily to using the technology, felt more professional, and gained a great deal of confidence about technology after mastering their laptops and using software packages specific to a module, discipline, or field. They became more confident in using technology with their students, finally understanding that they did not have to be experts to begin to use it with students.

Process: Guided development; producing while learning.

Deliverables: Products and processes specific to individual and team goals.

BIC expectations and articulation between high schools and higher education (1 day)

The day began with business, industry, and community (BIC) panels from various sectors, such as manufacturing, medical and health, agriculture, recreation, and waste facilities. They discussed careers across entry levels, educational requirements, and related knowledge and skills. This set the stage to look into more career clusters and to determine higher education paths necessary to enter the fields. Teachers worked with the professors to better understand what concepts, knowledge, and curricular content were taught at each level across mathematics, science, technology, and English.

We delivered this professional development component separately, one session at the community college, a second session at the university, and jointly, with professors in each discipline from both institutions working collaboratively with the teachers. Both approaches received high evaluations, but the joint session did seem to reduce redundancy. Because Northern Illinois University has good articulation with most of the regional community colleges, the joint sessions worked well and the professors and teachers enjoyed and learned from the exchange.

Process: Panel members presented; teachers questioned; members responded. Sometimes members deviated from the formal panel format and became part of small groups for more discussion. For the rest of the day, teachers and professors analyzed course content, teaching and assessment strategies, use of technology, and field-based learning experiences.

Deliverables: Documentation of gaps between secondary and higher education levels in MSTE relating to knowledge, concepts, principles, content, student assessment procedures, use of technology, and standards or objectives.

Educational paths to careers (2 days, one community college and one university)

The community college and university each offered a workshop. Program leaders divided one day into offerings in each of the higher-education disciplines: mathematics, the four sciences, a variety of engineering and technology disciplines, and English. Teachers could participate in three different sessions. Each mini-program focused on careers, educational paths to careers, and an activity related to the discipline that could be used with secondary students.

The community college program was divided into mini-sessions on mathematics, electronics, English, the sciences, aviation, and allied health disciplines. The university program included mathematics, all sciences, geography, English, engineering technology choices, agriculture, and others. Topics varied by year.

Process: Guided exploration, beginning with requirements for college entrance in mathematics, science, and English. We then discuss the requirements for various degrees and establish the difference between the programs and career options. Teachers then break into small groups to attend three workshops on educational paths to careers, organized by discipline.

Deliverables: Information, activities, and materials for inclusion in modules, lessons, or stand-alone activities with students.

Industrial visitation (3-5 days)

These sessions deepened the opportunity to learn about MSTE in the real world, discover career foundations, identify more authentic MSTE problems and performance tasks to stimulate students, and initiate long-term BIC and educational partnerships.

Process: We offered this opportunity in several different ways, but we favored two in particular.

The first involved teachers or teacher teams identifying the student learning standards upon which their new curriculum module would be based and the industries that could provide learning opportunities. They were then scheduled into three to five industries for half a day or a whole day, with the goal of visiting five industrial sites. Teachers also identified individuals who could become partners to work with students in the classroom or set up experiences as part of student learning in the new module.

In the second approach, teachers or teams were scheduled for visitations across different industry sectors as a follow-up to the panels. We placed these sessions near the end of the program or sometimes in the middle, when the teachers began developing their educational products. We preferred to place them at the point when they were about to write the module, but that was not always possible because it required normal working hours on weekdays, so only school holidays that fell on those days could be used. Saturdays or after-school visits usually did not work.

Deliverables: Draft assessment problems, performance tasks, and career projects. Identify potential individuals for further contact for teacher learning and for in-classroom or fieldtrip activities for student learning

Module development (5 days)

These were well supported workdays with the primary purpose of engaging teachers in creating new integrated interdisciplinary MSTE modules incorporating standards, teaching context, and new student performance tasks, and also educational processes and teaching models. The modules embodied curricula content and teaching and learning processes that teachers were going to pilot. The module had a very particular and required format to ensure quality.

Process: The sessions were not held consecutively. We offered them several different ways, the two main ones being: (1) five consecutive days at the end of the basic program as culminating-product and process-development days, with support, and (2) spread throughout the last half of the program, with two or three at the end, rather than five, so that hard product development was done progressively with immediate feedback. Both methods worked well, but we preferred the second. Teachers developed portions of the product format and processes gradually; program leaders provided immediate feedback, and then teachers completed those sections before going on to develop others. Program leaders were available for support. A peer teacher leader, a professor strong in pedagogy, an industrial liaison, and all the professors from both higher education institutions worked with the teachers on the first day while they conceptualized their modules. This ensured rigorous quality in discipline content and good teaching process.

Deliverables: See rubric attached to Chapter 12.

Teaching Models I (3-5 days).

Teachers were introduced to the state teaching standards, participated in self-reflection and study of the standards, and analyzed where they excelled or needed enhancement. This served as a basis to determine which models they needed to learn about. Some teachers were skilled in multiple models but most admitted that they relied on lectures, worksheets, and textbooks. They were usually inclined to want to try other models but hesitant to begin. The workshop included a day or so on brain research, multiple intelligences, and learning styles.

Then we presented teacher expectations and student achievement (TESA), which heightened awareness of perceptions about students and how these could affect performance. TESA is based upon the expectation theory: "Inferences teachers make about the future behavior or academic achievement of their students [are] based on what they know about these students now" (Good, 1987, p. 33). The second day focused on the 22 teaching models (Joyce & Weil, 2000); a third day was provided for teachers to select, prepare, and try models with each other in small groups using the observation instruments developed earlier. This workshop ranged from three to five days. In the five-day version, more theory was introduced. The small-group videotaping of teachers trying new models and then engaging in feedback with each other provided great insight. Our preference is the five-day version, if we can find the time commitment and funding.

Process: Interactive and guided decision making and development, performance.

Deliverables: Selected models, action plan, observation instrument, performance.

Cooperative learning (1-2 days)

This model was incorporated into the above workshop as one of the choices, but it was important for teachers to realize that particular skills and processes were key to cooperative learning. The workshop engaged teachers in learning to a greater depth about the three primary models for cooperative student learning: base group, formal, and informal. The base group required team training and was directly related to the interdisciplinary teaming workshop for teams and students (as described above). If teachers had not participated in team training and were interested in learning to use base group technique, it was best to combine abbreviated team training with the session on cooperative learning.

Process: Teachers participated in the three models of cooperative learning. They restructured lessons or developed new ones.

Deliverables: Cooperative learning lessons using at least two of the three models and many techniques.

Student performance assessment (3-5 days)

Students in typical mathematics and science classes are usually assessed traditionally, through multiple-choice or word problems and the like. This session prepared teachers to design and develop problem-based, performance-based, project-based, more authentic assessments in which students performed or solved open-ended or discovery-oriented problems. The discipline of English is less traditional than mathematics, for example, in that students are required to develop essays, prepare research papers, and develop speeches; these are all performance-based and at least somewhat authentic. Teachers studied the connection between curriculum design, standards, and the development of more authentic performance tasks and scoring rubrics. Many teachers needed five days to achieve basic competence, but some finished the work early. Three days was not enough time, while four seemed to work for almost everyone. With the five-day model, one day was spent developing improved pretests and posttests.

Process: Teachers developed tests and authentic problem- and performance-based learning scenarios with embedded performance tasks as part of their curriculum modules, as well as corresponding rubrics.

Deliverables: Pretests and posttests and problem-based learning scenarios, complex performance tasks, rubrics.

Instructional technology and software (1-2 days)

Teachers learned how to design and develop WebQuests and Web pages and use PowerPoint presentations, graphic organizers, and other software for technological student learning.

Process: Designed and developed WebQuests and Web pages while learning.

Deliverable: WebQuests linked to a Web page related to a new curriculum module.

Discipline updates

These workshops were usually for teachers in specific disciplines. For example, the teachers met with a physics professor; the same was true across the disciplines of biology, chemistry, geology/environmental science, physics, mathematics, technology, and English. Usually the professors had the opportunity to talk with teachers about what they would like to focus on before designing the workshops. The workshops could go in almost any direction and were designed for very small groups. In some, such as those for biology and chemistry, the professors teamed up to work with teachers on content and process for integrated biochemistry. Teachers responded with enthusiasm to all these workshops and were elated over the small-group opportunity and attention. The workshops differed considerably from one another, as the professors listened and then responded. Teachers "pulled" the content and process of the professional development events, rather than the professors "pushing" their preferences (Rusin, 2002).

One must be careful with this approach because it is possible to have the day disappear and wonder what was accomplished, or discover that the concept was an excuse not to plan a workshop. Professors met with teachers beforehand to discuss issues, concerns, and needs, and then plan the workshops. The aim was to have teachers come away with active strategies, deeper knowledge, extended skills, and newly conceptualized lessons.

Process: Interactive and guided decision making or development.

Deliverables: New lessons, modified lessons, or new or adapted teaching and learning strategies, techniques, procedures, or processes.

Evaluation session

Teachers self-scored their modules using the rubric, preferably with their direct administrators (e.g., the principal), and then met with a professor, the project director (usually, but not always, depending upon project), a peer teacher, and the external evaluator to review strengths and improvements. This session was handled sensitively. There were not supposed to be any surprises, for the teachers had individual and continuous feedback throughout the entire program, support when needed, and full access to the format and rubric with all requirements.

They developed the culminating product, including all new models, strategies, techniques, procedures, and processes, progressively with ample opportunities to work out any weak areas. The project team and external evaluator read and scored the complete module and then reviewed it. Every care was taken to make this session a celebration of accomplishments and excellence and to leave teachers stimulated, motivated, encouraged, and with an understanding of their success. The few instances where that did not occur had extenuating circumstances. The teachers were supposed to leave motivated to follow through with their pilot activities during the upcoming school year. Their administrator came away with a clear understanding of what the teachers had accomplished and its value to the school and students and understood the teachers' support needs.

Module pilots

Teachers participated in two sessions at two different times to prepare for their pilot activities. One session was embedded within the performance assessment workshops; the other was just before they began their pilot activities, usually August, going into the new school year. This refreshed their commitment to the pilot and their responsibilities; it also set their goals. After they completed the pretests and posttests for their modules, and those tests were reviewed and approved by the program leader, they reviewed the expected data collection and submission process. However, just before they began the pilot activities, they met with the external observer who would visit with them during the module pilots.

As a team, or individually, the teachers established or reviewed the goals that they wanted to achieve beyond piloting the integrated curriculum, such as using new teaching modules or performance assessments. These types of change were already built into the modules, but we found it best to have everyone review their change goals anyway, to reinforce what they were trying to accomplish during the pilots. Then they determined the dates for visitation, feedback, and debriefing after the module had been completed with the students. They were expected to share the outcomes and plans for revisions or changes, based upon the pilot results, with other teachers during the sharing and networking sessions. (See the data collection forms and pilot model at the end of this section.). Figure 1 presents the basic program's main components.

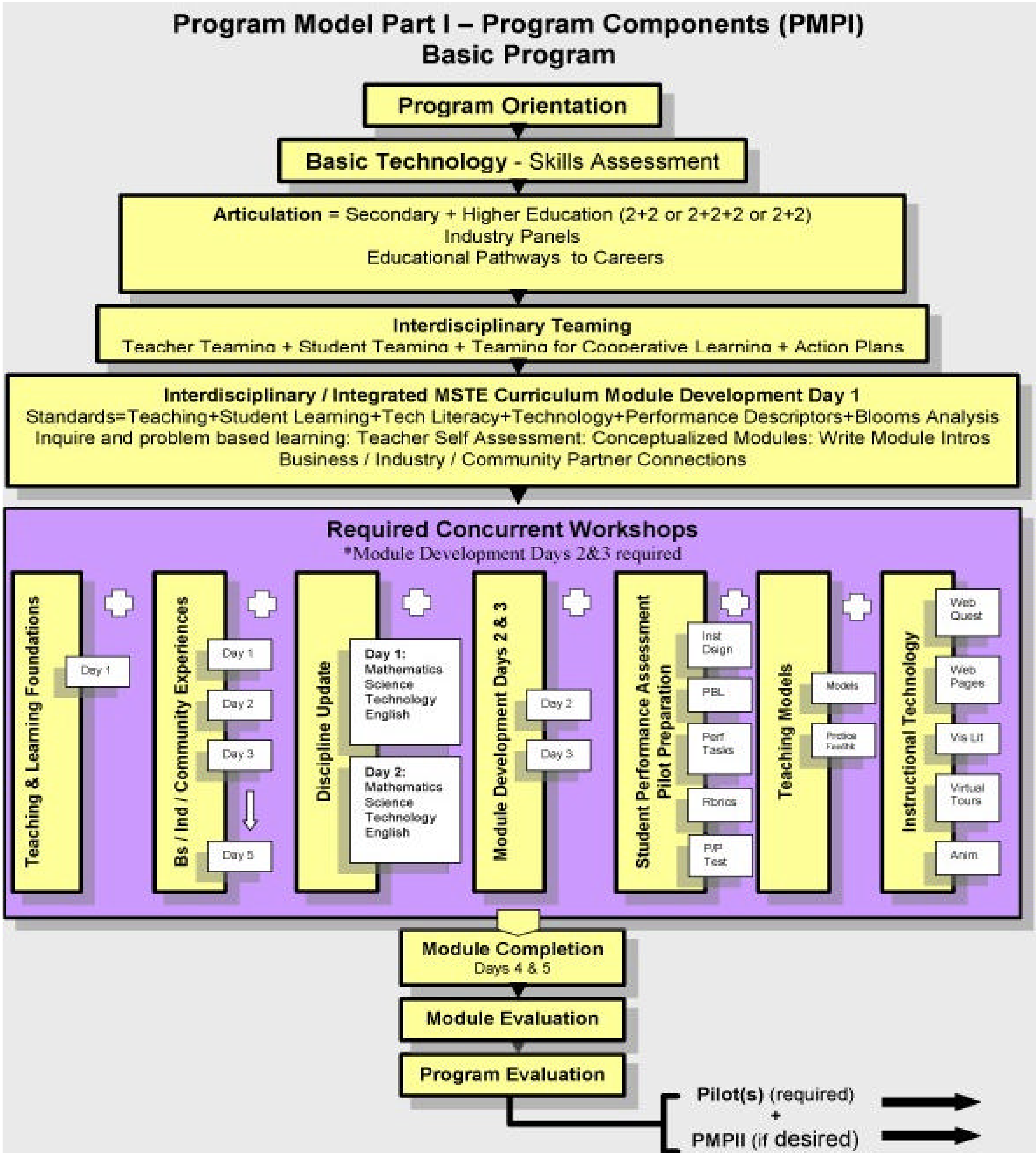

Figure 7.1 Program Model Part I – Components, Basic

Advanced Program Scope and Content (Figure 2)

Once teachers participated in the basic program, they usually wanted to continue professional development. They were permitted to continue even while piloting their new modules. A few workshops in the advanced program were open to first-year participants or those enrolled in the basic program; however, the advanced program was really intended for returning veterans who had completed the basic program and piloted their first new module. The advanced program provided a myriad of new topics and offered greater depth on continued topics. In some cases, where teachers did not feel secure about a topic, they were allowed to repeat. We considered it positive that teachers admitted when they felt a need to repeat something; however, we were careful not to allow that to occur as a fallback position when someone did not participate responsibly the first time.

One of our most important discoveries was that teachers aggressively sought more development when they felt respected; were learning and developing directly useful materials, products, or processes; were supported; and could openly admit safely and comfortably when they did not know or understand something.

The following topics were alternatives from which teachers could make choices for up to four to five years as returning veterans.

Layered curriculum (2-4 days)

These workshops helped teachers establish "layers" of curriculum, A, B, and C. Each layer had particular suggestions for visual, auditory, and tactile learners. The workshops discussed adapting curriculum, giving students choices of which level to strive for, grading, designing rubrics, and implementing the activities. Two days worked fairly well, but additional time for development with support was valuable.

Process: Interactive and guided development.

Deliverables: Modified lessons or new lessons.

Reading and writing across the curriculum (WRAC) (1-2 days)

These workshops prepared MST teachers to incorporate more reading and writing into their course requirements. The workshop focused on content, strategy, techniques, and procedures.

Process: Interactive plan development – plan while learning.

Deliverables: Plans to incorporate additional reading and writing projects into lessons and the new module.

Technical writing (½ to 1 day)

This session assisted teachers in understanding technical writing and then determining standards, techniques, and processes for improving or introducing it as an alternative or addition to traditional prose requirements across courses, including traditional English composition, but especially for MST.

Process: Lecture and performance.

Deliverable: Lesson concepts to incorporate or improve technical writing or introduce it into course requirements.

Visual literacy (1-2 days)

Participants learned the concepts and principles of visual communication, how to interpret images, and how to understand when there are hidden objectives in images. They created messages and designed and developed visual materials to communicate them.

Process: Guided development.

Deliverable: Visual materials to enhance teaching and learning and to incorporate in the modules.

Industrial visitation II (3-5 days)

Additional sessions beyond those experienced as part of the basic program provided more opportunity to learn about MSTE in the real world, career foundations, more authentic problems and performance tasks, and industry and community partnerships.

Process: We offered this opportunity several different ways. There were two primary methods.

One model engaged teachers or teacher teams in the identification of student learning standards upon which their newly integrated interdisciplinary curriculum module would be based. They identified industries that could provide MSTE opportunities specific to the learning and curriculum-building interests. The teachers were scheduled into three to five industries for half a day to a whole day, with the goal of visiting five industrial sites. Teachers also identified individuals as potential partners to work with students in the classroom or to set up learning experiences as part of the new module.

A second model scheduled teachers or teams for visitations across different industry sectors to expose them to clusters as a follow-up to the panels. These sessions occurred in the middle of the program, when the teachers began developing their curricula and other products. We preferred placing them just before they wrote the module, but that was not always possible because it required normal working hours on weekdays, so only school holidays that fell on those days could be used. Saturdays or after-school visits usually did not work.

Deliverables: Draft problems, performance tasks, and career activities. Identify individuals for further contact for teacher learning and for in-classroom activities or fieldtrips for student learning.

Instructional technology and software (4 days; 5-6 preferred)

WebQuest development. This workshop began with a thorough examination of the nature and purpose of WebQuests and how they could address district and state learning standards. Participants accessed a wide variety of WebQuests and learned to locate, evaluate, and develop websites to include in their own WebQuest.

Process: Guided development.

Deliverable: WebQuests for teaching and learning.

Web page development. This workshop guided participants to develop personal Web pages in support of their teaching. After reviewing existing teacher Web pages and considering how a page could support specific learning standards, participants learned basic elements and design conventions. They also learned how to incorporate digital multimedia elements and explore the potential for student projects (macromedia software).

Process: Guided development.

Deliverable: Web page for teaching and learning.

Virtual tours. When field visits were not possible for students, the teachers could create virtual tours. Starting with a conceptual base, participants explored existing tours and considered their format, elements, and potential links to learning standards. They constructed a tour using images taken in the field, materials retrieved from websites, and other appropriate resources.

Process: Guided development.

Deliverable: Virtual tours.

Animation. Many websites now use animation to enliven their content, and teachers are often curious about how this is achieved. Participants received an introduction to animation software and how to add animation to their own Web pages and other products to enhance teaching and learning.

Process: Guided development.

Deliverable: Animation for teaching and learning.

Graphic organizers (½-1 day)

This workshop informed teachers about graphic organizers, Web resources, and software to develop graphic organizers. Participants planned lessons, presentations, and ways to teach students to use graphic organizers.

Process: Interactive and guided development.

Deliverables: Modified or new lessons using graphic organizers.

Collaborative software -- SharePoint (2-4 days)

We tried various collaborative software packages and found that there are issues with all of them when working with school districts' environments and policies. However, SharePoint did facilitate teacher collaboration. This package used discussion boards to collaborate on planning, instructional delivery strategies, and more. It can create libraries of many different types of documents, create subscriptions, and track information about participants; it can be used as an instructional tool with students or for student learning. If the district did not support teachers in its use, if there were server limitations and no follow-through with technicians to keep things running smoothly, it would be unused. This was something that *had to be* supported. District system inadequacies made it difficult to achieve full collaboration.

Process: Guided collaborative development.

Deliverables: Shared and collaborative development of modules.

Student performance assessment – electronic portfolios (3 days; 5 preferred)

The first of the three workshops introduced participants to the concepts of portfolios in general and e-portfolios in particular. Participants viewed sample portfolios, looking at their purpose, organization, underlying learning standards, and style. They began to design an e-portfolio appropriate for their students. The second workshop explored the nature of electronic "artifacts," the content of an e-portfolio, and problems with viewing them. Participants practiced techniques for creating and manipulating digital images, digital audio, and digital video. The third session focused on creating the actual e-portfolio as both a presentation (PowerPoint) and a website. Samples in each format were available for review; participants learned techniques for producing each type of portfolio and then worked on their own creation. Posting the web version on the district server concluded the session and series.

Process: Learning through guided development.

Deliverables: Draft designs of e-portfolio format to use with students.

Teaching models II: Teaching styles (2 days)

Teachers who completed the Teaching Models I workshop in the basic program, described above, could take a second workshop, focusing on teaching styles for improving their teaching strategies. Styles A-K lay on a spectrum ranging from Command Style to Self-Teaching. Patterns of decision making were the basis for the spectrum of teaching styles. Teachers learned to make decisions and interweave styles with models.

Process: Interactive and guided decision making.

Deliverables: New styles incorporated with new models in the modules.

Action research (2 days)

Participants learned to design and perform action research. They considered how it enhanced professionalism, how achieving standards fit into the picture, the process of "using theory to drive action," how to choose the right research questions, how to determine the assessment criteria and collect data, and how to follow through with changes. They also considered its contribution to improved efficiency in the context of school culture and accountability.

Process: Interactive guided development.

Deliverable: Action plan for individual action research.

Discipline updates

These workshops revolved around specific teacher interests or perceived needs, based upon conversations with teachers prior to designing the workshops. Level I teachers participating in the basic program had one or two days with professors in their disciplines or in related disciplines. Teachers at the advanced level had the opportunity for two or three days of these workshops. The workshops groups were intentionally small to enable one-on-one time with professors.

Process: Some workshops engaged teachers in learning, some were responsive in nature, and others were oriented to meeting other needs (for example, building particular pieces of equipment for new lab activities or hands-on learning). Some were organic and discussion-oriented, some were more formally designed with planned programs and activities, and others were problem-centered. All were interactive, engaging, hands-on, and authentic.

Deliverables: Draft concepts for new lessons; expand lessons or improve MSTE lessons and learning activities; expand and deepen knowledge base.

Problem-based learning (1-3 days)

We covered how to structure problems and embed them within authentic scenarios; as part of the process, teachers learned to address the role and situation of the problem, map the problem, and finally develop a good problem definition or description. Teachers then selected knowledge (standards) and skills to determine the desired outcomes and build a problem log and summary performance. Finally, they structured student inquiry, framed information sources, built the instructional schedule, and planned how to coach. Our preference was to offer this separately for more depth and focused development. It needed to be closely related to or embedded within the teaching of performance assessment.

Process: Interactive, problem-centered, guided development.

Deliverables: Performance and project-based problems that provide for both learning and assessment interdependently.

Inquiry (1-2 days)

This workshop was offered separately or embedded within the Teaching Model I workshop. Successful either way – when done separately, it offered time for more depth and greater exploration of what inquiry really means. Teachers examined the nature of inquiry and how to structure inquiry-based learning in content, process, and activities. They were exposed to materials that improved understanding in a more authentic context and examined how to infuse their curricula with inquiry. They explored the characteristics of inquiry as well as the teacher's role and how it differed from the students'. They focused on the potential difficulties, how to rethink traditional lessons, and on the best characteristics of inquiry teaching. They designed draft lessons for their modules. This workshop was a good precursor to the assessment and problem-based-learning workshop.

Process: Interactive, problem-centered, guided development.

Deliverables: Draft inquiry-based lessons and strategies.

Marco Polo – Internet content for the classroom (1 day)

Teachers explored Internet resources to access, enhance, and add content to standards-based lessons and instructional strategies. They examined strategies for integrating Internet content into lessons across the curriculum and studied teaching techniques using Internet content across a variety of instructional settings.

Process: Interactive guided discovery and development.

Deliverables: Internet content for lessons.

Block scheduling for administrators and school programmers

This workshop supported administrators and programmers in block-scheduling interdisciplinary teaching teams and their students. It covered most block-scheduling models with creative combinations, so as to provide teachers with joint preparation periods and students for interdisciplinary delivery of integrated MSTE curricula. The workshops were very helpful, but stiff resistance to block scheduling made for spotty success.

Transitions

For two years of the program, we offered collaboration workshops for eighth- and ninth-grade teachers to plan joint events and projects for middle school and first-year high school students. Creative, interesting, and beneficial activities were planned. For example, freshman students prepared presentations on a variety of topics and presented them at the middle level. Middle school students visited the high schools and participated in activities. High school students and teachers spoke with the middle-school group about the importance of doing well in mathematics, science, and English as preparation for high school and careers.

Teachers led these sessions themselves. Once we suggested the workshop and goal, they immediately saw its benefit. They all participated in the activities, usually with their students. The activities gave the middle school students a future perspective and the opportunity for real time at the high schools. This was one of the most important and successful workshops, but it was seldom a priority when we had tight budgets.

Process: Interactive collaborative development of activities.

Deliverables: Fully described action plan with activities, schedules, leaders, and participants.

Theme-based workshops illustrating the integration of MSTE

These workshops were designed and led by university faculty teams to introduce teachers to knowledge and technology; to expand their vision of mathematics, the sciences, and technology; and to learn how particular themes naturally integrate into MSTE. Each of the following workshops deepened the understanding of MSTE in action and gave teachers new lessons, as well as extending their concept of communications through technology:

Laser Technology (2 days)
Astronomy (1 day)
Agricultural Innovations (2 days + help day)
Global Information Systems/Global Positioning Systems (1 days + help day)
Computer Aided Drafting/Design (2 days + help day)
Green Chemistry (2 days)
Navigation (2 days)

(For specifics, see the MSTE content chapters in Part II.)

Evaluation Session

Teachers met with a professor, the project director, a peer teacher, and the external evaluator to review the module, after self-scoring using the rubrics. This session was handled sensitively. Teachers were aware of what would take place. There were not supposed to be any surprises, since the teachers had received individual and continuous feedback throughout the entire program and had been given the format and rubric with all requirements at the beginning of the program. They developed the culminating product, including all new models, strategies, techniques, procedures, and processes, with ample opportunities to make changes.

Teachers used the rubric to score the module themselves and brought the evaluation to the session. The project team read and scored the complete module and then reviewed it, taking care to make the session a celebration of excellence. The few cases when the outcome was not positive occurred as the result of extenuating circumstances.

Module Pilots

Teachers participated in two sessions at two different times to prepare for their pilot activities. One session was embedded within the performance assessment workshops; the other occurred just before they began their pilot, usually in August, going into the new school year. This refreshed their commitment to the pilot and encouraged them to explore and set goals for what they wanted to accomplish. After they completed their pretests and posttests for the modules, and the tests were reviewed and approved by the program leader, they reviewed the data collection and submission process. Before beginning the pilot, they met with the external observer. As a team, or individually if not working with a team, the teachers established or reviewed the goals they wanted to achieve beyond piloting the integrated curriculum. Although these types of change were already built into the modules, we found it best to have everyone review them to reinforce what they were trying to accomplish during the pilots. Then they set the dates for visitation, feedback, and debriefing after the module was completed with the students. They shared the outcomes and plans for revisions or changes, based upon the pilot results, with other teachers.

Whether basic or advanced, programs seemed to work best beginning early during the school year (September/October) and ending in June, but we also offered programs with only an orientation during the school year, and then a very intensive period of three, four, or five weeks, mostly in June, during which time the teachers almost lived with us. In this intensive variant, there was a lot to learn fast, whereas in the other approach, the teachers had more time throughout the year to absorb the information, reflect, and generate new ideas. That was a less overwhelming approach. We have done it in the district, on campus with and without overnights, and off campus with overnights.

Saturdays, some school holidays, and some summer times (ending in June and revisiting in August) worked fine, with the following recommendations. We scheduled each required part of the program for not more than two Saturdays per month. Sometimes we had to schedule more Saturdays, but with the understanding that teachers really desired the learning experience. However, interestingly, when we scheduled the required days, taking care not to place too many events back to back, and then offered electives, the number of teachers who signed up for everything or almost everything was very high. Many teachers were with us for everything offered. When teachers reviewed the whole program of possibilities, they usually signed up for all or most of it. This provides strong evidence that most teachers do value staff development, especially since ours came with a caveat: the products had to be developed and then piloted. Therefore, each new level of program participation required a corresponding pilot. Few of our teachers participated solely for paid seat time.

Occasionally, when trying to make a complex schedule fit within a school district's calendar and accommodate a large number of participants, we delivered workshops after school, into the evenings, with a break for dinner, or after dinner, similar to how graduate classes or night classes at a community college are offered. This *did not* work well. Teachers were tired, unproductive, overwhelmed, and felt that the work was almost too much to accomplish. One of the most important workshops, and the most difficult to be successful with, was the one on authentic or student performance assessment. We tried this particular schedule after school, 5:00-9:00 p.m., with breaks. Although we got through it, the quality level and understanding were much lower than when we offered it three to five days in a row, beginning in the mornings for full days. Figure 2 presents the basic program's major components.

Tables 1 and 2 present a holistic picture of the basic program and products. Table 3 presents a sample calendar for both the basic and advanced programs.

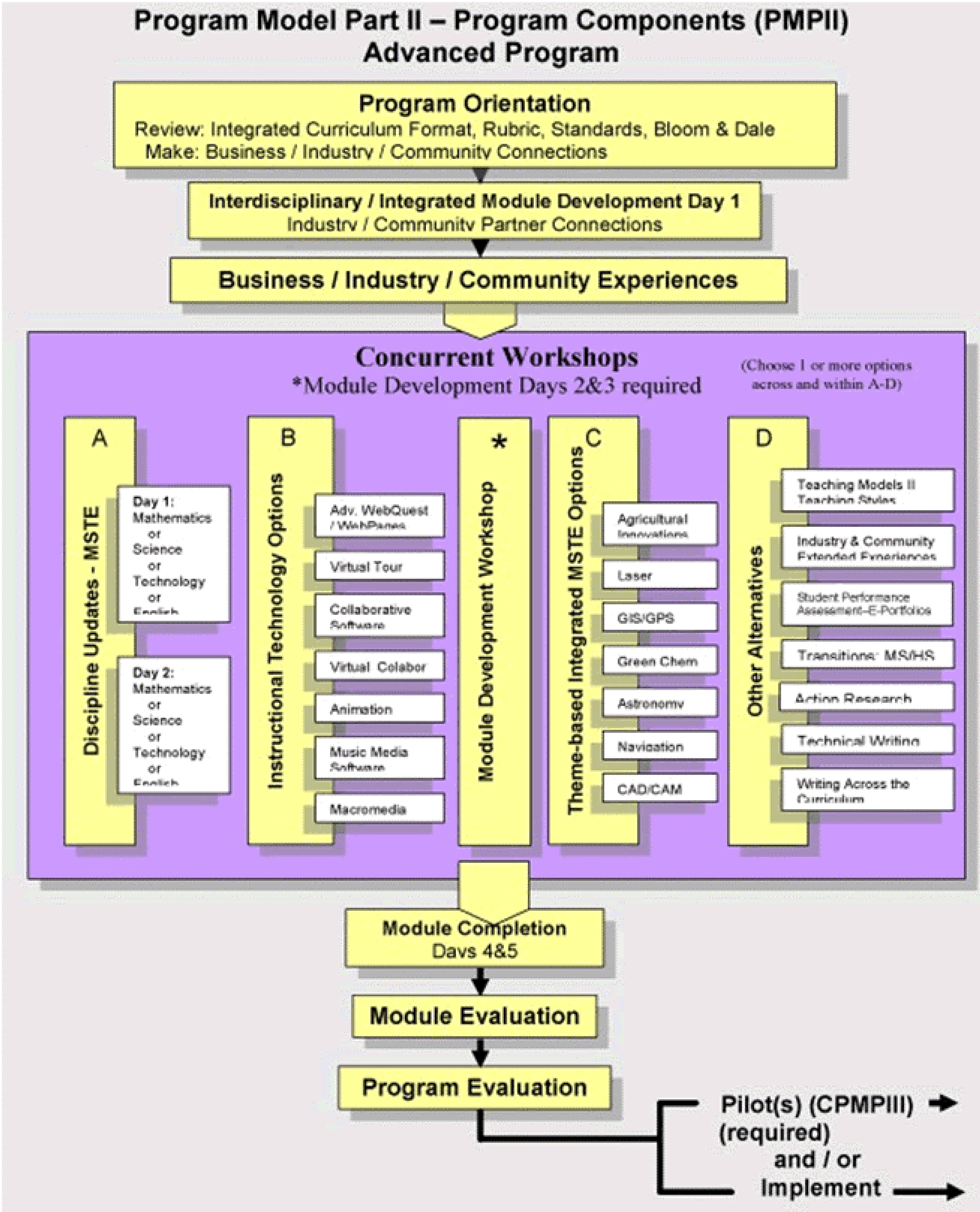

Figure 7.2 Program Model Part II – Components, Advanced

Table 7.1 Program Workshops and Products, Basic

Topic	Description: Basic Program	Product
	Requirements: teachers could add elective from advanced	
Orientation	Participation expectations, requirements, rewards, support	Commitment
Basic Technology	Training on hardware and software; navigating the Internet	NA
Standards-Based Curriculum	Illinois student learning and teaching standards; module format, standards, scoring rubric	Illinois learning standards and curriculum strengths. Need to improve analysis
MSTE "Real" World and Career Connection	1. Faculty interaction and teacher needs assessment; industry panels on job and career requirements 2. High school-community college articulation (individual and with university) 3. High school-community college-university articulation (individual and with community college) (2-3) Articulation of knowledge, skills, assessment, technology, and technology models 4. Educational paths to careers: (a. Community college) (b. University)	Needs assessment Career MSTE requirements Gaps analysis Gaps analysis MSTE requirements for higher education and careers
Interdisciplinary Teacher Teaming **Student Teaming**	Interdisciplinary teaming – (teacher and student) vision; mission; goals; objectives; team development; peer assessment and feedback; leadership; *metanoia*; trust and empowerment; effective teams; effective team members; operating policies and procedures; communication model; conflict resolution model; problem-solving model; decision-making model; hidden agendas; win/lose; teamwork; team member roles and responsibilities; team member styles; new teams and teams in trouble; energy and burnout; humor; meeting management; team documentation. How to use the content and process to develop student teams for cooperative learning and classroom and learning management	Vision, mission, objectives, goals for teachers, teams, and students Team operating manual and process Peer assessment instrument and process Documentation protocols
Block Scheduling	Teacher and student block-scheduling models	Schedules for pilots
"SharePoint" Collaborative Software	Collaboration throughout development; sharing lessons, modules, and networking; facilitates electronic feedback between program leaders and teachers	Curriculum components available through SharePoint

Teaching and Learning Foundation	1. Illinois teaching standards; brain research; learning styles; multiple intelligences; TESA 2. Teaching Models; Joyce & Weil 22 models 3. Cooperative learning (elective); base, formal, informal cooperative learning; student teaming for cooperative learning	Strength and need to improve analysis Growth plan Select teaching models and cooperative learning module
MSTE Discipline Updates	MSTE teachers meet with professors at both community college and university to identify needs or desires for learning. Based upon that, workshops are designed to work on deepening discipline-specific knowledge and skills and work with faculty at both institutions to deepen knowledge about MSTE as foundation in manufacturing, design/drafting, and other high-tech areas. Small groups ensure low ratio of teachers to professors.	Minimal: Lesson and module concepts Usual: Draft lessons for module Must: content, knowledge, skills, products from these workshops must be used in module
Interdisciplinary and Integrated MSTE Curriculum Development	Fogarty Integrated Curriculum Models; Bloom's Taxonomy; Illinois student learning standards and performance indicators; Illinois Bloom's analysis; review curriculum format and rubric	Standards for module focus; conceptualize modules; identify industry/community partners; write module introduction
Student Learning Assessment **Traditional/Authentic**	Curriculum design and assessment; standards-based assessment; authentic assessment; performance-based assessment, performance-task development and rubric development; problem-based learning through performance assessment; improving traditional-test student assessment; preparing pretest and posttests	Performance tasks Rubrics Pretest and posttests
Industry/Community Learning Experiences	Real-world learning experiences based upon selected Illinois student learning standards and selected module contexts	Authentic applications and performances
Instructional Technology	Visual literacy Graphic organizers WebQuest development Web page development	Organizers incorporate WebQuests Web page
Module Completion	Module development supported by project staff, professors, and BIC partners	3-6 week interdisciplinary module
Final Module Feedback	Each team and principal meet with key project personnel, external evaluator, and peer teacher leader to review final module; pilot preparation	Commitment and pilot readiness

Table 2 presents a holistic picture of the advanced program, schedule, and deliverables.

Table 7.2 Program Workshops and Products, Advanced

Topic	Advanced Program	Product
	Requirements:	
Orientation	Participation expectations, requirements, rewards, support	Commitment
Interdisciplinary & Integrated MSTE Curriculum Development	Review Fogarty's Integrated Curriculum Models; Bloom's Taxonomy; Illinois student learning standards and performance indicators; Illinois Bloom's analysis; review curriculum format and rubric	Standards for module; conceptualize modules; write module introduction
Industry/ Community Learning Experiences	Real-world learning experiences based upon selected Illinois student learning standards and selected module contexts	Authentic applications and performances
MSTE Discipline Updates	MSTE teachers meet with professors at community college and university to identify needs or desires for learning; based upon that, workshops are designed to work on deepening discipline-specific knowledge and skills and understand how MSTE is foundational and applied in high-technology sectors. Small groups ensure low ratio of teachers to professors.	Minimal: Lesson and module concepts Usual: Draft lessons for module Must: content, knowledge, skills, products from these workshops must be used in modules or new lessons
"SharePoint" Collaborative Software	Collaboration throughout development; sharing lessons, modules, and networking; electronic feedback between program leaders and teachers on curriculum products	Curriculum components available through SharePoint
	Electives	
Instructional Technology	1. Advanced WebQuest development to enhance lessons 2. Advance Web page development for teaching and learning 3. Virtual tour development to bring real world into lessons 4. Animation to enhance lessons, teaching, learning 5. "MacroMedia Studio" to enhance teaching and learning	WebQuests Enhanced Web page Virtual tour in module Animation in lessons, etc. Other, depending on teacher
Student Assessment Electronic Portfolios	Conceptual aspect of portfolio purpose for assessment and evidence of achievement; learning-standards based; style; technical requirements; file formats; design; creation; production techniques; posting; updating	E-portfolio designs
Teaching Styles	Focus on expanding teaching styles	Expanded styles to pilot
Virtual SharePoint	Collaboration for development across teams and schools	Virtual team products

Cooperative Learning	Base group, informal, formal cooperative learning; student teaming for cooperative learning	Cooperative learning lessons
Action Research	How to design and execute action research in the classrooms with students, determine what works best, what to change or try differently; enhance teaching and learning through classroom experimentation based upon best practices	Action research plan
Layered Curriculum	Integrating learning styles, multiple intelligences, and different achievement levels into a three-tiered instructional method that allows the teacher to facilitate individualized instruction based upon best practices	Selected strategies to incorporate into module methodologies
Marco Polo	Focus on best practices and accessing related websites; how to use the websites to improve teaching and learning	Selections to incorporate into module
Graphic Organizers	Using computer technology and calculators to organize and present data and information graphically	Graphic organizers to use in lessons and with students
PDAs **Hand-Held Computers**	Use of hand-held computers with students and student teams to collect, analyze data while engaged in a wide range of math and science experiments	New or enhanced lessons incorporating the technology
	Theme Workshops to Choose From:	Lessons
Agriculture Innovations	Manifestation and applications of MSTE	Lessons
Laser Technology	Manifestation and applications of MSTE	Lessons
Geographic Info Systems	Manifestation and applications of MSTE	Lessons
Global Positioning Systems	Manifestation and applications of MSTE	Lessons
Green Chemistry	Manifestation and applications of MSTE; interdisciplinary MSTE	Lessons
Navigation	Manifestation and applications of MSTE; interdisciplinary MSTE	Lessons
CAD	Manifestation and applications of MSTE; interdisciplinary MSTE	Lessons
Writing Across the Curriculum	Writing to learn as evidence of learning	Enhanced lessons
Reading Across the Curriculum.	Reading across contexts to deepen and broaden learning	Enhanced lessons
Technical Writing	Writing form sometimes more appropriate than traditional prose	Enhanced lessons
Transitions: Middle School to High School	Projects and activities to ease middle school to high school transition, motivate students, and inform them about MSTE and its importance to careers	Joint middle school and high school projects and activities

Table 3 provides a sample calendar of the program during one year.

Table 7.3 Sample Calendar, Basic and Advanced Programs

Date	Basic Program	Advanced Program
S Sept 7	Level I: Format, Standards, Integrated Models (8:00-3:00) Level I Orientation (3:00-4:00)	
S Sept 14 (add Jan 11)	Industry/Articulation	Agricultural Innovations
S Sept 21	Graphic Organizers (11:00-4:00)	Graphic Organizers (11:00-4:00) Advanced Orientation (8:00-11:00)
S Sept 28	RVC Ed Paths to Careers	SharePoint Virtual Student Project (VSP) - Day 1
S Oct 5		HS Discipline Update Advanced Level – Day 1
S Oct 12	Lasers - Day 1	Lasers - Day 1
M Oct 14	Industry Visits	Electronic Portfolios - Day 1
S Oct 19	NIU Ed Paths to Careers	Share Point VSP - Day 2
S Nov 9		Electronic Portfolios -Day 2
M Nov 11	Industry Visits	HS Discipline Update Advanced Level - Day 2
S. Nov 16 & Nov 23	GIS	GIS
S. Dec 7	GPS	GPS
S. Dec 14	Lasers - Day 2	Lasers - Day 2
S. Jan 11		Agricultural Innovations
S. Jan 18	Module Writing Level I & Advanced – D1	Module Writing Level I & Advanced - D1
M. Jan 20	SharePoint	SharePoint
S. Jan 25	Mod Writing Level I & Advanced - D2	Mod Writing Level I & Advanced - D2
S. Feb 1		MS Discipline Update Advanced Level - Day 1
S. Feb 8	Brain, LS, MI, TESA – D1	Green Chemistry – Day 1
S. Feb 15	Teaching Models - D2	MS Discipline Update Advanced Level Day 2
S. Feb 22	Cooperative Learning	Cooperative Learning
S. March 1	MS Discipline Update Level I - (no English, merged with Advanced: 2/1)	
M. March 3	Teaching Models - D3	Green Chemistry – Day 2
S. March 8	WebQuests	WebQuests
S. March 15, 22, 29	Student Performance Assessment	March 29 - Navigation: Astronomy, Physics, Math
S April 5	HS Discipline Update Level I (no Eng.: merged with Advanced: 10/5)	Electronic Portfolios - Day 3
M-T April 14-15	Action Research	Action Research
W-Th April 16-17	CAD	CAD
S April 26	Module Writing Level I & Advanced – D3	Module Writing Level I & Advanced - D3
S May 10	Marco Polo	Marco Polo
W-Sat, June 11,12, 13, 14	Webpage, Virtual Tours, Animation June 14 is a Help Day	Webpage, Virtual Tours, Animation June 14 is a Help Day
M-T June 16, 17	Module Completion	Module Completion
June 18/19	Read Modules & Feedback	Read Modules & Feedback

Pilots

Pretests and posttests, as well as performance tasks and scoring rubrics to measure student achievement on conceptual gains of MSTE, were prepared for the pilot activities as part of the performance assessment workshops. Teachers received data collection instruments for collecting pretest and posttest scores and student information, with identification of gender and ethnicity. They sent these forms and their tests to the research associate. Teachers also provided their performance tasks, rubrics, and performance scores. The pretest and posttests were used as the formal data comparison to determine student achievement or gain during the modules. The performance tasks were collected and reviewed but were not formally part of the pilot data. No comparisons were made between the two forms of assessment.

Teachers met with the pilot coach first to review strategies, models, techniques, or procedures. While teachers engaged in piloting, the coach visited for observation. Once the pilots were completed, teachers received feedback and the team was debriefed. At the end of each semester, teachers were invited to participate in a sharing and networking meeting across teams and schools. Each teacher was observed at least once during the pilot, which means that four or more observations occurred throughout the pilot. This was done to confirm that the pilots were occurring appropriately and to provide feedback by an external person. Each teacher received a confidential feedback report for personal growth purposes.

The project team also had another agenda for these observations. They wanted to stimulate teachers to use feedback for instructional decision making and lead them to using the peer feedback model and process rather than external observers. Therefore, when meeting with the principals of the regional initiative and the Rockford co-director (two concurrent but different initiatives), we decided that the time was right to move the process internally to their schools, rather than have a university person do the observations. We sought to institutionalize a peer observation and feedback process within each school. In the regional schools, peers did engage together when scheduling permitted. In the Rockford initiative, a central office staff member observed and provided feedback. These staff members were the district curriculum coordinators for MSTE and had all been MSTE teachers. Both processes worked well. Teachers seemed to value the feedback, but we did identify a preference by teachers for university personnel to provide modular feedback. Teachers were open, stimulated, and receptive to observation and feedback and seemed to appreciate its value for professional growth.

The networking sessions at the end of each semester's pilots across teams and schools were very successful. Teachers claimed great benefit from hearing about one another's results and activities. Teachers did not receive stipends or credit of any kind for these sessions. For the first few years, everyone attended, but attendance dwindled and then stopped. Principals must value and support cross group networking for it to be realized and/or sustained.

Pilots (Action Research) and Networking (Figure 3)

Once we realized that the pilots were close to the emerging focus on action research, workshops in the advanced program included action research. Action research preparation was tied to classroom follow-up of piloted strategies, materials, procedures, or techniques and capped with each semester's networking, sharing, and brainstorming event to help move teachers, schools, and districts toward new and more sustainable practices.

Figure 3 shows the process. Teachers met to review what they planned to do during the pilots. Each teacher of each team had individual goals for new strategies to try. The team piloted together, using a variety of interdisciplinary strategies, integrated curriculum, student performance assessment, partnership activities, and more. Each teacher had a role and was responsible for aspects of the module. There was a pretest at the beginning and a posttest at the end. During the pilots, teachers were individually observed, one to three times, and given immediate feedback when possible. The whole team got feedback at the end of the module.

Reports on each observation were written and submitted only to the PI and the individual teacher. No one else in the district received any other information except a composite report where teams and modules were not identified. That is part of our trust agreement with the teachers to prevent inappropriate misperceptions about the use of their data or pilot results. Although some modules crossed semesters or the entire year, most were completed within 3-6 weeks or a single semester. At the end of the semester, there was an attempt to have sharing and networking sessions in which teachers could describe what they tried to do and the outcomes. However, whether or not we were able to schedule these sessions depended on several factors: administrative support, reward structure, and scheduling. Tables 4, 5, 6, and 7 present the data collection forms.

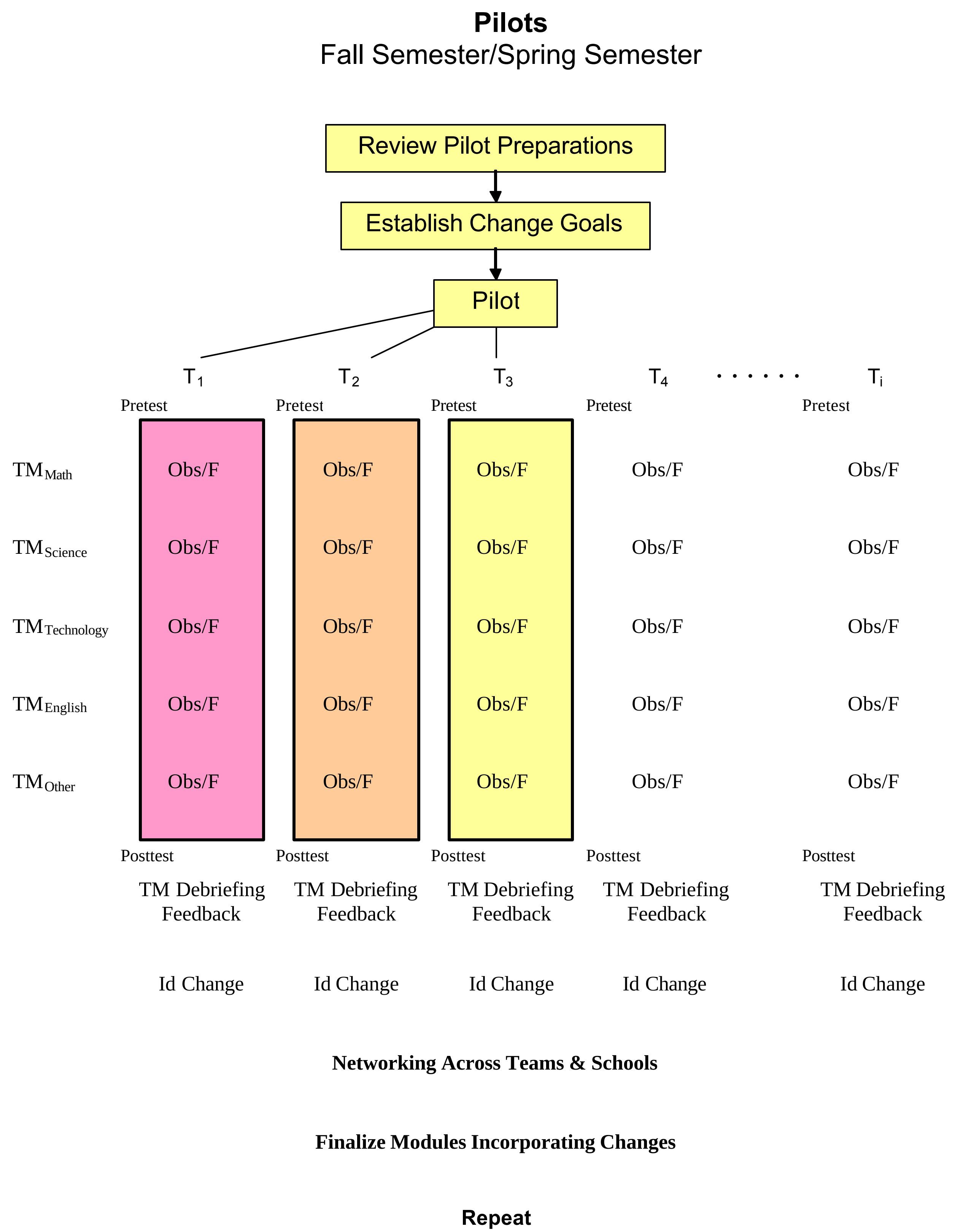

Figure 7.3 Pilots

Table 7.4 Reporting Form 1

Fax to:

Reporting Form 1 **Phone:**

Student Data Questions: call____________

Team ________________________

School ______________________

Teacher ______________________

Course ______________________

Class Period __________________

Complete the following: The students participating in the study were enrolled in __________________________ (English, Algebra, and Physics)

Class(es) at grade level(s) ____________ at ____________________School.

Student Name	ID#	Gender	Racial/Ethnic
__________________	_______	____	_______
__________________	_______	____	_______
__________________	_______	____	_______
__________________	_______	____	_______

Gender
1 = male
2= female

Racial/Ethnic
1= African Amer.
2 = Caucasian
3 = Native Amer.
4 = Asian
5 = Hispanic

Table 7.5 Reporting Form 2

Fax to:

Reporting Form 2

Pretest/Posttest

Questions: contact@email.domain

Team ______________________

School _____________________

Teacher _____________________

Course _____________________

Class Period _________________

Pretest Posttest (circle one)

Points Possible ____

Student Name	ID#	Score
________________	__________	__________
________________	__________	__________
________________	__________	__________

Table 7.6 Teacher/Team Information

Teacher/Team Information

School ________________________ School Address ______________________

City ___________________________ Zip __________

School Fax Number __________________ School Phone Number ________________

Team Name ____________________________________

Team Leader __________________________________

Home Address __________________________ City/Zip ______________________

Home Phone ______________ Email Address _______________

Team Member ______________________________

Home Address ___________________________ City/Zip ______________________

Home Phone ______________ Email Address _______________

Team Member __________________________________

Home Address __________________________ City/Zip ______________________

Home Phone ______________ Email Address _______________

Anticipated Module Start Date: __________________________

Table 7.7 Pilot Testing Instructions

Pilot Testing Instructions

1. **The traditional pretest/posttest developed in the assessment workshop is to be used in data reporting.**
   - **A. In teams where common students across content areas are NOT available, each content area teacher will administer a pretest/posttest for that content area and report results separately.**
   - **B. For teams having common students, a single pretest/posttest encompassing content for all content areas may be administered in one of the classes and reported as a whole.**
   - **C. Each test should be graded by the team or content area teacher and must result in a numeric score ranging from 0 to the maximum points possible as listed on Reporting Form 2.**
2. Complete one copy of **Reporting Form 1** per team listing each student participating in pilot testing.
   - A. If there are no common students, each content area teacher should complete this form.
   - B. Fax these forms to ______________ at the number listed on the form
   - C. PLEASE, do this as soon as you know which students will participate.
   - D. Fax a final copy of the instrument you are using also.
3. Administer the instrument as a **PRETEST** on the first class period at the beginning of the module.
   - A. Score and record these results on **Reporting Form 2**. Circle Pretest on the form.
   - B. WRITE LEGIBLY. Report a numeric score indicating the number of points for each student. Do NOT report percentages or letter grades.
   - C. Fax these forms to ______________ at the number listed on the form
   - D. SEND THE RESULTS OF THE PRETEST AS SOON AS POSSIBLE AFTER IT IS ADMINISTERED.
4. Administer this SAME test as a **POSTTEST** on the last class session of the module.
   - A. Score and record these results on **Reporting Form 2**. Circle Posttest on the form.
   - B. WRITE LEGIBLY. Report a numeric score indicating the number of points for each student. Do NOT report percentages or letter grades.
   - C. Fax these forms to _____________ at the number listed on the form
   - D. SEND THE POSTTEST RESULTS AS SOON AS POSSIBLE AFTER THE MODULE IS CONCLUDED.
5. If there are students in common among team members, the test only needs to be administered in one class.
   - A. If there are no students in common, or a mixture, a separate test for each content area should be administered in each class.
   - B. Results for each class are recorded on Reporting Form 2 and Faxed at the number shown on the Form.
6. If you have questions regarding pilot testing, call or Fax or e-mail

Items to Fax	**When Faxed**
Copies of all final versions of the pretest/ posttest used in pilot testing.	Beginning of Module Testing
Completed Reporting Form 1 showing Gender and Racial/Ethnicity of all participating students	**Beginning of Module Testing**
Completed Reporting Form 2 showing PRETEST results.	**Beginning of Module Testing**
Completed Reporting Form 2 showing POSTTEST results.	End of Module Testing

Registration

This could be an exciting, yet administratively, challenging series of events. Because we wanted to give teachers reward options rather than dictate how they could be rewarded, the process was more complex. The reward options were:

Technology + stipends + recertification continuing professional development units (CPDUs)
Technology + graduate credit
Technology + partial graduate credit + partial stipend
Technology + partial graduate credit + partial stipend + partial CPDUs

Note: Teachers received graduate credit at no cost in lieu of stipends.

Most of the teachers enrolled and successfully completed more than the requirements for both program levels. However, in striving to give them options for rewards, the registration and tracking process was rather demanding. Tables 8 and 9 provide an example of the form. Each year, it was modified based upon what was changed programmatically and learned about the process and options. The unofficial name of the program was usually the name of the funding agency. If NSF was funding it, it was "NSF"; if it was the Illinois State Board of Education's Scientific Literacy grant program, it became "Scientific Literacy," and so on.

The program for counselors (Table 10) was much less complicated, since they are not required to recertify. Therefore, they were released from part of the school day and received partial stipends for after-school hours or participated in the graduate class in lieu of stipends.

Table 7.8 Sample Registration Form

XXXX Registration Form

Level I – Math, Science, English & Technology Teachers

(For teachers who have not participated in Scientific Literacy or NSF previously)

Please check either the graduate credit option OR the CPDU option. Must attend A, B, C, D, & E

	Graduate Credit	CPDUs with Stipends
A.. Engaged Learning and Student *Performance Assessment*	**___3 graduate credits**	**___ 49 CPDUs and $980**
Interdisciplinary Curriculum Development	**___ 3 graduate credits**	**____ 49 CPDUs and $980**
Educational Paths to Careers Across Disciplines	**___ 3 graduate credits**	**____ 49 CPDUs and $980**

Engaged Learning & Student Performance Assessment (must attend 7 days as follows)

S 2/22	Cooperative Learning/Student Teaming
S 2/8, S 2/15, & M 3/3	Teaching Models/ Learning Styles, Brain Research, & TESA
S 3/15, S 3/22, & S 3/29	Student Performance Assessment

Interdisciplinary	Learning Standards & Integrated Curriculum Model Development
M 1/20	SharePoint Software Tool
S 1/25, S 4/26, M 6/16, T 6/17,	Interdisciplinary Module Development

Educational Paths to Careers Across Disciplines (must attend 7 days as follows)

S 9/14	Industry Panel and RVC/NIU Articulation
S 9/28 and S 10/19	Ed Paths to Careers at RVC and NIU
S 3/1 for MS or S 4/5 for HS	Discipline Update
S 2/8, W 6/11, S 6/14	Instructional Technology - WebQuests and Webpage Development

D. Industry M 10/14 or M 11/11 and 2 visits planned for module (not paid)

E. Feedback Th 6/19 (1 hour)

Note: Although every effort will be made to keep to the published schedule, there may be unexpected or unplanned changes

****

Expectations:

1. 2 days (4 locations) of verified industry visitations
2. Permit college/university faculty to visit your classrooms to better understand today's secondary students
3. Participate in laptop computer orientation
4. Complete modules incorporating all standards, new strategies, techniques, teaching models, assessments, workshop products, etc.
5. Pilot modules during school year 2003-2004
6. Revise modules after piloting
7. Feedback collaboration between District Coordinators and KIDS observation teams.
8. All workshop products (as outlined during Orientation Information Session on 8/16)

Quality, University Credit, ISBE CPDUs & District Expectations for Teacher Recertification:

1. Product quality will affect university credit and grades as well as CPDU awards toward recertification
2. Absences and tardiness or class time missed will affect university credit, grades and CPDU awards toward recertification.
3. District Coordinators and KIDS teams will observe during piloting activities.
4. Teacher recertification credit or CPDUs depend upon completion of all required activities.

****

Additional Workshop Opportunities for Level I - ***Please check each option desired☺***

A. ____Layered Curriculum (8 CPDUs and $160) M 8/19 & T 8/20 HS______; T 8/21 & W 8/22 MS ______

B. ____CAD (2 days = 14 CPDUs and $280) W 4/16 & Th 4/17

C. ____GIS (2 days = 14 CPDUs and $280) S 11/16 & S 11/23 ______; with GPS (1 day = 7 CPDUs & $140) S 12/7 _____

D. ____Lasers (classroom materials - no stipends) S 10/12 and S 12/14

E. ____Action Research for Teachers (2 days = 14 CPDUs and $280) M 4/14 and T 4/15

F. ____Marco Polo - Use of the Internet (1 day = 7 CPDUs and $140) S 5/10

G. ____Graphic Organizers (4 CPDUs and $80) S 9/21

H. ____Instructional Technology: TH 6/12 Virtual Tour ____; F 6/13 Animation ____; (each day 7 CPDUs & $140)

****

Name ____

E-mail ________________________

Social Security Number ____

School ____

Discipline ________________________

School Phone ______________ Fax___________________

Home Phone _________________________Fax_________________

Table 7.9 Sample Registration Form (continued)

XXXX Registration Form

Advanced Levels – Math, Science, English & Technology Teachers

(For participants include those who have had either Scientific Literacy or NSF Level I)

Must attend A, B, C & D

Content	**Dates**	**CPDUs w/ Stipends**	**Graduate Credit**
A. Integrated Curriculum Development Module Format & Development Module Development	S 9/21 (3 hours) S 1/18, S 1/25, and S 4/26 M 6/16 and T 6/17	**___38 CPDUs and $760**	**___ 3 graduate credits in *Applications of MSTE* when ABCD completed and B = at least 14 hours**
B. One or More Content Area Workshops from List Below	Varies by workshop(s)	**Varies by workshop**	
C. Industry Visit	2 visits planned for module	**Not Paid**	
D. Feedback	Th 6/19 (1 hour)	**Not Paid**	

Additional Workshop Opportunities: (if participant has not already had them)

Please check each option desired☺

A. ____Cooperative Learning (1 days = 7 CPDUs and $140 stipends) S 2/22

B._____Layered Curriculum (8 CPDUs and $160) M 8/19 & T 8/20 HS ____; T 8/21 & W 8/22 MS _______

C. ____CAD (2 days = 14 CPDUs and $280) W 4/16 & Th 4/17

D. ____GIS (2 days = 14 CPDUs and $280) S 11/16 & S 11/23 ______; with GPS (1 day = 7 CPDUs & $140) S 12/7 ______

E. ____Lasers (classroom materials - no stipends) S 10/12 and S 12/14

F. ____Electronic Student Portfolios (3 days = 21 CPDUs and $420) M 10/14, S 11/9, & S 3/1

G. ____Action Research for Teachers (2 days = 14 CPDUs and $280) M 4/14 and T 4/15

H. ____Marco Polo - Use of the Internet (1 day = 7 CPDUs and $140) S 5/10

I. ____GIS Help Day W 8/14 ___ &/or CAD Help Day T 8/13 ____ &/or SharePoint Help Day M 1/12 ___ (each day 7 CPDUs & $140)

J. ____PDAs or Handheld Computers: M 8/19 & T 8/20 for MS______ W 8/21 & Th 8/22 for HS _______ All workshop products (no stipends; use of classroom set for project implementation)

K. ____Transition Project (2 days = 14 CPDUs & $280) Grades 8-9 - S 10/26 & S 11/2 _____ or Grade 11/12 to post secondary at RVC - S 10/26 $ S 11/2 _______

L. ____Discipline Update (2 days = 14 CPDUs and $280) HS S 10/5 & M 11/11 ____; MS S 2/1 & S 2/15 _____ (can enroll again)

M. ____SharePoint (1 days - 7 CPDUs and $140) S 1/20

N. ____Agricultural Innovations (1 day - 7 CPDUs and $140) S 9/14

O. ____Green Chemistry (1 day - 7 CPDUs and $140) M 3/3

P. ____Navigation: Astronomy, Physics, Math (1day - 7 CPDUs and $140) S 3/29

Q. ____Graphic Organizers (4 CPDUs and $80) S 9/21 (after Advanced 3 hour Module Orientation)

R. ____Instructional Technology: S 3/8 WebQuests____; W 6/11 Webpage_____; Th 6/12 Virtual Tour_____; F 6/13 Animation______, S 6/14 Help Day_______ (each day 7 CPDUs & $140)

S. ____Virtual SharePoint (2 days - 14 CPDUs and $280) S. 9/28 & S 10/19

Note: Although every effort will be made to keep to the published schedule, there may be unexpected or unplanned changes

****

Expectations:

1. 1 day (2 locations) of verified industry visitations
2. Permit college/university faculty to visit your classrooms to better understand today's secondary students
3. Complete projects incorporating standards, new strategies, techniques, teaching models, assessments, workshop products, etc.
4. Pilot projects during school year 2003-2004
5. Revise projects after piloting and posting to district web site.
6. Feedback collaboration between District Coordinators and KIDS observation teams.
7. All workshop products (as outlined on Orientation Information Handout)

Quality, University Credit, ISBE CPDUs & District Expectations for Teacher Recertification:

1. Product quality will affect university credit and grades as well as CPDU awards toward recertification
2. Absences and tardiness or class time missed will affect university credit, grades and CPDU awards toward recertification.
3. District Coordinators and KIDS teams will observe during piloting activities.
4. Teacher recertification credit or CPDUs depend upon completion of all required activities.

****

Name ____

Email ____

Social Security Number_____________________________

School ____

Discipline ____

School Phone ______________ Fax___________________ Home Phone _________________Fax________________

Table 7.10 Sample Registration Form (Secondary School Counselors)

XXXX Registration Form

Secondary School Counselors

	Graduate Credit	CPDUs with Stipends
Career Education & Counseling	**___2 graduate credits**	**___ 36 CPDUs and $720**

Meetings to explore the following topics and develop an Exemplary Career Planning Program

A. National/State Standards for Counselors

B. Developmental Counseling Programs

C. National Standards for a Career Counseling Program

D. Exemplary Career Planning Programs

E. Role of counselors in school improvement and Middle School and High School reform

Three Saturdays from 8:00 -4:00 and five early release days from 2:00 - 5:00.

Dates to be determined.

For all participants:

1. Two job shadowing experiences in the community
2. Develop and implement career counseling lesson in conjunction with a teacher in your building that culminates in the completion of the ICP for the students involved.
3. Visit another school district with an Exemplary Career Planning Program
4. Develop and implement plan for an Exemplary Career Planning Program in your school
5. Attend a local or regional conference on Counseling and Careers and report to the group (reimbursed by the grant)
6. Evaluate piloting of ICPs and recommended revisions
7. All workshop products

Additional for counselors who did not have the NSF Counseling workshop in 2001-2002:

1. Complete classroom observations - two each of math, science, English and technology
2. Orientation to Industry and Articulation with RVC/NIU: Sat, ($140)
3. Education Paths to Careers at NIU and RVC: Sat. & Sat. ($280)

Quality, University Credit, ISBE CPDUs & District Expectations for Teacher Recertification:

8. Product quality will affect university credit and grades as well as CPDU awards toward recertification
9. Absences and tardiness or class time missed will affect university credit, grades and CPDU awards toward recertification.
10. District Coordinators and KIDS teams will observe during piloting activities.
11. Teacher recertification credit or CPDUs depend upon completion of all required activities

Name ___________________________________

Email __________________________________

Social Security Number ____________________

School ________________________________

Discipline ______________________________

Phone ___________ **Fax**_____________

FAX to: ____ **by:** ____

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8. Challenges and Lessons Learned

Jule Dee Scarborough

We have long been operating as a major teacher enhancement and support center and could be perceived, in today's new terminology, as having large groups of teachers actually engaged in action research with technical support. Our projects have all been very complex ones that present us with many challenges. The following discussion is intentionally problem-centered and focuses on how others could benefit from what we have learned. They do not need to repeat problems that could be minimized or eliminated by realizing what might occur. In the discussion below, our challenges and the lessons learned are presented in italics.

Project and Lead Personnel

Securing appropriate facilities

Challenge: Our expenses for on-campus facilities increased because of changes in the university's methods of assigning costs and its expectations for generating income from its infrastructure through cost centers.

Many university and college administrations have adopted a cost-center model, which means that any space not used directly for research and teaching or university administration may be financially tied to self-support or profit generation. The facility that we had been using for teacher training was the student center, which has appropriate meeting facilities and guestrooms, is located close to the library, and has easy access to departmental labs. However, external organizations began to regard it as an affordable choice for conferences and meetings. We gradually found it more difficult to schedule our events at the student center, and the facility also started raising its fees and finally became a cost center.

Using the university had other issues. We had to work with teachers on weekends, holidays, and in the summer, but the centers preferred weekday, non-holiday scheduling. When we needed several rooms for breakout, access to copying, and computer labs, they reacted as if overwhelmed; they were really still used to traditional use of their space. Then there was the food issue. We had to feed teachers when we had them all day, and even fairly inexpensive menus or refreshments became expensive when we could not contract outside of the center or bring food in. They, too, *are* cost centers and expensive.

Using off-campus university centers also had issues. We explored the possibility of using off-campus university facilities, but they did not always cater to our needs for using special equipment, copying facilities, and Internet access. Also, other organizations, especially business and industry, had realized that these centers, although expensive to us, were not as expensive for them, and they began using them as well.

We did, of course, use on-campus facilities at both the university and community college. We used particular laboratories, and academic facilities were available on Saturdays and national holidays. Computer facilities sometimes required overtime for technicians to be available, but we could deal with that. As with many higher educational institutions, most of the good space was overbooked and hard to schedule or had become expensive as a cost center .

Lessons learned: We find non-educational facilities that allow us the space for the cost of meals – a cost within our state-federal allowed budget. They give us cost breaks, almost as partners, and do not hold us to traditional use of space. They give us full access to a copy machine, Internet plug-ins, or wired computers, and we use laptops in the meeting rooms. We manage to find suitable locations almost everywhere we work and acknowledge them as partners, which helps as well.

Indirect costs on grant budgets are supposed to cover the costs of facilities, but that is not really true, nor is it possible at some state institutions. Even with the most supportive administrations, there are limitations. They are dealing with very tight financial situations and try their best to work with us, but there is a list of priorities ahead of our requirements, even when the grant-funded projects are part of our mission and service.

These issues require a great deal of time for searching, discussing, negotiating, and coming back to people with creative ideas of how to work things out; many times we have to present them with ideas of how to make things work. Finding solutions requires asking the right questions for the doors to be opened to new ways of doing things. Grant administrators are not compensated very well, even on major grant initiatives, unless a full-time position is funded. However, the fact remains that the grant's administrator has to assume the responsibility for resolving issues, often with the realization that identifying creative solutions that work can be exciting, leading to new ways of thinking, new perspectives, and often new partnerships.

Administration

Challenge: Larger and complex initiatives, such as ours, entail a great deal of administrative work, but most granting agencies do not support full-time grant administrators or clerical staff, although they do support some graduate student assistance. Our project work included the processing of stipends, the purchase of equipment, reimbursement for travel, preparation and support of workshops, the purchase of materials and supplies, and more, for a project staff of 50+ and teacher participants, approximately 80 per year. It involved coordinating multiple sites for events and activities, negotiating with department administrators or deans, and more. Also, there was the coordination of external partners and their events, the external evaluator, peer teacher leaders, pilot monitoring, coordination, and faculty involvement, and most importantly, the leadership necessary to move faculty and partners forward to sustain a program of high integrity.

Lessons learned: It is possible to find matching funds, especially combinations of local, federal, and state. Matching NSF funds with state funds made our "center-like" activities possible. This worked very well for us. It enabled us to reward personnel more appropriately, though far less than other endeavors such as consulting or working with research laboratories.

Rewards and compensation

Challenge: Faculty members were willing to work with schools, but needed respectable stipends as well as other types of support. Higher-education faculty members worked with us *in addition* to performing their full academic duties. Most of our work with teachers was on weekends, national holidays, or during the summer.

We paid faculty nominal stipends for the number of days of delivery. This included preparation, follow-up with teachers, and so forth on their own. Many who worked with us were actually penalized in their departmental personnel-review process because some mathematics, science, and engineering personnel review committees felt that the time spent working with teachers, even if it was the professor's own time, could have been better spent on research. Also, publishing the results of our work was not always possible, for reasons discussed earlier, reducing that avenue of professional recognition for university faculty, who were evaluated by their departments according to research-oriented criteria.

Lessons learned: When deans and department heads recognize the importance of faculty involvement with schools, at least the professors are not penalized, although they are not always rewarded or recognized for their work. Strong departmental leadership results in appropriate recognition and value of professors' work with teachers and schools.

Program

Challenge: If lead personnel went off on tangents, came unprepared, did not model best practices, or did not use technology well and appropriately, there were problems.

Lessons learned: It is worth our time and effort to check the background, knowledge, skills, interpersonal abilities, technological prowess, and problem-solving ability of lead personnel, as well as their willingness to be responsible for their own sessions.

Challenge: Many teachers were weak in their discipline and unable to take full advantage of our approach.

Lessons learned: We gradually evolved a more multifaceted approach that incorporates discipline-based learning with learning about teaching and learning. This enables us to demonstrate good teaching and learning models and techniques as the participants learn about both. They begin to realize that the disciplines are not discrete, that their knowledge and concepts cross disciplinary boundaries, and the disciplinary strengths are the foundation for excellence in teaching.

The big picture

Challenge: Most program faculty claimed they wanted to understand the big picture, the whole program, the goals, strategies, research components, and all the rest. But, in fact, it was difficult to schedule them, hold their attention, and most of them did not follow through with reading material provided.

Lessons learned: It is important to hold a required orientation annually, with a follow-up meeting later in the year, to provide the "opportunity" for program leaders to understand the entire endeavor and their relationship to the program. This is especially important for more complex endeavors. If the initiative occurs over several years, then an orientation has to mark the beginning of each year, with a midyear follow-up and a debriefing at the end. This works well for us as the core team, and we would expand it to include *all* program leaders and team members.

Maintaining quality

Challenge: It was crucial to maintain the integrity and quality of program content and process and to involve knowledgeable and skilled leaders. Once leaders understood the goals, they could usually take it from there.

Lessons learned: The first lesson is to involve people who understand the need to support schools. Those who do not know the teaching and learning buzzwords or formal concepts or best practices might, in fact, apply them to the satisfaction of all involved.

The second lesson is that professional development leaders need at least minimal training or education about the teaching and learning theory to be applied. They are asked to model the best practices as a way of deepening the focus on teaching and learning, as well as solidifying the program framework and building relationships while constructing applications across interdisciplinary contexts.

Work

Challenge: Some program faculty leaders were not prepared to organize and deliver work to meet deadlines or to perform to prescribed specifications.

Lessons learned: We recommend setting expectations related to communication, timelines, documentation (agendas and handouts), picture taking, and procedures or processes so that everyone can commit to them before beginning the program and can understand the importance of that commitment to the overall endeavor and their responsibility for delivering their own program components.

District or school administration

Challenge: Local leadership in schools was critical to success but not always easy to achieve. We could accomplish more if the administrators were involved. If they led and supported the teachers in making changes, and expected change, it happened and was sustained. The school principal was *potentially* the greatest barrier to implementation and sustainability. Principals and district administrators, even those who asked us to work with them, also sometimes showed poor follow-through. It took an exceptional leader to understand the opportunity and benefit that our type of partnership could provide; however, *when* the administrative leadership was in place, phenomenal changes could occur.

Lessons learned: Strong and positive leadership accomplish or result in the following:

1. <u>Follow-through with their commitments</u>. Committed leaders block-schedule teachers for simultaneous preparation periods, or block-schedule students into teaching teams' classes, visit classrooms, and send reports as asked. They find avenues for teachers to

share what they are learning and doing and the results of their efforts, and then they recognize the teachers and acknowledge their efforts to grow professionally.

2. Visibility. Committed leaders visit teachers during their learning experiences and workshops, remember to ask about particular events, and send feedback to us. They let the teachers know, visibly, that they are interested in and motivated by what they are learning and planning to try in their classrooms. They observe in the classroom during the pilot activities and provide feedback and encouragement.
3. Sustainability. Good leaders work toward implementation and institutionalization of good results. They become the safety net for sustaining what was realized during the grant period, but then help teachers continue to grow by encouraging them to try new teaching and learning methods.
4. Support. Strong leaders support their teachers in change efforts, establish partnerships with external groups, and help implement new teaching and learning strategies and curricula.
5. Continuous improvement. Strong leaders understand that teachers are capable of leading themselves toward positive change and that small but continual improvement can produce great results over time.
6. Networking. Effective leaders help teachers understand that when they work together, the workload is reduced for all and all learn more together. They lead internal partnerships and networking and find ways to extend them to interschool collaboration.
7. Transforming leadership using the superleadership model. Involved leaders understand their responsibility to enable teachers and teacher teams to lead themselves (Bass, 1978; Manz & Sims, 1989).
8. Project vs. initiative. Strategic leaders want to sustain the momentum gained during the formal "project" period. They realize that teachers need time, a most critical and difficult commodity to find, to work together. Sustainability is really at the heart of our initiative, and when we can work for longer periods of time with a district, we try to turn the leadership over to those who would assume it, gradually getting local leaders to join us in leading the events and making the project their own.
9. Learning organizations. Principals today understand the importance of creating a learning organization by developing teachers as leaders (Burns, 1978; Senge, 1990; Tewel, 1995).
10. Leadership by superintendents and boards of education. We encourage visible and active support from the highest levels. For grant-funded projects or partnerships to be accepted in a district, usually the board and superintendent must approve them. Too often that is where the support stops, when in fact that is where it should begin. The strong leaders know that they must keep the higher levels actively involved so that the teachers will feel supported. Principals have to see and feel active involvement by both to determine that the initiative is a priority, or they will not support it. Therefore, the priority has to be set by the superintendent and board, and then the principals have to sign on to it, and all three have to show active leadership. They need to schedule periodic reviews, less for accountability purposes than to inform

participants and stakeholders about progress and accomplishments and to resolve problems.

Teacher Participants and Related Issues

We faced many issues when developing our program for a broad range of teachers with varying knowledge, skills, capabilities, and attitudes. Our teachers had not been supported as they should have been. Many were endorsed rather than degreed in their disciplines and sometimes were teaching outside their primary fields. Furthermore, many of our teachers practice in teaching and learning climates and environments that are not conducive to the implementation of best practices.

Education, in-service training

Challenge: Teachers varied greatly in the depth of their understanding within a discipline; their knowledge across disciplines could be limited. Teachers, with the possible exception of particular vocational or technology teachers, had very limited exposure to MSTE in the working world. This was also true about pedagogy and best teaching and learning practices. Many teachers had not been to a national or state conference in years, had not visited other schools, did not have access to reading materials on teaching and learning (although that is changing with the Internet), and had not been supported or held accountable for implementing improvements that were observed with feedback. Even when opportunities or materials were available, teachers needed to be motivated to seek them out and use them when provided.

*Lessons learned: The first lesson is that we could work with a group more effectively by involving leader assistants or by pairing or grouping teachers with peers***.** It is also effective to offer learning experiences in small groups and provide additional help sessions or one-on-one assistance. When this is not affordable, we seek matching funds. Using such strategies is critical, since our priority is to move the whole group together into best practices.

The second lesson is to keep a close eye on peer assistance because some teachers regard that as our responsibility, not theirs. We learned to provide our own assistants on particular topics of in-service. But we also tried to build sharing and networking into the program as an integral component, to enable teachers to experience the positive results of sharing successes as well as the difficulties and to realize that trying new strategies, curricula, and processes is what professionals do. We set the stage for peer leaders, but provide program assistants as well when groups are large enough to require it. We also establish, in the permanent district calendar, sharing and networking meetings throughout the year that teachers are expected to attend. It is important to hold them accountable for professional exchange.

Technological capabilities

Challenge: Gradually teachers were receiving computers for their classrooms, but many lacked the training to use them, and teachers did not know the underlying learning theory for using technology for teaching and learning enhancement. Teachers need to be supported with various types of in-service related to instructional technology, and the program needs to address the learning theory as well as skill building on the use of technological tools.

Lessons learned: We can use technology as a tool and process for learning knowledge efficiently; the technology can become almost invisible when enhancing the learning process. Teachers need to understand that technology can be understood as a myriad of sub-disciplines, each with its own knowledge and skill taxonomy. It is important to build participant knowledge of theory, process, and skill for both teaching and learning.

Experience outside the classroom

Challenge: Few teachers had experience outside the classroom.

Lessons learned: The first lesson is that we can identify business, industry, and community partners who provide a range of experiences for teacher development and then continue into the classroom or as partners for new curriculum modules, revised lessons, or new or enhanced lessons. The range and willingness of our partners has few limitations. Teachers participate in police department forensic workshops, open only to very few law enforcement employees; they have experiences at airports, hospitals, many businesses and industries, park and recreation facilities, research labs, and more. These awaken the teachers to a realization of how MSTE is used, to career and education requirements, to learning problems that are more authentic, and to new criteria for assessments and rubrics or student achievement expectations.

The second lesson is that, while we need to find an ongoing way to get teachers out of the classroom because they never return as the same teachers who left, this requires major orchestration. It also requires someone who knows how to make the connections when there are none to begin with, and someone who knows how to ask the right questions to create the best experiences for the teachers. We recommend that a coordinator with these abilities be a major project leader and that schools identify someone who can sustain the relationships.

Follow-through

Challenge: Most teachers wanted to follow through and finish things as expected and committed, but some could not keep up with the program's pace. On the other hand, some teachers found the pace too slow. Why the discussion on pace? Because we engaged teachers in learning, producing, and performing; they actually identified, adopted, built, or adapted their products and processes, and, in particular content areas. The product or process expected actually occurred during the in-service activities. However because of variances in learning curves, some did not complete everything during the formal sessions, while others finished early. So, how well the teachers follow through between sessions was critical to moving on with the next program component.

Lessons learned: The first lesson is that the best we can do is to plan around some kind of average, once teacher knowledge and skill levels are explored. The term explored is used intentionally because testing or formal assessment is not usually permitted or agreed to by teachers; it is too much like evaluation. Therefore, in-depth discussions have to occur between leaders and teachers and between project administrators and school administrators to gain a feel for what was needed and to project the potential pace.

Our second lesson is that the expectations and rewards should be discussed in great detail, making it clear that it is a personal and professional responsibility to come to each session with the work completed from the previous session. In all fairness, many of the teachers have been burned by broken promises or an adversarial relationship between the administration and the union. Some have become very negative over the years about having more diverse and larger classes, the lack of leadership and support, tough finances, or lack of access to technology. In our initiatives, we have experienced all their issues. If the administration and union have an adversarial relationship, there are usually authority and accountability issues. Teachers sometimes transfer those feelings and attitudes to us because we have expectations and goals to accomplish, and we do hold them accountable for producing the deliverables before they receive their rewards. Thus, we are in an evaluative role about products, processes, and accomplishments and might even be assigning graduate credits, grades, and continuing professional development units (CPDUs).

The third lesson is the importance of having an established reward structure and clear responsibilities for participating teachers. It also helps to listen to the teachers, to learn more about their contexts and problems. We can be quite effective in helping to resolve conflicts or make teachers feel more empowered by our support. As outsiders, we can address problems and issues openly with both administrators and teachers, from the standpoint of accomplishing our goals with them. Listening honors them as individuals and also helps us gain insight about how they might learn best and what additional topics will benefit the program. This begins to build a climate of trust and respect; when we are responsive rather than critical or dismissive, we all gain. We plan time for discussion, negotiation, and problem solving. As trust and respect grow, teachers begin to focus on more important questions related to *how* to improve and begin to engage in what Senge (1990) identifies as the generative process.

Feelings and attitudes

Challenge: In complex schools and districts, the feelings, attitudes, and issues could be complex as well. There are no more complex districts in Illinois, perhaps the nation, than the public schools of Chicago and Rockford. In large and complex districts such as these, teachers may express strong feelings, either positive or negative, about their schools, administrators, and students. The strength of their emotions may be unknown to the college and university faculty who are on the project team. We have dealt with teachers who felt entitled to the rewards just for sitting with us each day, as well as with teachers who claimed that the district and contexts would never improve. We have encountered teachers who felt inadequate, unprepared, and too overwhelmed to manage their teaching and learning situations, climates, and environments.

Lessons learned: Members of the broader project group who have not been in the schools need preparation for the range of attitudes and emotions they will experience while working with the teachers. They also need to understand *why* the teachers have such strong feelings and to be prepared for this aspect of teacher development. It serves them well when advised about how to help teachers process their feelings.

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PART II. Program

9. Articulation: An Extended Model and Educational Pathways to Careers

Jule Dee Scarborough

Articulation refers to a partnership that smoothes the transition from high school to higher education, reduces redundancy in the curriculum or student learning, and, most importantly, helps students understand that high school is not necessarily an educational terminal point. Articulation is the connecting, aligning, or bringing together of parts and interrelating them to form a working, functioning unit, program, or process. It should result in better program alignment and continuity, a reduction in costs and time, better quality, the opportunity for higher-level learning, and sharing of facilities, equipment, and staff across educational institutions. The most important result, however, is the creation of a system for cooperation in the planning, evaluation, and improvement of educational programs and the seamless transition for students across programs.

As simple as the construct sounds, it is not easily accomplished, especially in a context of budget cutbacks, a shortage of educational staff and faculty, and a struggling economy. However, that is exactly the point where articulation can have the greatest results. Articulation must have clear leadership from the top of participating organizations, with defined goals and responsibilities into staff and faculty lines. Each organization must appoint someone who is to be responsible for working through the initial reviews and agreements and maintaining the process and agreements. The most important goal is "common focus," a difficult one to achieve, although statewide initiatives have somewhat reduced the academic turf wars.

Those leading articulation efforts need to understand the principles of efficiency, access, and quality:

- *Efficiency* means that planning should result in cost effectiveness through appropriate enrollments, program management, and the sharing of resources.
- *Access* refers to helping students understand the relationship between education and employment, the spectrum of exit points into jobs or careers. Well-designed articulation programs should result in an expansion of opportunity and employment. The first level of access is when students become knowledgeable and understand their options. Have you ever gone into a high school and asked students what their plans are? Too many of them will respond that they do not know. Nor do they seem to have any vision or understanding of what options are available. Many will give you a general, "Oh, I might go to college or get a job." Truly, they get excited when they begin to see how the puzzle fits together, how courses lead them to jobs and careers and an expanded vision of their opportunities. However, this is difficult to accomplish unless teachers first understand it. That understanding is lacking in many schools. In fact, many times when we have tried to put programs into place for students, teachers openly let us know that they first needed to be educated so that they could become a conduit of information for students.

- *Quality* involves aligning curricula with jobs and careers in actual communities of practice. This is best done through business, industry, and community (BIC) partnerships. By inviting others into the classroom or by having them provide off-campus learning experiences, learning takes on more significant meaning.

There are two modes of articulation, horizontal and vertical:

- *Horizontal* articulation is a process or mechanism for aligning programs across similar levels, such as middle or high school programs, or all courses across particular levels, such as first-year, second-year, and so on. This should occur as a normal process in most institutions.
- *Vertical* articulation is the focus here, where a process is created for coordinating and interrelating programs across different levels, for example, secondary, 11 and 12, to community college, 13 and 14, and then community college, 13 and 14, into university, 15 and 16. It involves the identification of responsibilities and resources to support quality programs, student access, and program efficiency.

When considering vertical articulation more deeply, time-shortened programs allow for advanced placement of students into higher-level programs to reduce duplication and save time and money. An option is to provide dual credit for high school (secondary) courses that meet community college or advanced-skills programs. Time-shortened is the more commonly used, but the advanced program is also receiving great attention. As more students have to go into debt to pay for their education and there are many more technology jobs and careers available for community college technical-program graduates, there is a greater need for the time-shortened. However, more and more institutions are coordinating 2+2+2 agreements that enable students to get a bachelor's degree by first completing a community college two-year degree, either associate's or applied associate's. These often involve direct articulation, program to program, course to course, and additional credit through testing at the higher level to reduce course duplication. Students cap their technical degree with the final two-years at the university for a bachelor's degree.

It is important to coordinate the institutions in this process. Articulation agreements are as varied as the partnering institutions. Many statewide articulation programs have had positive effects for achieving the historical and fundamental objectives of articulation.

Our Focus

We were not always successful in achieving fully developed articulation agreements by the end of an externally funded project because they take time to develop, pilot, and finalize. We were, however, successful in developing an understanding of the process. And if we could not always effect comprehensive program agreements for the sharing of resources, we at least influenced the efforts of individual teachers and professors or clusters of teachers and professors. We made a significant difference in enhancing teachers' understanding of their students' possibilities, revealing clearer pictures of where their courses lead, and helping them find a vision for their role in developing student visions of their future. We also helped to build the capabilities to achieve informal articulation so that teachers and students understood more about the results of their efforts and where success in particular courses could lead. We applied the SWOT (strengths, weaknesses, opportunities to improve, and threats) approach, with worksheets to organize the discussions. All participants received state teaching and learning standards, state performance indicators, the state Bloom's analysis, and the district curriculum analysis and testing structure as information upon which to base their discussions. Disciplinary groups of secondary teachers and community college and university faculty worked together to gain a deeper understanding of course content, teaching strategies, uses of technology, and student assessment and grading procedures and criteria.

Gap Analyses

We engaged the teachers and professors in performing gap analyses across the areas of (a) course content (standards), (b) technology for teaching and learning, (c) teaching models and pedagogy, and (d) student assessment and grading. When they extended articulation beyond the traditional course or discipline content by and across levels, they began to understand that learning considerations extended well beyond the "what" to the "how," and that particular strategies, processes, and procedures could enhance or hinder teaching and learning across levels. They also learned that they could benefit from one another's perspectives and strategies.

We performed these analyses in three ways:

1. High school to university and high school to community college, having the teachers work individually with each of the professors.
2. Secondary with community college and university professors all together in one session.

   Both 1 and 2 have worked well, but there was some repetition when doing two separate sessions with community college and university professors separately. When meeting separately, teachers may have gained deeper insight. However, it also worked well to have them all together to discuss perceived differences collectively and to have the joint discussion involving all three institutions.
3. Middle school to high school, then high school to higher education.
   It was more difficult for some of the higher-education faculty to work directly with the middle-school level because faculty struggled to relate to the middle school level directly, especially the mathematics professors. On the other hand, some professors had no difficulty at all. The professors were great leaders for these sessions, whether beginning at the middle school level or high school level. Worksheets were used to guide the discussion. (See worksheets and instructions that follow. They are simple and to the point. Discussions went well beyond these questions, and we were surprised at how much could be accomplished in a relatively short amount of time.) The extended discussions included performing gaps analyses of how technology was used for teaching and learning, what teaching models and pedagogies are most effective, and what types of student assessment procedures and grading criteria were used, including connecting assessments to knowledge.

Course Content

Those looking at course-to-course articulation across levels understand that they need to consider course content. What content means may be the question. To high schools, content is based upon student learning standards; for higher education, there are usually broader program/accreditation standards. Therefore, when examining course content, the different types of standards or bases for content must be carefully considered. However, if the examination focuses on concepts, principles, and possibly metacognitive or critical learning skills and other academic skills, such as problem solving, reading, and writing, it is more easily accomplished.

The gaps can be established in a reasonable, and usually relatively short, time period. As mentioned before, secondary teachers are often unclear about the fundamental knowledge concepts, constructs, principles, facts, and processes they are to teach. They may confuse knowledge and "other" more contextual information. They often assess students on "other" contextual information rather than the primary concepts and principles. These sessions between educational levels, on a course-by-course basis, help both groups better understand what should be taught.

Teachers who have experienced our process often comment that they now understand that their courses are not terminal but are part of a continuum, flowing into others at the next level, and that their students need to understand that as well. Professors become aware of the context of learning at the secondary level and gain insight about other hurdles or barriers to learning that secondary teachers face. They gain great insight about the students who are to become their students and a deeper insight into why they are having particular difficulties in getting students to achieve at higher levels.

Technology

In our attempts to deepen this exchange, we realized that students faced other learning difficulties when transitioning across courses. Not only did they struggle with knowledge and skill gaps, but they had to contend with the different uses of technology, the types of teaching models, the types of learning assessments, and how grades were determined. Therefore, we began to include consideration of these as part of the gaps analyses, to make the point that students might not perform to their potential for a variety of reasons, only one of which was a knowledge or skill gap.

For example, a special mathematics task force brought to the discussion the possibility that students were struggling with the transition from high school or community college courses to our university courses because of the philosophy about technology. At the university, students were not allowed to use calculators during the mathematics exams to ensure that they achieved concept attainment. However, the local community college rewrote all of their mathematics exams to ensure concept attainment when permitting the use of technology. Students claimed that the university's no-calculators policy was preventing them from performing at their best level. Possibly, the students had never achieved concept understanding and therefore could not perform without the technology, but it is also possible that they did achieve concept mastery and were simply confused when the technology was taken away.

We did not perform a study to determine what really happened. What was important was that educators realized that changes in the uses of technology might also require changes in other areas, such as curriculum, teaching models, assessment of knowledge/skills, and grading criteria. Therefore, it was important to have educators across levels discuss how technology was to be used for teaching and learning and agree on operational strategies so that students could transition across levels successfully. This usually meant that an assessment must be revised to ensure the measurement of knowledge when using technology.

Regardless of the reason, we found that the discussion across levels helped to deepen the understanding of how technology could affect teaching and learning and also identify any gap in uses and expectations across levels. Therefore, we treated this area of consideration the same as one for content analysis. The teacher/professor group discussed the uses of technology and left with ideas to incorporate into their own courses and an understanding of student learning and performing issues.

Teaching Models and Styles

Secondary schools may actually be in advance of community colleges and universities in striving to enhance teaching and learning through the use of varied teaching models, especially more active ones that go beyond traditional lectures. This means that students who move on from the secondary schools confront yet another challenge as they enter the world of the formal lecture. (Universities often try to mitigate the challenge, at least in courses that have large enrollments, by providing optional review sessions where students can meet, usually with graduate teaching assistants, to review or question what they do not understand.) The most effective teachers, regardless of institution or level, intuitively use the more active learning models without realizing it, and those less effective or motivated rely on lectures.

In our initiatives, the discussions seemed to help those who were less creative, knowledgeable, or more intimidated realize that they, too, could accomplish more active learning and authentic and performance-based learning in their courses. Because this program component usually came early in the sequence, before the teachers had taken the teaching models and styles workshops, and also because most professors had not researched teaching models, we provided Joyce and Weil's (2000) 22 models as a baseline for the discussions.

Student Assessment

Student transition across various types of assessment procedures can also affect performance or an educator's understanding of concept attainment. Throughout this report, we allude to the disparity between what is taught and what seems to be measured through assessment procedures. “Test or test items are meant to be useful indicators of valued real world performances” (Linn & Baker, 1996, as cited in National Society for the Study of Education, 1996, p. 85). We are trying to move the secondary teachers to more authentic and performance-based measurement and improved traditional tests, but it is important to note that higher education has the same concerns.

Many higher-education faculty do realize that their assessment measures are weak, not well designed or not well connected to what is actually being taught. The “good” educators teach substantial knowledge and then measure at least at recall (Bloom’s knowledge level); however, there are probably an equal number, proportionally across institutional types and levels, who do this poorly or not at all. When we included this area for discussion and they shared their measurements, procedures, and processes, we identified the gaps and discussed the content of the measurements, striving to link test items and performances with the knowledge and skills being taught.

Performance-based teaching, learning, and assessment are familiar to many educators, especially those in technology or vocational education, but they are new to many in general education. For example, those in mathematics consider a complex word problem as problem-based and performance-based; those in more technical fields would consider something performance-based when it requires the manipulation of conditions, materials, principles, facts, or theories under particular constraints to accomplish a design, build a model, or solve a more authentic problem. In these discussions, it is important to define what is meant by "authentic," "problem-based," "performance-based," and the like. Typically, it should mean that students are given a set of conditions that may or may not be manipulated (particular constraints, materials, information) and are expected to perform problem solving at the higher levels of Bloom's Taxonomy of learning, meaning at least application, synthesis, analysis, and evaluation, preferably at the final evaluation level within a more authentic context. The revised Bloom's Taxonomy is becoming more appropriate for today's learning, as it includes "create" as the higher learning level (Anderson & Krathwohl, 2001). Ultimately, the analysis of content to be measured, and the procedures and processes for doing that, should identify all gaps, strengths, weaknesses, and possibilities for improvements, focusing on both traditional and more authentic, or performance-based, measurement designs and procedures and linking them to the knowledge and skills to be learned.

Grading

Grading is a difficult area to assess. However, the discussion helps improve and reassess the connection between what is being taught and then measured, how well knowledge and skills are being measured, and finally to what level students are learning if using Bloom's or Bloom's Revised Taxonomy as a metric for levels of learning or critical thinking. Are grades subjective or objective? Are they based on concept attainment of "real" knowledge? Are they based upon memorization or can students use knowledge to solve problems? Can they analyze, make rationalized judgments, reason through procedures and processes, and base decisions upon logical and rational evaluation where solid judgments are made? And, very importantly, do students understand how they are to be graded? Is there a clear rubric? Is there a connection between course knowledge and skills and measurement? Are criteria established and clear to inform students how teachers arrive at their grades?

Each professor is different; each teacher is different. And, for many, if not most, there has been very little, if any, education or training about how to design and develop good measurements, with a clear understanding of the criteria upon which grades will be based. Many still do not understand outcomes, standards, or competencies conceptually. Many do not know how to analyze their knowledge content to determine what and how to assess.

We discussed how grading occurred, what it was based upon, as well as the gaps or differences between individuals and across levels. We raised questions about the appropriateness of grading parameters for different age groups or developmental stages, and most importantly asked if grades reflected or provided evidence of real learning of substantial knowledge. Individuals should leave with an expanded horizon about grading structures and learn to question the integrity of their own structures and criteria. However, if the participants all use the same strategies, or have similar strengths or weaknesses, it might be good to have someone else lead the discussions.

In summary, the discussion on course-to-course articulation should extend *well beyond* course-content knowledge or skills, delving into how learning occurs; how teaching is accomplished; what models, strategies, processes, and procedures are used; how student assessment is accomplished; and then ultimately, how students are graded. It should result in gap analyses in these areas, leading into self-analyses through comparisons across individuals and discipline levels. We used worksheets with initial leaders.

Usually, everyone participated as equals. Somewhat to our surprise, we never encountered the perception by teachers that higher education faculty would be dictating to them. Secondary school teachers were more than willing to hear the higher-education faculty describe what was needed or required, and the faculty responded with encouragement about what helped students to succeed more readily. The care and concern for teachers exhibited by our professors was something special to observe. Teachers left commenting that they understood that their course or high school level was not terminal and that they had a great informal support group only a phone call away. Possibly the greatest result of these sessions was that most participants left wanting (a) to strengthen the integrity and quality of their own courses and (b) remain connected across groups.

Agenda

The following agenda was compiled based on experience at several venues and incorporated participants from both the community college and the university.

- The day begins by setting the context within which the secondary teachers work. Participants review the district curriculum, establish that it is standards based, and review what is supposed to be accomplished by level.
- Next come presentations about admission and placement requirements for community college and university mathematics, science, and English; how placement tests work; the requirements for being placed into particular general education courses; and how articulation occurs between the community college and university.
- A communities-of-practice roundtable validates educational requirements. Representatives from industrial or community sectors make presentations about what is expected of employees at various levels of employment. They review academic requirements as well as other types of industry-specific requirements.
- There is an extended opportunity for questions and then reflection in small groups.
- The second half of the day is spent in the gaps analyses described above, culminating in the completion of the summary worksheets and evaluations.

Examples and Comments from Professors

Each year's agenda was somewhat different. During the first year, the chemistry and biochemistry duo engaged teachers in the SWOT analysis. As strengths for student learning, they identified that students wanted to learn, wanted learning to be relevant to life, and that to be successful, students had to attend and have extracurricular activities available. For teachers, the strengths identified were that teachers should want to teach, be eager to please, be enthusiastic about the subject, be available to students, and provide relevant applications. For commonly encountered weaknesses, they listed that students lacked study skills, showed low attendance, and lacked motivation and background knowledge. Educator teaching weaknesses included biases against students, lack of subject knowledge, poor attitudes, and lack of organization. Opportunities to improve student learning were greatly influenced by lack of resources, negative peer pressure, crowded classrooms, and fear of violence; teaching was affected by lack of materials, fear of losing one's job, fear of violence, threats from students, and lack of administrative support. Rockford was a district in perpetual turmoil and politically charged, which showed in the less positive responses. After performing this analysis, professors and teachers felt prepared to engage in a later discussion about articulation.

These discussions helped professors determine what they could develop to offer in teacher classrooms, as well as what to design special workshops around. The chemistry and biochemistry professors designed a two-day "green" chemistry workshop for teachers. They determined that the district's chemistry curriculum and Northern Illinois University's (NIU) general education introductory courses dovetailed nicely, but that there was a difference in the level of coverage and a need to reinforce concepts. However, the courses were similar and there were no serious redundancies.

The university English professors created an articulation website to provide teachers with a resource to which to refer students. They incorporated the community college information, which made it an easy-to-use joint site for articulation and other purposes. The teachers liked this approach. The English group identified gaps in expectations for how well students could perform and what they expected to be able to teach them. Teachers gained insight about language arts longitudinally and vented about problems and frustrations related to their students, facilities, and curriculum. They mentioned that when participating jointly with both community college and university professors leading, there was a better examination of differences between community college and university composition classes. They shared texts, syllabi, and assignments. The gaps analysis provided insight for the professors, leading some to continue to participate in annual articulation activities between secondary and higher education.

Teacher Reflections, Evaluations, and Comments

Comments centered upon improving weaknesses, describing strengths, listing new ideas for approaching teaching and learning, finding resources, discussing partnership activities, offering ideas for counselors and teachers to work on together with students, suggesting new uses for using and sharing technology, suggesting new connections with higher education, requesting assistance with responses from professors, BIC partners in communities of practice, and more. Teachers and professors identified new teaching models they could try, standards that they covered well, and others that they needed to better address, as well as new learning activities, projects, and problems they could incorporate, and ideas for better assessments. The engineering technology professors from the community college and the university worked with the vocational or technology education teachers. They identified a need to understand how students learn best, how to assist them with particular knowledge and skills, and how to reduce their anxiety and improve learning. There was an interest in more authentic and performance-based learning and assessment and how to design rubrics with better criteria and levels. The teachers began to make comments about new visions for themselves in their teaching.

This session was a great segue into the overall general program. Almost everything that the teachers said they wanted more of was included in the program sequence to come later. The session also served to help teachers orient themselves about the learning to come. Each group's summations on articulation documented what they had learned about each level, identifying gaps across curriculum or knowledge and skills, redundancy, assessment, student performance expectations, use of technology for teaching, learning, assessment, teaching models, grading structures, and other topics. Many teachers mentioned that they would like more time to work with individual courses and professors across higher-education institutions, for professional collaboration and also partnership activities in their classrooms with secondary students. They expressed an interest in articulation agreements. Most said they wanted to close gaps identified in the analyses. In Chicago, we were able to achieve fully articulated agreements between high schools and the city community colleges. However, the turmoil in the Rockford district prevented us from establishing fully developed articulation agreements for either specific courses or programs.

Finally, teacher evaluations of these sessions, over the years of the grant-funded project, remained extremely positive. The very few less positive responses were on state evaluation questions that did not directly relate to the program component but were required for the state recertification program.

Table 9.1 Summation on Articulation Worksheet

Name:______________________________ Subject Area: ____________________

Summation on Articulation

A.	Identify where there are serious gaps between the curriculums that are covered at each level.
B.	Identify where there is redundancy in curriculum across levels.
C.	Determine where there are serious gaps between what is taught and what is assessed.
D.	Determine where there are serious gaps in student performance expectations.
E.	Determine where there is overlap in student performance expectations.
F.	Determine where there are serious differences in the types of technology used by teachers/ professors as well as serious differences in what technology students are required or permitted to use.
G.	Determine where there is consistency in use of teaching models.
H.	Determine where there are differences in the use of teaching models.
I.	Determine where there are serious differences in the grading structure across grade levels.
J.	Sum up weaknesses.
K.	Sum up strengths.
	Wrap up question: Where would you like to go from here on articulation?

Table 9.2 Curricular Standards or Knowledge-Base Worksheet

Curricular Standards or Knowledge Base								
Middle School			High School			College or University		
Standards & Curriculum		Resources	Standards & Curriculum		Resources	Standards & Curriculum		Resources
Discussion: Identify gaps, overlaps and/or appropriately articulated steps between **high school and college/university.**								
Discuss the similar standards that are taught in **middle school**: degree of difference, if any.								
Discuss the **topics** through which the standards are taught.								
Discuss the differences and similarities in use of resources - exchange ideas.								
Content Area__________________								

Table 9.3 Technology Worksheet

Technology		
Course: _________________________________ Course: _______________________________________		
Middle School	High School	College or University
Technology Use (T, S)	Technology Use (T, S)	Technology Use (T, S)
Discussion: Compare gaps and/or appropriately articulated uses of technology **for teaching by staff.**		
Compare gaps and/or appropriately articulated uses of technology for learning **by students.**		
What can be done to close these gaps?		
Discuss how this compares to the use of technology in the **middle school** in the same areas.		

Table 9.4 Teaching Models Worksheet

Teaching Models					
Middle School		High School		College or University	
Model	Bloom	Model	Bloom	Model	Bloom

Discussion: Is any one model used more than any other model, or less than any other?

Are students being exposed to a variety of appropriate models at all levels?

(See Models list and descriptions) (Joyce & Weil, 2000)

Table 9.5 Assessments Worksheet

Assessments								
Middle School			High School			College or University		
Assessments (T, P, PP)	Level	Bloom	Assessments (T, P, PP)	Level	Bloom	Assessments (T, P, PP)	Level	Bloom

Discussion: Compare the gaps between what is taught and what is assessed.

Compare the differences or similarities in level of expectation (difficulty level).

Compare the levels of Bloom required in the assessment between MS, HS, and College or University.

Literature Sample Related to Articulation

Literature on this topic is easily accessible through ERIC or OCLC FirstSearch. The articles are diverse and address various topics mentioned above. For example: Just and Adams (1997), Pucel and Sundre (1999), and Doty (1994) discuss tech prep programs, especially the 2+2 articulated program aspect where secondary schools articulate either courses or programs with corresponding community college partners. They discuss articulation agreements and processes, issues, barriers, strategies, articulation designs, and examples and results. Doty presents 14 principles for tech prep at the high school level.

Although tech prep programs have been in the press since the 1980s, there are few studies that examine their success or determine outcomes. Just and Adams study 13 tech prep consortia in Ohio. They discuss the articulation agreements between high schools and community colleges, but also include the extension to 2+2+2 to include the final two years in a bachelor's capstone. They provide examples and discussion. Pucel and Sundre, however, study the extent to which eight consortia in Minnesota articulated tech prep programs that were actually being implemented and monitored to ensure that student benefits were realized. The findings of their qualitative study indicate that the programs were not achieving some of the most basic goals set by the U.S. Department of Education (USDE) for a seamless, non-duplicative curriculum. They argue that the findings should alert policymakers to the need to revise the tech prep program or put a compliance system in place to ensure that funds were expended appropriately and programs were accountable to prescribed goals.

Hayes (1995), Hershey, Siverberg, and Ownes (1995), and Grubb and Bragg (1997) all present less than encouraging information about whether tech prep was accomplishing its goals. Bailey et al. (2002) and Greenberg (1992) discuss the role of dual enrollment for easing transition between high school and postsecondary education. Crist et al. (2002) describe Minnesota’s efforts to improve student success after high school by trying to understand the challenges faced by its students, educators, and institutions. Their efforts resulted in several innovative initiatives, including tech prep and school-to-work programs, developmental programs, postsecondary enrollment options, and the alignment of graduation standards for college preparation, early assessment, and charter schools. The authors recommend that to prepare students for success in higher education, there should be an information campaign, support for implementing best practices, and documentation of student success. In addition, a report on Canada’s Northwest Territories provides similar information about a framework to help high school students and adults make successful transitions into and through postsecondary institutions. Stanley (1994) also describes a school-to-college-to-career transition model. Clark and Woloszyk (2002) support community college involvement in the preparation of technical educators by allowing students to transfer their technical degree from the community college as their teaching major at the university. This is usually viewed as inappropriate by universities, but that viewpoint may begin to change as community colleges take on an expanded role in higher education.

Floyd et al. (2002) discuss community colleges involved in teacher education. They note that more than 80% of community colleges supported articulation models and had university articulation agreements that enabled teacher-education students to earn the first two years of their degree at the community college and then transfer to a university. More importantly, they identify questions concerning the role of community colleges in teacher preparation. How far should community colleges go in addressing the goals of teacher education?

Hendley (1997) establishes that universities, especially their engineering programs, overlooked thousands of potential engineering students at community colleges while complaining that they could not find enough qualified students for their programs. With almost 50% of all college freshmen, especially women and minorities, starting at community colleges, that seems neglectful and shortsighted. Hendley considers the state of community college engineering education, transfer barriers, and efforts to improve transfer rates. Chatman (2001) reports how important the community college will be for serving an expanded population. In California's three-tiered higher education system, the community college to four year transfer programs were going to be stretched while striving to address the anticipated growth and increased demand since they were committed to open access and selective admissions and to accomplish racially and ethnically diverse access. The population growth could increase community college enrollment by 36%, with an associated increase in transfers. California had transfer articulation agreements or contracts between universities and community colleges for a prescribed curriculum and required performance. Students enrolling in these contractual agreements were slightly more likely to graduate from the university than other transfers.

The Seattle Community College and University of Washington (Campbell et al., 2002) have a Coordinated Studies program developed to ease anxiety for students about transferring to a four-year university. These are theme-based interdisciplinary programs or learning communities. Themes focus on inquiry, identifying issues, solving problems, and generating solutions. Burstein (1996) discusses transfer and articulation agreements and programs at the higher education level. For example, he discusses the Illinois Board of Higher Education's statewide articulation initiative to develop a model general education curriculum that would ease the transfer of students across institutions. Also, the Arizona Board of Regents (1996), in its *Report of the Transfer Articulation Task Force*, describes a model transfer system for the state community colleges and universities. It discusses a new management system, advising system, and computer-based information system.

Rifkin (1996) also discusses transfer and articulation policies, beginning with an historical perspective, the rather new involvement of state agencies and its impact, a need to collect better data on students as they passed through two-year institutions, and equal access for underrepresented groups. He makes a critical point of discussing the differences between high- and low-transfer colleges and whether the community college emphasized transfer to a bachelor's program as an academic objective with services to support that transfer. He considers the impact of tech prep, where high schools articulated with community college (and then university) programs and cites authors who wrote in depth on the subject.

Finally, although about global education between high schools and colleges, Stevenson (2001) provides a prototype model, including steps for articulating between high schools and colleges. Helpful guidelines for articulation can also be found easily in tech prep information from USDE or CORD.

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10. Developing Interdisciplinary Teaching, Student, and Cooperative-Learning Teams

Jule Dee Scarborough

The most important aspect of creating and developing teams is to share leadership (Pearce & Conger, 2003). Individuals work best in teams if they are prepared to better understand what teamwork means and what team issues may arise, and if they are provided some process tools. Teams should be made up of very diverse individuals; otherwise there is no need for a team. Each member should bring something different to the group (knowledge, skills, capabilities, or expertise), and the team should understand that not everyone should be doing the same things. However, in teaching teams and curriculum development, sometimes all team members are developing like curriculum across different disciplines, so they all do a similar activity that is different in knowledge base or discipline. In these cases, teams are usually put together to bring about some type of change or improvement in content or processes.

At a minimum, teaching team members need a simultaneous preparation period so that they can plan, develop, or change curriculum; assign tasks; assess progress; give feedback; and evaluate their ongoing activities together, but especially so they can intellectualize and generate together. Very importantly, they need time together to assess student work and learning and to connect regarding students across shared classes. They also need a common place where they can leave work in progress and not have to constantly be setting up and taking down a team space.

If teams are delivering interdisciplinary curricula, whether for an entire year or modular ones for shorter time durations, they need to have access to students through block scheduling, back-to-back classes, or team teaching through exchanges across classrooms. Finally, teachers need active and open support from their administration. The principal, beyond approving simultaneous preparation periods, space, and block scheduling, needs to observe, give feedback, and show interest in what the teams are doing.

A school that wants to move toward a team culture, whether partial or full team operations, should understand that things will change, that classrooms and other school spaces will be used differently, that the teams will teach differently, and that students will begin to learn differently. The administrators must be open to exploring new venues for teaching and learning: in other words, a change-oriented culture where exploration, experimentation with a purpose, and continuous improvement becomes the norm. Interdisciplinary teams can thrive in this type of culture. However, in most situations where we have introduced teams, they have struggled to survive. We know that if teams are provided professional development for teaming purposes and if the support is in place, they greatly improve teaching and learning. We also know that when the support is not there, the individuals may be connected but do not really function as teams because it is not possible.

The program described below functioned well to inform and prepare teams. It provides a program to use in the development of student teams or cooperative learning teams. Each topic includes particular related activities and product or process outcomes, which are, in turn, used by the teams as they operate.

Team Development Program

Many resources are reflected in the basic program described below. Phillips and Elledge (n.d.), *The Team Building Resource Book* and *The Encyclopedia of Team Building Structure*, are invaluable foundations, while Thompson (2004) ties theory to practice. Also Michaelson et al. (2002), Vermette (1998), and Brody and Davidson (1998) are great resources on team-based and cooperative learning.

Change

Our focus is on helping teachers understand purposeful change: that it can occur in small steps and that many small changes can become a significant change. The connection between change and learning is critical. Using Senge's (1990) *Fifth Discipline*, we discuss learning organizations from the perspective of the learning person. Learning people are central to the critical core of learning organizations, e.g. schools. Therefore, teachers, administrators, and professional staff must be learning professionals if purposeful change is to be accomplished. When leading teachers to identify improvements requiring change, we help them analyze their strengths and areas needing improvement by comparing what they know and do to the state teaching and learning standards. This helps teachers become "grounded" for what they are about to engage in with each other and their students. Senge et al.'s (2000) *Schools That Learn* is an important resource as well.

Individual and hidden agendas

Individual team members have their own agendas for participating. When we better understand their reasons for joining, we have a clearer grasp of their commitment levels, which helps gauge what can be accomplished by the team. We have worked with team members who were there for a variety of reasons: their principal required them to be part of the team; they had a desire to improve their teaching and student learning; they wanted the technology provided each teacher or the stipends for the non-school days; they respected others who were there and wanted to work with them; or they had been recruited by other teachers – to mention a few. The PI and project team seldom have a voice in teacher selection and must work with those who appear in our groups. Most of the teams and members are highly motivated, but there are those in every school who show up for the extrinsic rewards and really do not relate to the real purpose for the endeavor. Some of those we "convert," and they become highly motivated. Some we are not able to reach.

It is important to explore the agendas of participants because, in the process, many become more highly motivated, explore their inner selves, and become stronger in their commitment. Openness about each other's potential commitment levels and understanding about why some members may be less able to commit to higher levels reduces the number of assumptions and harsh judgments that can cause negative feelings. Teachers make their individual commitments and identify their individual agendas, and then the team sets its agenda with a realistic level of commitment. This prepares them well for defining their vision, mission, and goals.

Team Vision, Mission, Goals, Purpose, Values

Participants come to us with a very general idea of what they are going to learn about and try in their classrooms, but no deeper understanding of what it might entail. This is where we get down to the specifics and build that "picture" together. This program component motivates the teachers through making clear to them what they want to do, how they are going to accomplish it, and what their operating values are. Typically, teachers become so excited, they ask for more depth and components. After discussing the nature of visions, missions, and goals, teachers develop an individual vision, a collective team vision, and one for their students. Sometimes we talk about the superleadership theory (Manz & Sims, 1989), explaining that their ultimate purpose is to develop self-leadership in one another and their students. An examination of values must come into play. Pragmatic values can relate to being on time, following through with commitments and assignments, communicating in a timely manner, and supporting each other. Other values get at the deeper meaning: ethical grading, how students are to be treated, gossiping about team members, and building self-esteem. Other types of values can go as deep as moral perspectives and religious convictions. Teachers need to understand that the team has to agree on values to which all members can commit and be held accountable. Once the teachers have defined the team's vision and their values, they must make it operational by defining their mission (Cleland, 2003). They then break the mission down into the work that has to be accomplished. This work is defined through their goal and objective statements, which are measurable to particular standards and timelines.

Team Building vs. Team Development

There is an important distinction between these two constructs. Team development happens only over time, as members work together to solve problems, generate ideas or solutions, or develop products and processes. Overcoming hurdles and barriers together is part of the development process that promotes cohesion and finally success to establish a lasting camaraderie. Team building is something different. Teams may encounter a problem, conflict, barrier, or have a need to learn something. This is where they take a conceptual time out and build the team, address deficiencies, or learn something needed to accomplish its mission. Team building occurs with a focus for short periods of time, while team development occurs as members work together over a longer time.

Our teams learned about the phases of development as they became cohesive, focused, productive groups:

Teamwork. The leader and teams discussed what it meant to work together, how to share ideas, how to build self-esteem and confidence, how to lead and to follow, and how to measure decisions against the metric of what will best achieve the team's goals.

Trust and Empowerment. Trust was discussed broadly, ranging from trusting one another to being respectful to building self-esteem rather than engaging in destructive criticism. Participants were reminded that the beginning point is self-knowledge and an awareness of one's own assumptions and interpretations. Empowerment was defined as freedom to both lead and follow, to learn and thus to change. The team became greater than the sum of its members in capability and achieved far more by realizing the talents of each member.

Team Health: Effective Members and Conflict Assessment. We directly engaged the teams in describing what they felt were effective team member traits, actions, and behaviors. Then they adapted or developed a peer assessment inventory, a team assessment inventory, and a conflict assessment inventory as tools to measure perception and satisfaction and to engage in conflict resolution when needed. They also designed a process for using the tools, giving feedback, and engaging in necessary changes. The teachers highly valued this activity.

New and Troubled Teams. The dysfunction experienced by troubled teams was almost identical to that experienced by new teams. We discussed the characteristics and how to prevent dysfunction.

Effective Teams. As teams developed their own description of effectiveness, they began to realize that they needed guiding principles, simple policies and procedures, and process tools. These were all identified, and then the teams adapted or developed each strategy, tool, or process.

Roles and Responsibilities. Teams considered two or three types of roles and responsibilities. They had work roles, team process roles, and administrative roles. In work roles, everyone contributed to accomplishing the team's goals. Other important roles that for team members are:

- Gatekeeper – kept the team on task
- Harmonizer – ensured that conflict did not become destructive
- Closure artist – wrapped up meetings and events, reviewing what was assigned and who was responsible, and set the next meeting or event's agenda
- Manager or coordinator
- Leader (might be same as manager or coordinator)
- Finance manager, if necessary
- Recorder
- Communication coordinator
- Others determined by the team as needed

Teams often develop "work packages" as in industry. A work package is a description with all standards, expectations, budgets (if applicable), and timelines for the work to be accomplished. Work packages are an easy method for organizing work and establishing responsibilities, schedules, and levels of quality. Teams developed a simple form to be completed for each package. Each package had a manager, who might do a package in its entirety or possibly with other members. The manager was responsible for updating the team and the leader about progress, difficulties, or issues. The finished package was presented for approval to the team or team manager. Often, however, team members work individually, contributing to a single work package, e.g., a curriculum module.

Process Models

The following process models were identified and defined; the teams also described the process to be used with the models. Some of these models were intertwined. For example, if it was hard to decide if a conflict was a problem or if a problem was causing a conflict, we tried not to get too tied up in analysis, but instead we advised teams they were going to have to identify a process for making decisions and moving on with their work. The other models were used individually and were not necessarily connected to others in time and use.

Problem-Solving Model. Most of us could list the five- to seven-step problem-solving models that we have been taught but rarely ever use or unconsciously use intuitively. We introduced these steps to the teams and helped them understand they might occasionally need methods for formally solving problems. We used videotapes along with discussion or simply presented the steps and described them. Team members then described a process they could use to achieve the ultimate goal, a solution that was the best to achieve their goals and purpose. That was the key metric. They determined how to put everyone's ideas for solutions on the table and how to begin discussing what might be a more significant problem. They used simple processes such as putting everyone's ideas anonymously on index cards on the wall or a board, reviewing each one for strengths and areas needing improvement, sometimes anonymously. At other times, they just brought the problem to the group more informally and openly discussed it. The more significant and dynamic the problem, the more anonymous they made the process.

Other models used in tandem, such as the problem-solving process: identify what the problem is and what it is not. It moves the group more quickly to problem identification and the root cause. The steps usually put into the process are:

Problem Identification.

What is the problem?

What is the problem not?

Problem Definition.

Describe the problem.

Problem Causes.

What are the problems' symptoms?

What are the root causes?

Alternative Solutions.

List 10 possible solutions.

Rank the solutions.

Identify the top 3-5 for further analysis.

Analysis of the top 3-5 alternative solutions.

Identify the strengths of each.

Identify the weaknesses of each.

Rank the top 3-5 again after strengths and weaknesses analyses.

Implement top ranked solution.

Monitor implementation.

Evaluate if the solution works.

If yes, continue.

If no, loop back to alternative ranked second and begin process again.

Conflict Resolution. There are many accessible and useful sources of information on conflict resolution. We reviewed them, and the teams adapted some to create their preferred model for resolving conflicts. The most important point was that *conflict is positive*, and that without it, the best solutions or decisions would probably not be identified or presented. The best resolution, solution, or decision could only come about if all participated in building it and engaged in its evolution using a primary metric – that which best achieved their goals and purposes.

Decision Making. We discussed various approaches and offered them as options: (a) leader makes decisions; (b) leader consults with team and makes decisions; or (c) team uses a participative decision making process, either by consensus or majority vote. Usually the teams decided that they needed to use a variety of options depending upon the conflict, problem or situation.

Communications. Team members needed a simple communications process for reaching one another in a timely manner. Each member identified his/her best two methods of contact, as well as the best times. A team communication officer was responsible for agendas and minutes and keeping members up to date between meetings about work and other team matters. It is important to mention that if email is chosen as the primary method of communication, team members must determine when to post emails, day and time, and when team members are to check emails, day and time. Otherwise, often team members do not check their emails regularly, causing the team distress.

Meetings. Every meeting or work session had an agenda, a simple recording process, an assignment process, a review of work accomplished, and due dates. We encouraged teams to create a one-page form (with copies on file in the portfolio or files) for listing date and time, members present or absent, items for action, a section to record actions taken, an assignment section with due dates, and an agenda for the next meeting. The teams also determined a meeting process and reviewed strategies for keeping members involved.

Recognition and Rewards. Most of our teams enjoyed finding ways to have fun together to celebrate their milestones and successes. We encouraged the district to reward them, but that was not within our control and usually did not happen. So we encouraged them to identify ways that they could reward each other, ranging from grab-bags to taking one another out to lunch.

Humor. We made it clear in our projects that we did not condone inappropriate use of humor to mask criticism. However, it was just as important to help individuals understand that they should not take things too seriously, and we encouraged them to see the funny side, especially if that helps reduce tension and stress.

Policies and Procedures. Teams formalized an operating manual to guide their interactions, processes, and work. Typical components in such a manual were:

- Team charter
- Leadership model
- Organizational chart
- Skills bank
- Peer, team, and conflict assessment instruments and process description
- Meeting agenda/minutes form
- Team communications model
- Problem solving model
- Conflict resolution model
- Decision-making model
- Team roles and responsibilities
- Team member work roles and responsibilities/work packages
- Team change form and process
- Recognition and reward process

Finally, we kept a log of problems, solutions, and dates addressed, and then made them into a lessons learned summary.

Pictures. Teams documented their entire process, digitally if possible. They found many uses for good pictures of their members in action, as well as pictures of the products, humorous events, and more. We provided each team, and sometimes each teacher depending upon the year, with digital cameras.

Leadership. We offer the teams a review of basic leadership theories, especially transforming and self-leadership. We also review other simple models, and the teams then decide on their model and philosophy. We urge them to choose a leader, manager, or coordinator. Some younger teams prefer to have all members participate equally because they do not want to empower one person over others. We prefer a shared leadership model with a formal team manager or coordinator and try to lead teams toward that model.

Team-Building Program

We arranged this program in various ways over the years. Below is simply one possible configuration, and it worked well. An asterisk (*) denotes components of the team manual that were developed as part of this program. Others were developed at the end of this program.

I. Change – A purpose for teams
   - The learning organization requires learning individuals.
   - Schools are learning organizations.
   - Learning – what is it, really?

II. Hidden Agendas – Why team members are participating
   - *Identify each member's own agenda for participating.

III. *Team Vision, Mission, Purpose, Values, and Principles
   - Establish team values.
   - Develop a vision for members, teams, and students.
   - Develop a mission and break the mission into goals and objectives.
   - Describe individual and ultimate team purpose.

IV. Team Building vs. Team Development
   - *Develop individual member knowledge and skills list.
   - *Develop team knowledge and skills bank.
   - Identify gaps in knowledge and skills where building is necessary.
   - Review the difference between "building" and "development."

V. Team Work – What is it? What do teams need to be successful?

VI. Trust and Empowerment – A philosophy for high-performance teams

VII. New and Troubled Teams – (symptomatically one and the same) How can they move beyond the stage and become successful?

VIII. Effective Teams
   - Identify characteristics, traits, attitudes, actions, and behaviors.
   - *Develop team assessment instrument and process.

IX. Effective Team Members

Identify characteristics, traits, attitudes, actions, and behaviors.
*Develop peer assessment instrument and process.

X. Team Member Roles and Responsibilities
*Determine team member health roles and responsibilities.
*Determine team member work roles and responsibilities.
*Determine team member administrative roles and responsibilities.
Use linear charting for simple communication purposes.

XI. Problem-Solving Model
*Identify, adapt, or develop team problem-solving steps and processes.

XII. Conflict Resolution Model
Identify, adapt, or develop team problem solving model and process.
*Identify, adapt, or develop CR assessment instrument and process.

XIII. Decision-Making Model
*Identify, adapt, or develop team decision-making model and process.

XIV. Communication Model
*Identify communication methods and process parameters.

XV. Team Meetings
*Create an agenda/minutes format.
*Develop a meeting process.
*Identify or develop a meeting assessment questionnaire.

XVI. Recognition and Rewards
*Identify recognition criteria and strategies.
*Identify reward criteria and strategies.
*Develop selection process.

XVII. Develop Team Operating Manual Components (not completed above)

A. Policies and Procedures – A guide for the team
1. *Develop attendance policy for being absent or late.
2. *Identify deliverable policies for quality standards, being on time with work, and consequences for delivering late or not delivering at all.
3. *Identify other types of policies and procedures that teams individually determine important for their work process.

B. Log Formats
1. *Create Problem Log.
2. *Maintain Conflict Log.
3. *Generate Lessons Learned Summary.

C. Team Change Format and Process
1. *Create team change form for making changes to products in quality, content, timeline, format or style, etc.
2. *Establish change approval process.

D. Work Packages
1. *Design work package description form.
2. *Develop work packages for each individual or sub-teams.

Teams received a packet or handbook that included information adapted from commercial sources for team-building consultants. Other information came from sources on leadership theory or more practical books on leadership.

Teams were led through the development of the above tools and processes in a two-to-five-day format. When developing interdisciplinary teaching teams using this basic program and process, a three-to-four-day process worked best. A two-day process accomplished everything, but in a very hurried way with less deep processing of the content. Teachers commented that they needed more time. Since the goals were to provide team members the opportunity to get to know each other; prepare them for high-performance teaming; and assist them develop their process tools, vision, goals, and mission, a two-day process was not enough time. The process could be done well in four days, with time for all the above. For some teams, a five-day process was best, but that left some with no work to do. We preferred at least three days or four days – five days was ideal.

Teachers responded very well to this program. When teachers were supported by their school leaders, they followed through and actually used their process. However, when they were not supported, teams were unable to follow through.

Cooperative Learning and Student Teaming

Our basic program helped teachers to prepare students to work in teams. It also provided the knowledge, content, process, and skills for developing student teams and team processes. Students used the basic program in a variety of ways:

> *Basic student teams.* Many of our teachers successfully used the program described above, in its entirety, as a module for career preparation or to begin team operations in their coursework. If they needed a shorter version, they omitted topics such as hidden agendas, trust, and empowerment. Student groups (individually first, then as a team) were asked to describe their ideas about effective team member characteristics, attitudes, and behaviors. Then they developed a brief rubric for assessing team members, with an understanding that it was perception based. They identified 10 descriptors of a well-performing team and designed a brief rubric to assess the team as an entity. The teacher explained that a team was more than the sum of its members, informed them about the problem-solving steps, and gave them a sample problem. The teacher also provided the conflict-resolution and decision-making models as tools to enhance team process and lead to more objective and better solutions.
>
> Students needed an agenda/minute format, a meeting or work session process, and an understanding of their roles and responsibilities as team members. They considered them the work at hand and designed either assignments or work packages for each member. Work packages often functioned well with students because their projects accommodated such an approach. Finally, student teams developed their communication model. Students were given a rubric that was used for scoring their completed project. The project was a joint effort; otherwise, there was no need for a team. The project worked even better when it

was multidisciplinary and operated across several teachers and disciplines that were scored by the teacher team.

Cooperative Learning. The team-building program was especially useful for teachers who wanted to create *base group* cooperative learning groups for extended periods of time. Johnson et al. (1998) provide a great resource for formal, informal, and cooperative base groups, including almost everything necessary to implement a wide range of cooperative learning strategies. Base groups are about the creation of long-term, committed, and caring relationships that result from working together over time. In base groups, individual students are supported in learning by their group. Then the students assist each other with assignments, peer teach, and ensure that all members are successful.

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11. Integrated Interdisciplinary Curriculum Development*

Jule Dee Scarborough

Curriculum development is not for every teaching professional. "Who is to design and develop the curricula?" is one of the first and most important questions to explore when working with teaching professionals. Many assume that teachers have the knowledge and skills to design and develop curricula. We have found that some do, but they must prepare to do it successfully. The curriculum must have a solid academic base and purpose and include answers to basic questions about the teaching and learning process. The development of appropriate curricula requires a design, clear goals or standards, and student assessments with high integrity. We incorporated Bloom's Taxonomy as a metric to assist in designing curricula (Bloom, 1949; Bloom et al., 1956) and Anderson and Krathwohl's (2001) revised Bloom's Taxonomy to incorporate new knowledge and thought into the framework.

Current Literature

Many resources are available to assist in the development of the integrated or interdisciplinary curriculum. Those discussed below reinforce what we have done and inform our continuing process and work.

The nature of curriculum design has changed. Wiggins and McTighe (1998) explain the new approach as "backward design." As they note, "To begin with the end in mind means to start with a clear understanding of your destination. It means to know where you're going so that you better understand where you are now so that the steps you take are always in the right direction" (based on Covey, 1990). This involves focusing on the standards, for they specify what students are to know and be able to do. They become the teaching and learning priorities upon which the curriculum and assessments are based. Standards combined with student interests, needs, levels of development, and prior achievements are considerations in designing a curriculum. The curriculum is the means to the end. Wiggins and McTighe call the process backwards because rather than beginning with lessons, activities, or textbooks, it begins with goals or standards, "the end," to determine what evidence of learning is desired and then derives the rest of the curriculum content. More than 50 years ago, Tyler (1949) described something very similar to this process. And as noted earlier in this book, good vocational or technical educators have long used this process.

Backwards design requires one to "identify the desired results, determine the acceptable evidence of learning, and then plan the learning experiences and instruction" (p. 9). Decisions are critical regarding the evidence of learning. If tests are only indicators of performance potential, then performances are evidence of what one can do. It is important to determine what is acceptable as evidence of learning, indicators of performance potential, or direct evidence of

* Jerry Allen often served as primary leader of this program component.

authentic performance. Tests are not genuine but rather are a means to an end (Chatterji, 2003; Wiggins, 1998). Some student learning assessment questions to consider are: What is worth being familiar with? What is important to know and do? And finally, what is so important that one would want to provide evidence of "enduring" understanding?

Pinar et al. (1995) trace the development of curriculum with an historical focus on "understanding" it. For example, in Chapter 3, "Understanding Curriculum as Historical Text: Crisis, Transformation, Crisis, 1928-1969," they discuss John Goodlad's (1966) *School, Curriculum and the Individual*, which focused on "the interwoven nature" of curriculum. In Chapter 13, "Understanding Curriculum as Institutionalized Text," they discuss Murphy's (1991) six organizational threads: "(1) flexible use of space, (2) less regimented scheduling patterns, (3) nontraditional grouping patterns within classes, (4) more flexible instructional arrangements, (5) less emphasis on self-contained classrooms, and (6) less use of age grouping patterns" (p. 679). Furthermore, in addressing curriculum sequence, they refer to Armstrong's (1989) most common strategies: chronological, thematic, part-to-whole, whole-to-part, and integration, referring to Goodlad and Su (1992) and Aceland (1967) "to interweave curricular elements such as concepts, skills, and values so that they are mutually reinforcing." The most important point made is that curricular integration really occurs within the individual student (p. 697).

Fogarty and Stoehr (1995) and Fogarty (2002) also provide integrated models, specifically making this point. Design of the curriculum and the teaching and learning process provides the opportunity for students to internalize what they are learning in a way that leads them to see the interrelationships and interdependencies across the disciplines. There are many other relevant and important references mentioned throughout Pinar et al. (1995), as the authors provide a rather comprehensive review to deepen understanding about the purpose of curriculum and what leads to successful learning. This work is a must for those who really have a desire to understand curriculum and its evolution for development purposes and want a quick reference to all the great thinkers on the topic of curriculum.

Drake (1993, 1998) and later Drake and Burns (2004) are good sources for the process to use with teachers to develop their knowledge and skills in curriculum development, especially integrated or interdisciplinary curricula. Their method helps to simplify and streamline the process without losing integrity and rigor. They also present assessment as an integral component. The authors address why integrated curricula work and discuss the academic gains, student benefits, and effects if teachers are to be leaders of learning. This puts the burden of learning where it should be – on students. For example, when an integrated curriculum is weak or superficial, it is impossible to engage students in a deeper learning experience.

We have worked to ensure that a deeper level of knowledge or skill was the focus of learning for each discipline included in an integrated unit. Each discipline had to go beyond the superficial and lead students to a more substantial level of learning. This was not always easily accomplished when working with teacher teams or curriculum development. The members of an interdisciplinary team were likely to be diverse in background and outlook and to vary in knowledge, skills, and ability. Program leaders need to ensure that the content of each discipline has depth, rigor, and integrity.

Drake (1998) discusses preliminary evidence beginning to accumulate related to integrated curriculum. She looks at Vars's reviews of more than a hundred studies done between

1956 and 1995. Vars concludes that “students in integrated programs do as well as, and often better than, students in conventional programs. …[Also,] almost without exception, students in any type of connected curriculum program do as well or better on basic skills than students in traditional programs.…[T]he results of standardized tests follow the same pattern” (p. 33). There is not yet sufficient evidence to determine if integrated curriculum produces superior results. The NSF PHYS-MA-TECH project confirmed Vars’s conclusions in a yearlong course that integrated physics, mathematics, and technology education at the high school level (Scarborough, 1993a). However, there needs to be a more tightly controlled study on integrated curricula, one that also studies each teaching/learning treatment individually as well as together. Our approach involves more than the integrated curricula content. Each treatment variable needs to be studied independently, and the combined interaction effects of multiple treatments also need to be studied. Drake (1993) and Scarborough (1993b) also reinforce the nonacademic benefits of using an integrated approach: the quality of school life seems to improve; teachers, students, and even parents report that learning is more enjoyable, relevant, stimulating, and motivating.

This type of learning does require teachers to engage in deep change. They must think and teach differently and must unlearn the models, processes, and strategies that are not as effective, or at least let them go. However, once the changes begin and teachers see the advantages of transferring the burden of learning to the students, they become “leaders” of learning. Teachers in the Rockford program began to request additional program components and also deeper levels for initial program components. We used Fogarty’s Models of Integration, but Drake presents a more substantial model, which we used as our basis for leading teachers to deeper “understanding” about curricular integration, especially when considering the integration of the metacognitive skills as well as more discipline-specific knowledge and skills.

Erickson (2003) distinguishes among multidisciplinary, interdisciplinary, and transdisciplinary. However, curriculum development leaders often use these terms differently. Jacobs (1989) presents a continuum of options, ranging from discipline-based to parallel disciplines, multidisciplinary, interdisciplinary, integrated day, and complete program. We made her models integral to our process and models before it became common to focus more substantially on the integrated or interdisciplinary curriculum. For example, we used a layering approach, trying to lead the teacher to think of interdisciplinary and integrated curriculum as having levels. (This is not the same as the Nunley (2002) approach to layered curriculum.) We wanted teachers to understand that “inter” meant “between” and that “meta” meant “beyond.” We wanted teachers to achieve an integrated curriculum that was inter-disciplinary, inter-cognitive, and inter-curricular, where

- the inter-disciplinary aspect focused on the “knowing” of the discipline-specific theories, concepts, techniques, principles, and processes
- the inter-cognitive emphasized cognitive processes such as analysis, reasoning, etc.
- inter-curricular meant something much broader, where teachers emphasized anything, like writing or technology, that they wanted to thread throughout the curriculum

This could even include developing and organizing learning through student teams or the development of classroom social skills necessary before learning can begin.

Our approach was successful. Teachers began to understand the importance of integrating or threading (Fogarty, 2002) other knowledge or skills across disciplines to reinforce learning across contexts and courses. Threading provided an opportunity to reinforce learning considered important across disciplines and teachers. We integrated from many different perspectives. Even when not integrating across related disciplines, such as mathematics, science, and technology, we saw the potential to integrate on other curricular topics critical across disciplines, especially cognitive skills and processes, use of technology for learning, behavior skills, and more. Integration can extend beyond discipline-specific standards or content (knowledge or skills) and can build stronger general knowledge, processes, or skills.

When working with teachers or choosing models for integrated or interdisciplinary curriculum from particular authors or analysts, it is important to consider their definitions and either make them your own, modify them to fit, or use your own with very definite meaning. Leaders must then clearly present the definitions to teachers. This will confuse them at first, but soon they will understand that terminology means different things to different people, and that once they agree on the meanings, they can operate from a unified basis. I suggest favoring terms and definitions represented by the best and most commonly cited research.

Erickson (2003) discusses the major trends and issues, noting why it is important to integrate the curriculum: to promote deeper understanding of more complex issues, problems, and topics; to bring about an understanding that knowledge is interrelated; to illuminate relevance to students' lives; to build interest in learning; to motivate learning; and finally to better manage curriculum by contextualizing it. She believes it is more efficient and meaningful when curriculum is contextualized around themes, making it possible to achieve interdisciplinary standards in a single unit. We agree with all this. She also presents models and processes for building integrated units of high integrity.

Mallery (2000) reviews 10 years of educational reform in an enlightening historical perspective that gives context for integrated curriculum. She reviews the history of interdisciplinary curriculum and the arguments about its benefits. The definition she favors is from Brazee and Capelluti (1995):

> Integrated curriculum is based on a holistic view of learning and recognizes the necessity for learners to see the big picture rather than to require learning to be divided into small pieces. Integrative curriculum ignores traditional subject lines while exploring questions that are most relevant to students. As a result, it is both responsive to students' needs and intellectual because it focuses on helping learners use their minds as well. There is, in fact, no one integrative curriculum, but rather principles of teaching and learning that guide the development of integrative curriculum in diverse setting. (p. 8)

This is very important to our work, since we believe that curriculum products should encompass the teaching and learning process, assessment content, process, and procedures.

Meinbach et al. (1995) provide a guide for the development of thematic units. They address teaching from a thematic perspective: how to plan units and their instruction, select and organize materials and resources, design activities and projects, and implement the unit. They describe the nature of more authentic assessment, including the use of portfolio assessment, types of portfolios, portfolio development and management, engaging students in self-assessment through their portfolios, criterion checks, and more.

Campbell and Harris (2001) also provide a substantial resource for teachers collaborating on the development of integrated curriculum. The authors focus on the importance of teacher team development. And, although Campbell and Harris's review of team-building content and process is brief, they do address the topic. The team-building aspect of our program was very important because the professional development on teaming was where teachers determined their focus: their vision for themselves and their students, their team process, their mission, and the direct goals and objectives for accomplishing their vision.

In summary, resources available today can assist those interested in the development of the integrated or interdisciplinary curriculum. These are a few that seem to reinforce what we have done and further inform our continuing process and work with teachers to integrate curricula.

Integrated Curriculum in Our Program

The integrated MSTE curriculum modules developed by teachers in our programs were culminating projects in themselves. They were developed gradually, with each component contributing a strategic focus and fit to the ultimate goals. When teachers began to see the elements come together, they became very excited about the possibilities with students in their classrooms and realized they were going to be able to use what they learned in a very real sense. For example, the learning styles, teaching models, assessments, and other workshops became even more real as they fit into the whole framework of the integrated module. The module was designed to bring it all together; the teachers developed aspects of the curriculum through the professional development program and then were provided with dedicated time at the end of the program to complete and finalize the modules. The framework is fully described below.

In "Practicing What We Preach in Designing Authentic Assessments," Wiggins (1996-1997) identifies the assessment of *faculty products* and how that might take place. He questions how we ensure that ongoing design and reform work is more rigorous and credible. He discusses how the Center on Learning, Assessment, and School Structure (CLASS) in Princeton, New Jersey, "use[s] design standards and a workable peer review process for critiquing and improving all proposed new curricular frameworks, tests, and performance assessments" (p.18). Since 1990, we have been doing a very similar version of what he describes. However, Wiggins and CLASS confirm that our process is credible and very important.

When teachers began their adventure with us, they focused on designing their culminating project and products: the interdisciplinary, integrated mathematics, science, technology, and English curricula modules, one per team or teacher. This product incorporated much more than content, for it consisted also of standards, context, assessments, new strategies, and new teaching models and activities. We provided a template, explanation, check-off form, rubric, and reference books (Tables 1 – 10). Teachers engaged in a guided development process that included immediate, direct, and one-to-one or team feedback and a review process with self-assessment and assessment by the program leaders and others. The session ended formally with a review of accomplishments (evaluative in nature) with the teams, teachers, program leaders, and school administrators. In addition, we reviewed with local administrators to celebrate their accomplishments.

The module required the following components:

- *Check-off Form (Table 1).* A list of all minor and major requirements.

- *Introduction (Tables 2, 3, 8, 9).* Title, Timeline, Description, Purpose and Rationale, Learning Standards, Interdisciplinary Content Areas, MSTE, Industrial Partners and Partnership Activities, Specialized Vendors and Equipment (sources and contact information), Teaching Models and Models of Integration, Technology Utilization (WebQuests, Websites, PowerPoint Presentations, Spreadsheets, Imaging, Videos), discipline-specific technology requirements (CAD, heart monitors, etc.), Bloom's Taxonomy by lesson, Opportunities for Further Fields of Study or for Further Curricular Integration, Performance Task Descriptions; Pretest - Posttest and procedures, as well as Lesson Titles, Number, Benchmarks Addressed, and Ranking.

- *Lesson Activities and Procedures (Tables 4, 7, 10).* Lesson Titles and Numbers; Lesson Topics; Lesson Benchmarks (by standard); Length; Materials, Equipment, and Supplies Needed; Student Assessments; Lesson Activities and Procedures (including all handouts, worksheets, visuals, post-lab questions, problem analysis forms, etc.); and Technology Descriptions.

- *Student Activities (Tables 5, 6).* Lesson Titles and Numbers, Lesson Topic Descriptions ("What is the lesson about?" and "What are we going to do today?"), Student Artifacts, and Assessment Procedures.

- *Module Rubric (Tables 11-19).* During orientation, teachers received a graphic organizer on the module framework, along with a description of what each section was to include. They received a rubric (Tables 9-12) describing standards and levels of descriptors that the project team used to score the modules. Teachers knew what was expected before attending workshops and agreed to the expectations or requirements and the timeline, or we adjusted them based upon their comments or those of their district's administration. The format and process evolved over several projects. When beginning with a district, we asked them to determine if it would work or need adjustments, or if they had one of their own they preferred. This format invariably exceeded what was available in the district for curriculum development. We did, however, make one adjustment in the last year of the Rockford initiative. Teachers at the most advanced level, who had already produced full modules, could choose either to develop a "collection" of new lessons to infuse into their overall curriculum or develop a new module. We provided feedback and assessment by section. As they finished each section, we gave it a final review and checked it off with them. This progressive method, with check-off procedure, kept teachers focused and feeling accomplished. A module check-off list was used in conjunction with the template, explanations, and rubric.

- *Evaluation Check-off Form.* (1) Module Conference, (2) Schedule for Implementation, (3) Copy of Module for District Office, (4) Industry Partners, (5) Electronic Copy of Module, (6) Workshop Questionnaire, and (7) Completion Certificate.

- *Final Conference Check-off.* In the final evaluation procedure, (a) modules were turned in, (b) modules were reviewed by professors and master-teacher peer teams, (c) and teachers or teams participated in a conference with the principal and other district personnel, the full team, and the project PI and the external evaluator to review evaluation, commit to piloting or implementation, and receive congratulations.

Teachers engaged in a workshop to prepare for these components and continued with related workshops to support their growth within and across disciplines. The format was initiated by the project PI, reviewed and modified by a project team each year, and then reviewed and adapted by each teacher group. It worked well for very different or diverse teams and districts: Chicago, suburban schools, rural and small schools, mixed northern Illinois regional groups, and Rockford.

The modules ranged from three to eight weeks in duration and were rather complex but very complete in standards, content, models, strategies, processes, procedures, partnerships, activities, and other requirements, including worksheets, project information, visuals, tests or performance assessment information and procedures. They were easily replicable across groups when shared. Individual teachers, when working alone, produced a complete module like the others and accomplished the interdisciplinary MSTE integration as well, but they usually used partners or visiting professors or teachers to help deliver when no team was available.

Process

In later years, the PI, other professors, and a master teacher peer leader led this program component. Based on his experience as a participant in the prior PHYS-MA-TECH project, the master teacher peer became a leader and expert, guiding teachers through an exploration of learning standards, benchmarks, and learning objectives. This exemplified Sims and Manz's (1989) superleadership theory. The teacher-to-teacher relationship was powerful and positive in leading peers through curricular change. Discipline-specific teams thoroughly examined their standards and benchmarks and analyzed coverage and gaps. They reviewed the integrated curriculum, models, the development process, and how to achieve consensus for building an interdisciplinary module. They also examined other aspects, such as pre- and graphic organizers.

After selecting standards and benchmarks upon which to base their modules, teachers met with the partnership coordinator, who organized and managed their experiences with real-world partners in the communities of practice. Teachers began to write their module introductions. We sometimes involved professors in the conceptualization of modules if the team wanted more varied exposure. Teachers divided and visited sites, each bringing back information to the team. On day one, the professors came in to work with them on ideas for their modules, as well as for a better understanding of the standards, concepts, and principles they were trying to teach and for other creative aspects. The teams had everyone there as a resource while writing the drafts of the module introduction. They emailed the master teacher peer for feedback and then made changes based upon his feedback. They made changes based upon his feedback before coming to the third day of development. On day two, the teams began to develop the lessons, activities, and procedures sections. For days three, four, and five, they continued in the same pattern.

One or more professors and the PI usually supported these days of activity, depending upon the need. Teachers submitted the modules for review by the master teacher peer, one or more professors, sometimes industrial partners, and the PI and external evaluator. Teams and teachers then participated in the final review with the master teacher peer, professors, district personnel, PI, and external evaluator. We tried to have the principal visit during the workshops and participate in the review. When principals could not attend, we asked other district administrative personnel to visit.

We tried several strategies for having teachers work with higher educators in MSTE. In some years, we had professors available on site to help the teams with discipline-specific content work; during other years, we had professors on call rather than just sitting and waiting. These models work to some degree, but there is a lot of down time for the professors and a lot of development time where the teachers do not seem to really need any help. We have also had professors read and evaluate the modules, after working with the teachers, when the modules were completed. These methods all worked rather well. In between, we had teachers participate in discipline-specific workshops called updates, learn more deeply about MSTE, and then have an expert in curriculum and a master peer teacher evaluate the modules. This system also worked well. Teachers felt rewarded when a master peer *and* a professor they trusted and respected evaluated the modules. In fact, they really preferred and more highly valued a professor's evaluation of their work rather than a district evaluation.

Teachers highly respected the role of the external evaluator, our third party, who contributed insight and feedback. Depending upon the year, industrial partners were asked to validate or review the curriculum or participate as review team members.

Another aspect of the curriculum development was the participation of industrial or community partners. Teachers spent three to five days visiting five industries or more each summer or during the year. They entered into these learning experiences with the assignment of learning more about standards in real-world contexts, while also seeking more authentic performance tasks or assessment procedures, deepening their understanding of MSTE in more authentic contexts, and learning more about careers. Teachers highly valued these experiences, and our program would have lacked a critical component without them. However, a change in the model occurred over the last few years. For a while, we paid stipends for the days spent visiting BIC partner sites, as long as they were not school days. Later, as we began the transition to sustainability in Rockford, we made these days required "homework," where only continuing professional development units (CPDUs) were provided. The Rockford district has since implemented a new policy that there are to be no stipends for professional development, but the teachers will receive recertification CPDUs or professional development credits. This reinforces the professional responsibility of staying current on new research and ideas.

Designing effective curricula requires addressing key questions about focus, standards, assessment, and evidence of learning. What are students to learn and be able to do? Learning must have a specific purpose, and so must the curriculum. How do teachers want students to provide evidence of what they have learned, and to what level do they want students to show what they have learned? Evidence can range from simple memorization (Bloom's knowledge level) to manipulation of knowledge, concepts, or principles.

The "how deeply" would better address capabilities to synthesize, analyze, and evaluate – or to "create" on Bloom's Revised Taxonomy (Anderson & Krathwohl, 2001). In our initiatives, the teachers based their modules on standards chosen from each MSTE discipline, after analyzing those that naturally crossed over disciplines and those that might be specific to each discipline. Both could easily be incorporated, using several integrated curriculum models simultaneously. Cognitive or academic skills could be threaded across disciplines. And for the assessment component, we suggested a range of assessments, including both traditional and authentic and performance-based assessments, as well as portfolios. Inclusion of the English discipline provided opportunities to build good assessments using communication as the process for providing evidence of learning.

Once the teachers addressed the key questions, they moved on to the decisions related to contextualizing the learning. What type of learning experience will best suit the standards and assessment? What other content can be used to excite students about learning? What teaching models will best suit the focus of learning? We guided the teachers through the development process and provided support for instructional decision making.

At this point in our initiatives, the process was led by the master peer teacher leader, not the PI. We had a gifted individual for this role, an expert in curriculum development who was knowledgeable about mathematics, physics, and technology and very capable in chemistry, biology, and English. As a secondary technology education teacher with good foundations in MSTE, he had been a key leader and was greatly respected by the participating teachers. Various external factors, including teacher preference, the awarding of university credit and state CPDUs, and district perception about evaluation, encouraged us to maintain the involvement of the professors, PI, and external evaluator in the evaluation process.

Integrated Curriculum

Fogarty and Stoehr's (1995) *Integrating Curricula with Multiple Intelligences* addresses integrated curriculum models, multiple intelligences, teams, themes as organizing centers and catalysts, and threads from several perspectives, while weaving in the theory information. It is regularly updated. Our teachers also read *Awakening Genius: In the Classroom* by Armstrong (1998).

Fogarty and Stoehr posit 10 models of integration:

1. Fragmented (least integrated, representing disconnected content typical of isolated teachers and single-discipline curriculum)
2. Connected (subtle connections are made between disciplines)
3. Nested (skills are nested within a subject matter)
4. Sequenced (curriculum is rearranged to coincide with others)

5. Shared (concepts naturally overlap)
6. Webbed (theme-based, with disciplines organized around a related theme)
7. Threaded ("metacurricular approach": social skills, technology skills, metacognitive skill development, writing, etc. can be threaded across disciplines)
8. Integrated (matching natural overlaps across related disciplines through team teaching)
9. Immersed (students immerse themselves and filter the discipline through their own lens to create relevant learning)
10. Networked (making internal disciplinary connections through experts)

We used these for years and tried a range of different requirements in the modules. The most successful were shared, webbed, threaded, and integrated, with some teachers using immersed and networked. We later required integrated, webbed, and threaded in each module. Other models were optional. Teams were also required to show their integration through appropriate graphic organizers.

Some other respectable sources of very good information about integrated or interdisciplinary curriculum are: *Interdisciplinary Curriculum: Design and Implementation* by Jacobs (1989); *Planning Integrated Curriculum: The Call to Adventure* by Drake (1993); and *Curriculum and Aims* by Walkers and Soltis (1992).

Over the years this workshop was taught in a variety of ways. Teachers previous to the initial year with Rockford spent time looking at interdisciplinary models more deeply, as we led them to understand that, when building curriculum, they needed to consider cognitive and curricular factors. Other than the state learning and teaching standards and Bloom's Taxonomy, we gave teachers the following tools: the state's Bloom's analysis for all disciplines; the state's performance indicators to go with the learning standards in each discipline; Dale's Cone of Learning (Wood, 1989); the national *Standards for Technological Literacy: Content for the Study of Technology* (ITEA); *The National Technology Standards* (ISTE); the *Quick Flip Questions for Critical Thinking* (Bloom's-based) by EDUPRESS, a flipchart of questions to ask at different levels of Bloom's Taxonomy; and *Models of Teaching* by Joyce, Weil, and Calhoun (1995; 2000). There are many other sources, some are out of print but excellent nevertheless and available in district offices or libraries. We provided access to reference copies of some, for example, *The TimeTables of Science* (1988), *The TimeTables of History* (1991), *The TimeTables of Technology* (1993), and *The Timelines of the Arts and Literature* (1994).

Teachers should be involved in the curriculum development process. A natural side benefit is that teachers own the curriculum, become expert through the development process, and deepen their understanding of disciplinary content. Interdisciplinary team members broaden and deepen one another's knowledge bases and skills in many areas, especially technology. The best curriculum was developed when we teamed teachers, counselors, professors, and field experts from real-world communities of practice. This resulted in the inclusion of all relevant context, knowledge, skills, and career-building concepts, as well as long-term partners who co-owned it with the teachers and became willing to be involved in teaching and student learning. The involvement of business, industry, community or field experts from communities of practice occurred to varying degrees and in different ways. They helped us identify critical knowledge and skills, helped teams develop the modules, and continued to partner in the classroom learning experiences. When successful, an informal learning community evolved between teachers, professors, and especially the BIC partners.

Professor Modules

We invited professors to develop modules and then deliver them to students of the teachers with whom they were working. The professors met the teachers and then observed the classrooms. They worked on their own with the format, standards, and other aspects to develop modules and then to deliver them to students in classrooms, with teachers observing or participating. This experience engaged the professors with the secondary students, provided the opportunity for more time with the teachers with whom they would be working, and gave them a feel for the workload, expectations, standards, and needs of those teachers.

Professors developed and delivered the following module samples:

- "Oxygen, A Molecule on a One-Way Trip. We breathe it, we take it for granted, but what really happens to it once it's breathed into the body? Learn about its journey and explore the tiny magnets in our cells (some are carriers, some are consumers) that can attract and bind oxygen molecules. Finally, learn about the 'demagnetizing' effects of two common poisons." A three-lesson module.
- "Solving Mathematical Problems Using Computer-Aided Design. Create specified two-dimensional geometry using CAD, use both mathematical formulae and CAD techniques to determine areas of 2-D shapes and solve typical trigonometry-based problems." A five-lesson module.
- "History, Design and Use of Trebuchets. Investigate history, development, and use of projectile throwers, then build a working model to test the design."
- "Chemistry and the Environment. The relationship between chemistry and the environment…how chemicals cause pollution and how modifications can reduce or eliminate these problems." A four-lesson module.
- "Cell Structure and Function. The processes of scientific inquiry and technological design to investigate questions, conduct experiments, and solve problems."
- "Exploring the Geography of the Local Community. The use of geographic information systems for making scientific discoveries in Rockford, IL." A four-week module.
- "Genres of Technical Communication. The why and function of technical communication." A two-lesson module.
- "Writing Center Links Between NIU and a High School. NIU graduate students work with high school students on writing."
- "Using Accurate Description to Write a Crime Scene Report. As part of a proposed unit built around the concept of 'mystery,' students will work as pairs of detectives describing a crime scene in a written detective's report, revise, edit and finalize their reports."
- "Expanding Horizons Creating Web Pages. Students will learn and practice effective information-gathering skills, learn to evaluate webbed sources, learn to make a

> rudimentary but functional web page, and learn to make brief annotations explaining the relevance of the sources they find."

This is a great way to give professors hands-on experience in K-12 classrooms. Actually engaging with the students develops a deeper understanding of the teaching and learning requirements, issues, and constraints and brings about a greater understanding that there must be a wide repertoire of instructional strategies, models, processes, curricula, and procedures from which to draw. A side payment is that professors return to their own teaching and classrooms with important questions and considerations about their own curriculum and teaching process.

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Table 11.1 Module Template

<table>
<tr><td colspan="2">Introduction</td></tr>
<tr><td>Team Name:</td><td>School:</td></tr>
<tr><td colspan="2">Team Members:</td></tr>
<tr><td>Module Title: Be sure that the title accurately describes the activities included in the module.</td><td>Timeline: How many weeks will the module take and when do you anticipate beginning the modules activities?</td></tr>
<tr><td colspan="2">Brief Description of Module: Give a one or two sentence description overview of the scope and content of the module.</td></tr>
<tr><td colspan="2">Purpose and Rationale of Module: What are the specific educational goals of this activity? Why are we teaching this lesson? What makes it important enough in its role outside of education to include it in the curriculum?</td></tr>
<tr><td>Related State Learning Standards: List all State <u>standards</u> that will be addressed in this module. Use the following form when listing them.

(5 B, Analyze and evaluate information acquired from various sources)</td><td>Related District Standards:</td></tr>
<tr><td colspan="2">Interdisciplinary Content Areas Involved in Module: List all content areas involved in this module and the topics to be covered by the content area.</td></tr>
<tr><td colspan="2">Industrial Partnership Activities: Describe any activities in which industrial partners are involved. Be sure to indicate who the partner is as well as the type of help they are giving your module.</td></tr>
<tr><td colspan="2">Specialized References, Vendors, or Equipment: List all sources or references that are specific to this activity and may be difficult to locate. <u>Do not waste time listing all common sources like the hardware store or dime store. If you don't have specialized references of vendors, then just type "none."</u></td></tr>
</table>

Table 11.2 Module Template (continued)

Teaching Models: (indicate # of times each model is used in the module)					
	Memory/Mnemonics		Graphic Organizers		Inquiry
	Progressive Part Method		Concept Attainment		Simulations
	Advance Organizer		Concept Formation		Jurisprudential
	Lecture		Concept Presentation		Direct Instruction
	Reciprocal Teaching		Conceptualization		Training Model
	Mastery Learning		Inductive Thinking		Synectics
	Cooperative Learning		Deductive		Others (identify)
	Psychomotor		Metaphorical		
Model of Curricular Integration		Technology Utilization (Check all that apply)		*Pre-Identified Web Sites*	
	Fragmented		Word Processing		
	Connected		Spreadsheets		
	Nested		Presentation Software (e.g. PowerPoint)		
	Sequenced		E-Communications		
	Shared		Imaging (cameras, scanners etc.)	Level's of Bloom's Taxonomy (# of times each is used)	
	Webbed		Web Searches		Knowledge
	Threaded		Multimedia		Comprehension
	Integrated		Desktop Publishing		Application
	Immersed		Video		Analysis
	Networked		CAD		Synthesis
			WebQuest		Evaluation
			Other (explain)		
Are you working with student teams in this module? Please check one				Yes	No

Opportunities for further curricular integration: In this section, we would like you to give some ideas for integration and exploration that were not developed but could be. For example, are there other content areas that could be included to enhance the module? Dream a little here!

Performance task description: Each module must include at least two complex, integrated, performance tasks or one complex, integrated performance task, and an individual performance task from each discipline (as described by the performance task rubric). Give a brief description of the performance task. Be sure to include a description of how you will assess both the product that you are asking the students to create, as well as the process that they will use to deliver it. Attach performance tasks and assessments immediately behind this page.

How will you assess a) Process and b) Product

Please place performance tasks and assessments behind this page

Performance task description: **How will you assess a) Process and b) Product**

Please place performance tasks and assessments behind this page

Pre-Post Test Procedures:

Table 11.3 Module Template (continued)

Lesson Order and Titles		
Lesson **Number**	**Lesson Title**	**Benchmarks Addressed**

Table 11.4 Module Template (continued)

Lesson Activities and Procedures
Lesson Number and Title:
Lesson Topic: In a well-formed sentence describe the topic of the lesson.
Lesson Benchmarks: Type out the actual State Benchmarks or District objectives that the lesson will address. If the lesson does not address a specific benchmark/objective, write "N/A" in the space provided.
Length of lesson: (number and length of class periods):
Materials, Equipment, and Supplies needed: List all materials, etc. needed to complete the lesson
Student Assessment Describe process and instruments to be used. Attach tests and other traditional assessment. Authentic assessment activities and their rubrics should be attached to student activity manual
Daily Lesson Activities and Procedures (include tasks, references, and attach materials to be used): List each activity with its necessary procedures. Clearly describe the use of technology by both teacher and the students. This is a "cookbook" approach. It will allow other teachers to easily follow this activity. It should include both the content and how it should be taught. Note: In this section, include all handouts, worksheets, visuals, post-lab questions, problem sheets, etc. that are to be used with this activity. These should be integrated into the packet. However, each form should be on its own sheet. This is so they may be photocopied for use in class. For each activity indicate which teaching model(s) you will use and which level of Bloom's Taxonomy the students will achieve.

Table11.5 Module Template (continued)

Student Activities					
Lesson Number and Title:					
Lesson Topic:					
Lesson Benchmarks:					
What is this lesson about?					
What are you going to do today?					
Student Artifacts (Check all that will be used):					
	Written Report		Notebook/Journals		Models (physical/graphic)
	Posters		Multimedia		Web Pages
	Debates		Classroom Presentation		Other (Explain):
Assessment Procedures **(Attach all authentic assessment activities and their rubrics):**					

Table11.6 Module Template (continued)

Module Checklist

Introduction

Description	Date Completed
Purpose & Rationale	____________
Module Objectives	____________
Related Learning Benchmarks	____________
Interdisciplinary Content Areas	____________
Teaching Models Included	____________
Model of Curricular Integration	____________
Technology Utilization	____________
Problem Solving Activities	____________
Pre-requisites/Co-requisites	____________
Specialized References/Venders	____________
Lesson Order and Titles	____________

Teacher Activity Manual

Description	Date Completed
Timeline	____________
Materials, Equip. & Supplies	____________
Opportunities for Further Integ.	____________
Industrial Partnership Acts.	____________
Student Activity Manual	____________

Table 11.7 Module Template (continued)

Teacher Activity Manual (continued)

Description	Date Completed
Lesson Number and Title	____________
Lesson Topic	____________
Lesson Objective	____________
Lesson Introduction	____________
Activities to be Completed	____________
Student Artifacts	____________
Assessment Procedures	____________
Performance Tasks	
Performance Task 1	____________
Assessment/Evaluation 1	____________
Performance Task 2	____________
Assessment/Evaluation 2	____________

Lesson Activities and Procedures

Description	Date Completed
Lesson Number and Title	____________
Lesson Topic	____________
Lesson Objective	____________
Length of Lesson	____________
Teaching Model(s) Used	____________
Level(s) of Bloom's Taxonomy	____________
Materials, Equip. & Supplies	____________
Lesson Procedure	____________
Student Assessment	____________

Table 11.8 Module Format Explanation

Module Format Explanation

Use this module format to help you fill in your module template

Module Introduction

Module Title: Be sure that the title accurately describes the activities included in the module

Timeline: How many weeks will the module take and when do you anticipate beginning the module activities?

Module Description: Give a one or two sentence description overview of the scope and content of the module:

Purpose and Rationale: What are the specific educational and technical goals of this activity? Why are we teaching this lesson? What makes it important enough in its role outside of education to include it in the curriculum? What's the real world scenario?

Related Illinois and District Learning Standards: List all State and District standards that will be addressed in this module. Use the following form when listing them. ISTE Technology Standards can be used to describe technology related learning outcomes.

Interdisciplinary Content Areas: List all content areas involved in this module and the topics to be covered by the content area.

Industrial Partnership Activities: Describe any activities in which industrial partners are involved. Be sure to indicate who the partner is as well as the type of help they are giving your module.

Specialized References, Vendors and Equipment: List all sources or references that are specific to this activity and may be difficult to locate. Do not waste time listing common sources like the hardware store or dime store.

Table11.9 Module Format Explanation (continued)

Teaching Models: After you have completed your lesson activities determine how many times each model is used, and then mark the number in the box ahead of the model name.

Model(s) of Integration. Check the model(s) of curricular integration used in developing the module.

Web Sites: List those major web sites used in the teaching of the module. Caution, be very careful to copy the site address accurately including capital or lower case letters.

Bloom's Taxonomy: After you have completed the activities and procedures for all lesson(s), determine how many times each Bloom's level is attained, and then mark the number in the box ahead of the level name.

Opportunities for Further Curricular Integration or Further Fields of Investigation: In this section we would like you to give some ideas for integration and exploration that were not developed but could be. For example, are there other content areas that could be included to enhance the module? Dream a little here!

Performance Task Description: Each module must include at least two complex, integrated, performance tasks or one complex, integrated performance task and an individual performance task from each discipline (as described by the performance task rubric). Give a brief description of the performance task. Be sure to include a description of how you will assess both the product that you are asking the students to create, as well as the process that they will use to deliver it.

Pre-Post Testing Procedures: Describe how students will be assessed to determine how much they learned as a result of delivering the module. Attach assessment instruments to be used.

Lesson Order and Titles: List the lessons in the order that they are placed in the module. List the title and the numerical identifier for the benchmarks taught in each respective lesson. If the lesson does not address a specific benchmark, write "NA" in the space provided.

Table11.10 Module Format Explanation (continued)

Lesson Activities and Procedures

Lesson Number and Title: Lesson number should correspond to the "Lesson Order and Titles" page. Be sure that the title accurately describes the lesson to be taught.

Lesson Topic: In a well-formed sentence describe the topic of the lesson.

Lesson Benchmarks: Type out the actual State and District benchmarks that the lesson will address. If the lesson does not address a specific benchmark, write "NA" in the space provided.

Materials, Equipment and Supplies Needed: List all materials, etc. needed to complete the lesson.

Student Assessment: How can you tell whether your students were successful or not? This is your assessment. A combination of traditional and authentic assessment tools is preferred. Don't forget that students all learn differently. Good assessment and evaluation take this into account. Include all tests and other traditional assessments with answer keys.

Lesson Activities and Procedures: List each activity with its necessary procedures. This is a "cookbook" approach. It will allow other teachers to easily follow and successfully complete this activity. Note: In this section, include all handouts, worksheets, visuals, etc.

Student Activities:

This section should be written in a format that can be duplicated and handed to students, informing them of the purpose of the lesson, what they are to learn, how they are going to be assessed, etc.

Lesson Number and Title: Lesson number should correspond to the "Lesson Order and Titles" page. Be sure that the title accurately describes the lesson to be taught.

Lesson Topic: In a well-formed sentence describe the topic of the lesson.

Lesson Benchmarks: Type out the actual State and District benchmarks that the lesson will address. If the lesson does not address a specific benchmark, write "NA" in the space provided.

What is this lesson about? This section is written to the students. Don't get too technical or wordy. Bring out the interesting and tantalizing aspects of the activity. Really try to get them excited and intrigued.

What are we going to do today? This should be a description of what the students will be doing on a day-to-day basis. For example, if your lesson lasts 5 days, this section should contain information telling the students what kind of activities they will be doing each day. Don't forget to pique their interest!

Student Artifacts: Check each type of work the students will complete.

Assessment Procedures: Describe to the students in detail how they will be assessed and evaluated during the lesson. Include all authentic assessment activities and their associated rubrics.

Table 11.11 Module Rubric

Standard	Descriptor Level I	Descriptor Level II	Descriptor Level III	Descriptor Level IV
Module Introduction				
A Brief Description of Module is provided that outlines the activity being undertaken by students participating in the module	A concise paragraph describing the activity in the module is provided	A description of student activity is given but does not adequately portray the module.	A description is given, but it is confusing or is not clearly understood.	No description of the module is provided.
The Purpose and Rationale clearly describes the reasons for including the Module in the curriculum.	A justification for the content contained in the Module is provided, which is based on sound educational practices and provides a clear link from the Module to applications of learning beyond the school.	A substantial justification for the content is made but is not related to learning required beyond the school.	A justification for the Module content is stated, but it is not sufficient enough to be convincing to justify the inclusion of the Module in the curriculum.	No case is built within the Rationale that would justify the inclusion of the Module in the curriculum
Related State Learning Standards are identified that describe minimum levels at which students are expected to perform after completing the activities in the Module.	At least one standard from the *Illinois Learning Standards* is identified for each of the content areas integrated into the module.	*Illinois Learning Standards* are listed for some content areas, but not all.	*Illinois Learning Standards* listed are not related to the module content.	Standards from the *Illinois Learning Standards* are not identified.
Related District Curricular Learning Standards are identified that describe minimum levels at which students are expected to perform after completing the activities in the Module.	At least one standard from the *District Curricular Standards* are identified for each of the content areas integrated into the module.	*District Curricular Standards* are listed for some content areas, but not all.	*District Curricular Standards* listed are not related to the module content	Standards from the *District Curricular Standards* are not identified.

Table 11.12 Module Rubric (continued)

Standard	Descriptor Level I	Descriptor Level II	Descriptor Level III	Descriptor Level IV
Each Interdisciplinary Content Area Involved in the Module is identified and described.	Each school subject area (course) integrated into the Module is identified and content area described.	Each subject area is identified, but content to be included is not described.	One or more subject areas have been omitted.	Interdisciplinary content areas are not identified nor described.
Ways that Industrial Partnerships are utilized to enhance the instructional activities within the Module are described.	Multiple examples of student activities utilizing the resources provided by industrial partnerships to enhance the Module are provided.	Examples of uses of industrial partnerships are listed but not fully described.	Examples of uses of industrial partnerships are listed that are NOT appropriate to the listed activities or are obvious, i.e. guest speakers or field trips.	No examples of the uses of industrial partnerships are described.
Specialized References and Vendors are listed that are specific to the activities contained in the Module.	A complete list of specialized references and/or vendors is provided for each activity contained in the Module.	A list of references and/or vendors is provided, but it is not clearly related to the activities contained in the Module.	A list of references and/or vendors is provided, but is incomplete.	No specialized reference or vendor list is provided.
Teaching Models employed within the Module have been identified.	All Teaching Models employed within the Module have been identified and frequency of use indicated.	Some Teaching Models used in the Module have been omitted and/or frequency of use not indicated.	Some Teaching Models are identified that are not employed in the Module.	No Teaching Models have been identified.
The Model of Curricular Integration employed within the Module is identified.	The Curricular Integration Model employed in the Module is accurately identified.	The Curricular Integration Model identified is not evident in the Module.	The Curricular Integration Model evident in the Module is not the one identified.	A Curricular Integration Model is not identified.
Technology utilized in the Module activities has been identified.	All Technology utilized within the Module is accurately identified.	All Technology identified is not evident in Module activities.	All Technology described in Module activities has not been identified here.	Technology has not been identified.
Web Sites are identified that relate to Module activities.	Major Web Sites are accurately identified that relate to Module activities.	Identified Web Sites are not evident in Module activities.	Major Web Sites described in Module activities have not been identified here.	No web sites have been identified.

Table 11.13 Module Rubric (continued)

Standard	Descriptor Level I	Descriptor Level II	Descriptor Level III	Descriptor Level IV
The Levels of Bloom's Taxonomy of Objectives are identified.	The frequency of use for each of Bloom's Levels is identified and accurately relate to the Module activities.	Bloom's Levels are accurately identified, but frequency of use is not indicated.	One or more of Bloom's Levels checked do not relate to the Module activities.	No Bloom's Levels are identified.
Opportunities for Further Curricular Integration that allow teachers to explore expanding instructional activities are described.	At least one additional integration model is suggested and described that might be employed by future teachers using this Module.	An additional integration model is suggested, but the description does not support the identified integration model.	An additional integration model is suggested, but no description is outlined.	No ideas for expansion of curricular integration models are presented.
The Module includes at least two properly constructed Performance Tasks.	Each Performance Task scores at least the 75% level as measured by the Performance Task Rubric.	One-half of the Performance Tasks score at least the 75% level; all others score at least the 50% level.	All of the Performance Tasks score at least the 50% level.	All Performance Tasks score below the 50% level as measured by the Performance Task Rubric.
Assessment and Evaluation instruments utilized to measure accomplishment of each performance task are indicated and copies of each included.	Each performance task has at least one rubric that scores at or above the 75% level on the *Rubric for Scoring Rubrics* and includes an adequate number of other assessment instruments to measure student performance.	Each performance task has at least one rubric that scores at or above the 75% level on the *Rubric for Scoring Rubrics* but does not include sufficient other assessment instruments to measure student performance	Each performance task has at least one rubric that does not score at the 75% level on the *Rubric for Scoring Rubrics* but includes several other assessment instruments to measure student performance	Neither rubrics nor a sufficient number of other assessment instruments are included for measuring student accomplishment of performance tasks.
Pre-Post Testing Procedures for the Module are described and instruments attached.	Pre-Post Testing Procedures are comprehensive and reflect the objectives of the Module. Assessment instruments are attached.	Pre-Post Testing Procedures reflect the objectives of the Module, but the assessment instruments are not attached.	Pre-Post Testing Procedures are described, but not adequate to evaluate the effectiveness of the module.	Pre-Post Testing Procedures are not evident.
Lesson Order and Titles				
Standard	**Descriptor Level I**	**Descriptor Level II**	**Descriptor Level III**	**Descriptor Level IV**
Titles for each lesson to be presented within the Module are listed in the order in which they are to be presented to the students and the corresponding ILS and/or District Curricular Benchmarks identified.	All Lesson Titles are listed in an order that is efficient and appropriate for achieving Module objectives and the corresponding *ILS and/or District Curricular Benchmarks* are accurately identified for each.	Lessons necessary for the achievement of the Module objectives are provided, but the *ILS and/or District Curricular Benchmarks* identified are inappropriate.	Some Lessons appear to be missing that are necessary for students to achieve Module objectives.	Lesson Titles and Benchmarks are missing.

Table 11.14 Module Rubric (continued)

Lesson Activities and Procedures for each lesson title listed:				
Standard	**Descriptor Level I**	**Descriptor Level II**	**Descriptor Level III**	**Descriptor Level IV**
The lesson contains a descriptive <u>Lesson Topic</u>	The Lesson Topic includes a statement that adequately describes the material to be covered in the lesson.	The Lesson Topic does not completely describe the material to be covered in the lesson.	The Lesson Topic statement is unclear.	No Lesson Topic is provided.
The lesson contains one or more <u>Lesson Benchmarks.</u>	Listed Benchmarks match ones taken directly from the *ILS and/or District Curriculum* (Technology Standards/Benchmarks can be taken from the ISTE Standards/Benchmarks) and reflect the content of the lesson.	Listed Benchmarks do not reflect the content of the lesson.	Listed Benchmarks are not taken from the *ILS and/or District Curriculum* (including ISTE Standards/Benchmarks).	Benchmarks are not listed.
An estimated <u>Length of Lesson</u> is provided for each lesson.	An estimated number of class periods and time is provided to complete all lesson objectives that seem appropriate to student level and lesson difficulty.	The estimated Lesson Length provided does not appear to match student ability level.	The estimated Lesson Length provided does not appear to match lesson difficulty.	No Lesson Length is given.
List of <u>Materials, Equipment and Supplies</u> necessary for students to complete lesson activities is provided.	A complete list of all necessary materials, equipment and supplies is present, and they reflect the lesson activities/procedures.	A list of materials, equipment and supplies is present, but obvious omissions are apparent.	The list of materials, equipment or supplies does not clearly reflect the lesson activities.	No list of materials, equipment or supplies is provided.
<u>Student Assessment</u> process is described and instruments used to measure accomplishment of lesson objectives are attached.	An adequate amount of well designed tests, quizzes, etc. are included to allow the teacher to periodically assess the progress of students and make instructional decisions.	Assessment process and/or instruments do not accurately measure the lesson objectives.	Assessment process or instruments do not adequately assess student progress.	No additional assessment instruments are included in this session.

Table 11.15 Module Rubric (continued)

Standard	Descriptor Level I	Descriptor Level II	Descriptor Level III	Descriptor Level IV
Activities and Procedures for each Lesson in the Module are described that allow teachers to design daily class activities.	All Lesson Procedures encompass all activities necessary for the expected time-frame and are comprehensive enough to make daily assignments.	Lesson Procedures contain necessary activities; however, additional Procedures are necessary to fully cover the activities in the Module.	Ample Lesson Procedures are present; however, several of them are not comprehensive enough to make daily assignments.	An insufficient number of Lesson Procedures are included, and most lack significant depth required to teach the activities.
Activities and Procedures for each Lesson in the Module include the teaching model(s) and level(s) of Bloom's Taxonomy.	Teaching models and levels of Bloom's Taxonomy are accurately reflected in the lessons.	Teaching models are listed but do not accurately reflect the lessons.	Levels of Bloom's Taxonomy are listed but do not accurately reflect the lessons.	Teaching models and/or Levels of Bloom's taxonomy are missing.
Activities and Procedures include at least one WebQuest lesson.	At least one of the Activities and Procedures includes a WebQuest lesson evaluated by the WebQuest rubric at 75%.	A WebQuest is included in the teaching activities but does not meet the 75% rubric criteria.	A WebQuest is included in the teaching activities but does not meet the 50% rubric criteria.	No WebQuest is evident in the Activities and Procedures.
Activities and Procedures include the use of technology by the teacher and the students.	The use of technology by the teacher and the students is evident and comprehensively described in the lessons.	The use of technology by the teacher and the students is evident but not comprehensively described.	The use of technology is limited to either the teacher or the students and not both.	The use of technology in the lessons is not evident.

Table 11.16 Module Rubric (continued)

Student Activities: All entries in this section must be written in a voice that is addressing the student				
Standard	**Descriptor Level I**	**Descriptor Level II**	**Descriptor Level III**	**Descriptor Level IV**
Lesson Number and Title, Topic, and Benchmarks match those in the Lesson Activities and Procedures Section.	The Lesson Title, Lesson Topic and Lesson Benchmarks match those in the previous Module section.	The Lesson Title, Lesson Topic and Lesson Benchmarks mostly match those in the previous Module section.	The introductory sections in the Student Activities somewhat match those in the Lesson Activities and Procedures.	This section is not completed.
The Student Activities contains a description of What is this lesson About written in a form that students can comprehend.	This section contains a paragraph or two communicating to the students what they will learn, is written in non-technical terms, and piques student interest.	This section adequately communicates Lesson outcomes but is not written in a way to pique student interest.	This section does not adequately communicate Lesson outcomes nor does it pique student interest.	This section is not completed.
The section describing What You are Going to do Today is comprehensive enough for students to follow.	This section describes the activities that will be taking place and includes several interesting and tantalizing descriptions aimed at motivating students. This is written in a fashion that is easy for students to follow and refers to instructional material, worksheets, equipment, textbooks, etc. that are to be used. If investigative questions are to be answered, they are to be listed here as well.	This section comprehensively describes the activities that will be taking place, but is not written in a way to peak student interest.	This section is not complete enough for students to follow nor does it pique student interest.	This section is not complete.
All Student Artifacts to be collected from students are indicated.	Artifacts checked are reflected in the activities described in the "what are you going to do today" section.	Artifacts checked are NOT reflected in the activities described in the "what are you going to do today" section.	Artifacts are not checked nor do they exist in the description of student activities.	This section is not complete.
Assessment Procedures to be distributed to students prior to instruction are identified, described, and attached.	Assessment Procedures, which include how student artifacts are to be assessed, are described in student understandable terms and attached (ready for distribution to students).	Assessment Procedures are not completely described and not ready for student distribution.	Assessment Procedures are not described in student understandable terms and are not ready for distribution.	Assessment Procedures are not complete or attached.

Comments Title of Module: ____ Name(s) of Module Designers: _______________ Team Name: ____________ Date: _____________

Table 11.17 Alternate Module Rubric

<u>Instructional Module Introduction</u>
Standard: A <u>Brief Description of Module</u> is provided that outlines the activity being undertaken by students participating in the module.
Level Descriptor
a. A concise paragraph describing the activity in the module is provided.
b. More detail is needed to adequately portray the module.
c. No description of the module is provided.
Standard: The <u>Purpose and Rationale</u> clearly describes the reasons for including the Module in the curriculum.
Level Descriptors
a. The purpose and rationale for module content explain its importance both in school and in life.
b. The purpose and rationale for module content are not related to both school and life applications.
c. The purpose and rationale for module content are not related to either school or life applications.
d. The purpose and rationale for module are not sufficient to warrant its inclusion in the curriculum.
Standard: <u>Related State Learning Standards</u> are identified that describe minimum levels at which students are expected to attain after completing the activi ties in the Module. *Level Descriptors*
a. A Standard from the *Illinois Learning Standards* is identified for each of the content areas integrated into the module.
b. Standards are listed for some, but not all, subject matter areas.
c. Standards from the *Illinois Learning Standards* are not identified.
Standard: Each <u>Interdisciplinary Content Area Involved in the Module</u> is identified and the topic areas from each are listed. *Level Descriptors*
a. Each school subject area (course) integrated into the Module is identified and topic areas are listed.
b. Each school subject area (course) integrated into the Module is identified but topic areas are not listed.
c. One or more of the subject areas have been omitted.
Standard: Ways that <u>Industrial Partnerships</u> are utilized are described that enhance the instructional activities within the Module.
Level Descriptors
a. Multiple examples of student activities utilizing the resources provided by industrial partnerships are described that enhance the Module
b. One or two examples of student activities utilizing the resources provided by industrial partnerships are described that enhance the Module.
c. Examples of uses of industrial partnerships are listed but not fully described.
d. No examples of the uses of industrial partnerships are described.

Table 11.18 Alternate Module Rubric (continued)

Standard: <u>Specialized References and Vendors</u> are listed that are specific to the activities contained in the Module (if there are no specialized references and vendors needed in the module, type "none")
Level Descriptors
a. A complete list of specialized references and/or vendors is provided for each activity contained in the Module.
b. No specialized reference list is provided.
Standard: <u>Teaching Models</u> employed within the Module have been identified.
Level Descriptors
a. All Teaching Models employed within the Modules are identified.
b. Some Teaching Models used have been omitted or some that are identified are not employed in the Module.
c. No Teaching Models have been identified.
Standard: The <u>Model(s) of Curricular Integration</u> employed within the Module is/are identified and graphic organizer is attached.
Level Descriptors
a. The Model(s) of curricular integration have been identified and graphic organizer is attached
b. The Model(s) of curricular integration have been identified but no graphic organizer is attached
c. Model(s) have not been identified.
Standard: <u>Technology Utilized</u> in the Module activities has been identified.
Level Descriptors
a. The Technology Utilized within the Module has been identified.
b. The Technology identified has either not been utilized in Module activities or Technology described in lesson activities have not been identified.
c. Technology has not been identified.
Standard: <u>Web Sites</u> are identified which relate to module activities.
Level Descriptors
a. At least one web site is identified that is related to module activities.
b. No web sites have been identified.
Standard: The levels of *Bloom's Taxonomy of Objectives* are identified.
Level Descriptors
a. The frequency of use for each Bloom's level is identified and correctly relates to the module activities.
b. One or more Bloom's levels checked does not relate to the module activities.
c. No Bloom's levels are checked.
Standard: <u>Opportunities for further interrelated activities with additional fields or disciplines are described</u>
Level Descriptors
a. At least one opportunity is suggested and described that might be employed by others using this module.
b. No opportunities are suggested.
Standard: The Module includes at least 2 Performance Tasks with assessments.
Level Descriptors
a. Module contains at least two performance tasks with assessments.
b. Module contains at least two performance tasks, but some or all of the assessments are missing,
c. Module contains less than two performance tasks with assessments.
d. Module contains less than two performance tasks but some or all of the assessments are missing
Standard: Module includes a pretest-posttest.
Level Descriptors
a. A pretest -posttest is attached.
b. No pretest-posttest included.
<u>Master Schedule of Lesson Activities</u>
Standard: Lesson topics are scheduled by week/date and content areas in the order in which they are presented to students.
Level Descriptors
a. All content areas, lesson topics, and week/dates are listed,
b. Some content areas, topics or week/dates are missing.
c. All content areas, lesson topics, and week/dates are missing.

Table 11.19 Alternate Module Rubric (continued)

<u>Lesson Activities and Procedures For each lesson title listed:</u>

Standard: The lesson should contain a descriptive <u>Lesson topic.</u>

Level Descriptors

a. The Lesson Topic should include a statement that adequately describes the material to be covered in the lesson.

b. No Lesson Topic is provided or it does not describe the lesson material.

Standard: The lesson contains one or more <u>Lesson Benchmarks/District Objectives.</u>

Level Descriptors

a. Each benchmark/objective listed matches one taken directly from the ILS and/or District Objectives.

b. Not all of the listed benchmarks/objectives match those in the I.L.S. and/or District.

c. None of the benchmarks/objectives listed are taken from the I.L.S. and/or District

Standard: An estimated <u>Length of Lesson</u> is provided for each lesson.

Level Descriptors

a. An estimated number and length of class periods is provided that seem appropriate for the content.

b. The estimated number and length of class periods provided seem inappropriate for the content.

c. No Lesson Length is given.

Standard: A list <u>of Materials and resources</u> necessary for students to complete Module activities is provided

Level Descriptors

a. A complete list of all necessary materials and resources is present.

b. A list of materials and resources is present, but obvious omissions are apparent.

c. No list of materials and resources is provided.

Standard: All <u>Student Products</u> to be collected from students are indicated.

Level Descriptors

a. Each Product required is checked.

b. One or more Products are checked that are not indicated in other Lesson Activities.

Standard: Module contains traditional and authentic instruments used to assess student products and/or process(es).

Level Descriptors

a. Traditional and authentic instruments are attached that assess student products and process(es).

b. Traditional and authentic instruments are attached that assess some student products and process(es).

c. Most assessment instruments attached are traditional in nature.

d. No assessment instruments are included in this section.

12. Student Performance Assessment[*]

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Foundation

The Education Commission of the States (1995) has identified the attributes of good practice for higher education, but they apply equally to secondary education. The commission argues that good assessment can lead to the transformation of education when considering "…that when [educators] systematically engage in these good practices, student performance and satisfaction will improve" (p.5). These quality indicators show the integral aspect of assessment. They provide evidence of successful teaching and learning or evidence for setting improvement goals and are also helpful in guiding and structuring improvements (Huba & Freed, 2000):

Quality begins with an organization culture that values

1. High expectations
2. Respect for diverse talents and learning styles
3. Emphasis on the early years of study [e.g., general education]

A quality curriculum requires

4. Coherence in learning
5. Synthesizing experiences
6. Ongoing practice of learned skills
7. Integrating education and experience

Quality instruction builds in

8. Active learning
9. Assessment and prompt feedback
10. Collaboration
11. Adequate time on task
12. Out-of-class contact with faculty (possibly an exception for secondary school teachers)

Wiggins and McTighe (2000) provide a "backwards" design process where student learning standards are considered as the foundation for all curriculum and instruction decisions and are followed by choosing the assessment procedure that will provide the desired type of evidence of learning. Wiggins (1998) identifies three types of educational standards: "Content standards: What should students know and be able to do? Performance standards: How well must students do their work? And Task (work-design) standards: What is worthy and rigorous

[*] Conard White served as primary leader of this program component.

work? What tasks should students be able to do?" (p. 106). Wiggins and McTighe state (pp. 110-111) that assessments should be

1. Credible to all stakeholders, but especially to teachers, parents, and older students.
2. Useful, meaning user-friendly and helpful to the student performers and their coaches, namely teachers.
3. Balanced, in the use of all assessment methods, to provide a rich, defensible and feasible profile of achievement, but anchored in authentic and complex performance tasks.
4. Honest yet fair, reporting how each student is doing against important standards but not uselessly ranking novices and experts against each other.
5. Intellectually rigorous and thought provoking; focusing on core ideas, questions, problems, texts, and knowledge; but also engaging and stimulating of inquiry and interest in intellectual work.
6. Feasible in terms of resources, logistics, politics, and redeployment of time for collaboratively designing, debugging, using, evaluating, and reporting work.

Lissitz and Schafer (2002, pp. 23-26) also provide standards for assessment quality:

1. Quality assessments arise from and accurately reflect clearly specified and appropriate achievement expectations for students.
2. Sound assessments are specifically designed to serve instructional purposes.
3. Quality assessments accurately reflect the intended target and serve the intended purpose.
4. Quality assessments provide a representative sample of student performance that is sufficient in its scope to permit confident conclusions about student achievement.
5. Sound assessments are designed, developed, and used in such a manner as to eliminate sources of bias or distortion that interfere with the accuracy of results.

Kuhs et al. (2001, p. 2) add that "in addition to guiding classroom instruction," assessment helps teachers

- formulate plans and strategies to support the instructional needs of students
- share information with students about their progress
- collect information to assign student grades
- evaluate the effectiveness of their instructional strategies and curricula
- prepare summative information on student progress for decisions such as promotion, retention, assignment to special programs, and referrals to other needed assistance programs.

Additionally, they (p. 4) offer characteristics of quality assessment through the following questions:

1. Does the assessment focus on knowledge and skills that were taught in class and are outlined in district curriculum guides and in state and national content standards?
2. Does the assessment provide information about student learning that represents typical performance?
3. Does the assessment provide opportunities for all types of students to demonstrate what they have learned?

These authors also discuss the types of assessments, observation, performance tasks, scoring-guides checklists and rubrics, tests, portfolios, and interviews, as well as what they term a multifaceted assessment system (Figure 1).

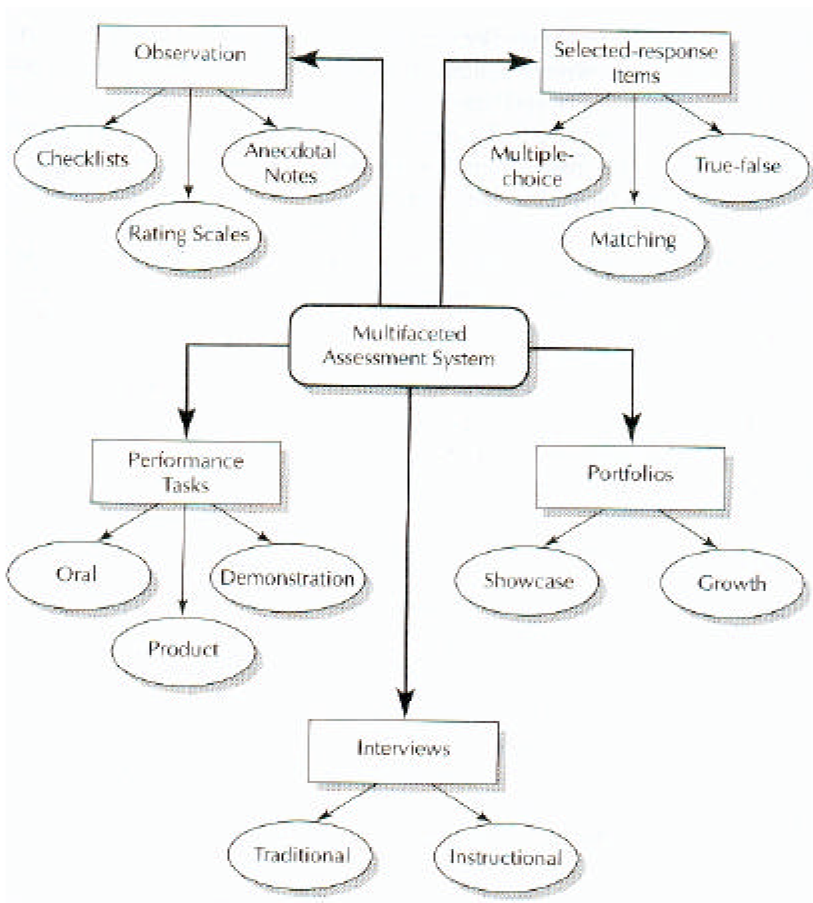

Figure 12.1 Multifaceted Assessment System **(Kuhs et al., 2001, p. 157)**

Teachers rely greatly upon "teacher-made tests." Most of the teachers we worked with identified test construction as an area in which they felt little confidence about their own capabilities. The second area within testing is grading. The meaning of grades within a single course by one teacher, and across several courses by several teachers, as judgments about student learning or achievement can be problematic when considering all the factors and issues. And finally, teachers are aware of a current focus on student performance assessment versus traditional testing, but not of how the two relate; therefore, how to develop performance tests and rubrics has also been an important area for professional development. Teachers are somewhat confused by the movement toward performance assessment, while the continued reliance of schools on standardized testing makes them question the value of active learning and performance-based assessment. Most teachers understand the test as the terminal measurement of student achievement rather than understanding that tests or "test items are meant to be useful as *indicators* of valued 'real world' performances" (Linn & Baker, 1996, as quoted in National Society for the Study of Education, 1996, p. 85). Therefore, performance assessments should create additional opportunity for students to provide evidence they can use the knowledge measured on the test.

Wiggins (1998) defines "educative assessment" as "deliberately designed to teach (not just measure) by revealing to students what worthy adult work looks like (offering them authentic tasks). It should provide rich and useful feedback to all students and to their teachers, and it should be designed to assess the use of feedback by both students and teachers" (p. 12). A learning-centered assessment system should

1. Be designed to improve performance (of student and teacher)…built upon a bedrock of meaningful performance tasks that are credible and realistic (authentic), hence engaging students. This system must also:
    a. Be open – that is based on tasks, criteria, and standards known to students and their teachers…less reliant on audit testing methods that require test questions are kept a secret.
    b. Model exemplary instruction, encouraging rather than undercutting desirable teaching practice and showing all teachers how the most rich and vital educational goals and pedagogies can be assessed.
    c. Use grades that stand for something clear, stable, and valid…linked directly to credible and important state or national standards for assessing performance on authentic tasks.
    d. Measurably improve student performance over time so that standards once thought very high and reachable by only a few become reasonable expectations for many students.
2. Provide useful feedback to students, teachers, administrators, and policymakers. A useful feedback system must:
    a. Provide data and commentary that are rich, clear, and direct enough to students and teachers to self-assess accurately and self-correct their own performances increasingly over time….not center on praise and blame.
    b. Provide ample opportunities to get and use timely and ongoing feedback. (Wiggins, 1998, pp. 12-13)

Wiggins (pp. 17-18) presents five key ideas on assessment and its reform:

1. Assessment must center on purpose, rather than merely on techniques or tools.
2. Assessment is a moral matter in that teachers and students are entitled to systems that are user friendly and enhance teaching.

3. Assessment is central to instruction, not peripheral to it.
4. Assessment "anchors teaching, and authentic tasks anchor assessment."
5. Performance improvement is local. Although guided by national and state standards, student learning occurs locally.

A Balanced Assessment System

The best approach is to use a variety of assessment tools or procedures to produce a balanced system over the course of the standards to be achieved. The idea is to offset the limitations of one type of assessment against the strengths of another.

A balanced system should include good and reliable traditional assessment, performance assessment, and portfolio assessment. Traditional assessment is typically used to determine grades and rankings, whereas performance assessment provides the opportunity to observe learning results, and portfolio assessment provides the opportunity to determine growth and development over time. A system encompassing various assessments can develop students' ability to perform in types of assessment where they have traditionally shown weaker performance, while also giving them the opportunity to perform through procedures in which they have excelled (Wiggins, 1998, pp. 115-116). (See Figures 2 and 3.)

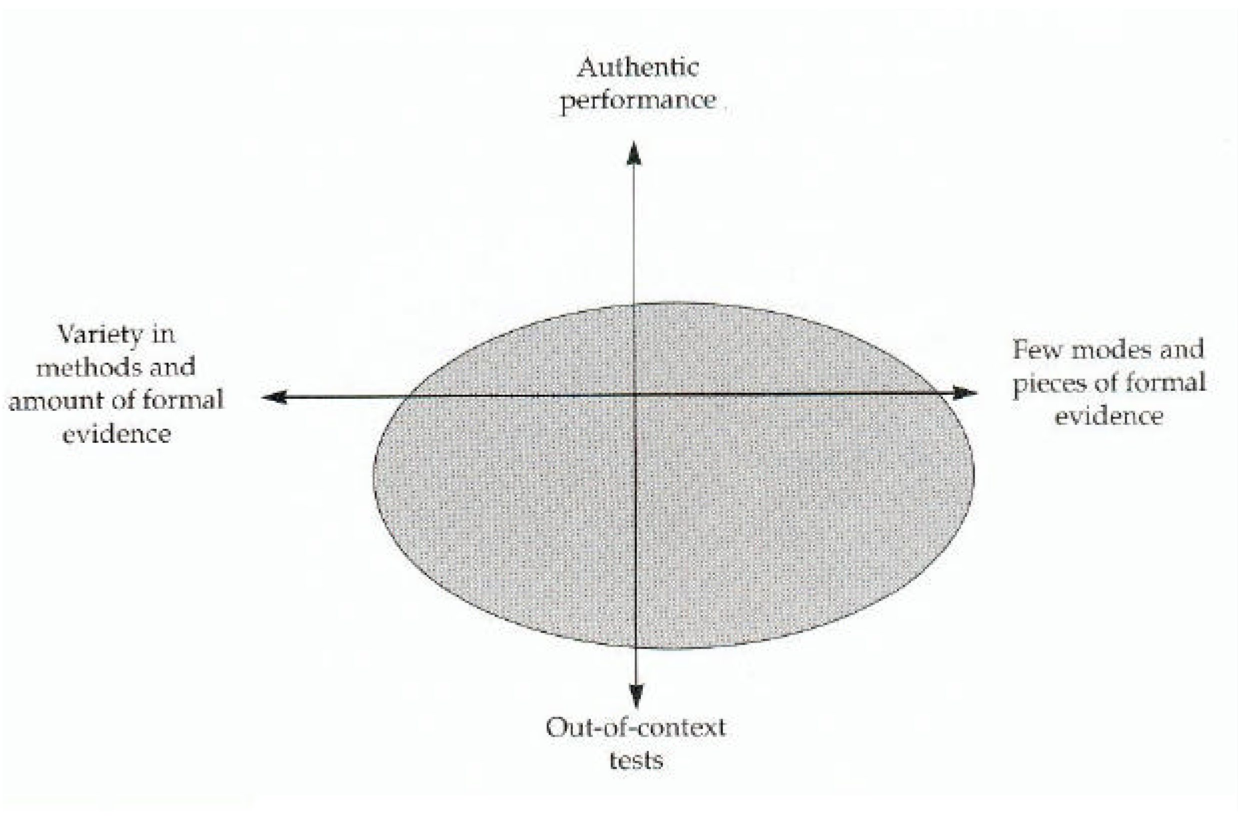

Figure 12.2 Typical Unbalanced Assessment in Classrooms and Schools (Wiggins, 1998, p. 115)

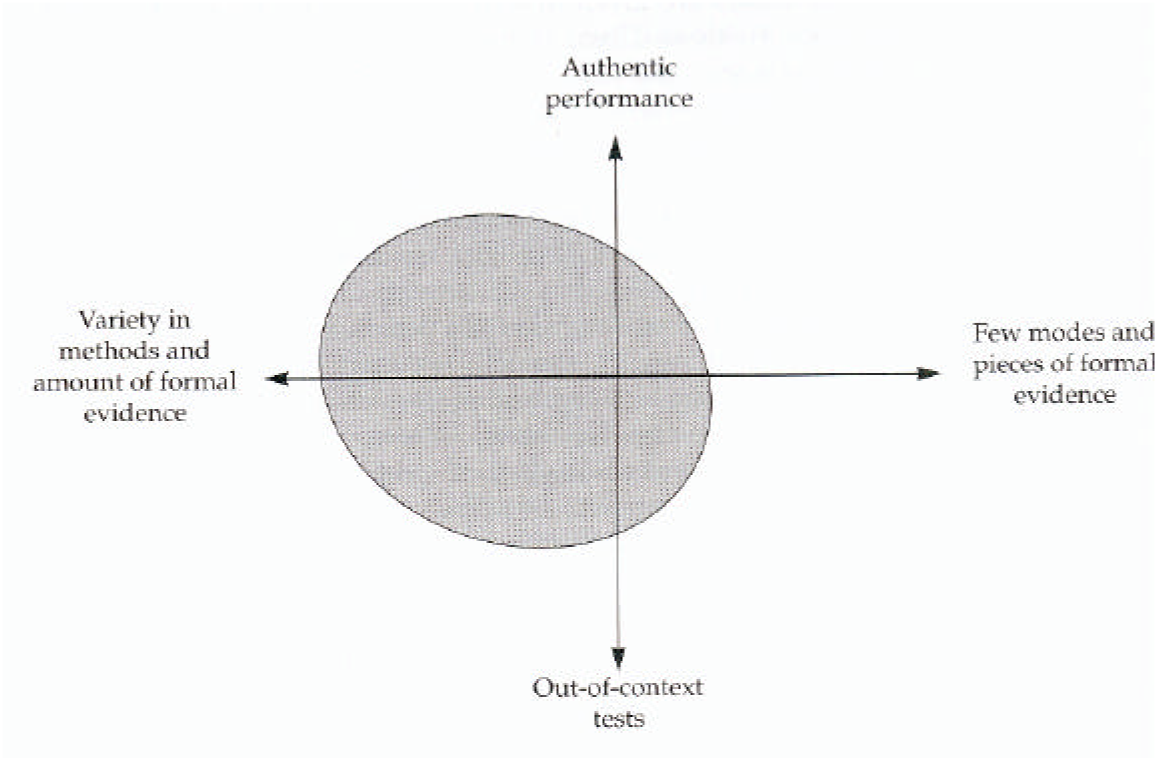

Figure 12.3 Exemplary Assessment Balance (Wiggins, 1998, p. 116)

When providing professional development for teachers, it is impossible to address all student assessment issues in a single program. Therefore, we chose to focus on improving their traditional test development skills by working with them on the development of their module pretests and posttests, making sure that those tests were measuring student progress toward achieving standards. However, to introduce them formally to more authentic performance assessment, we helped them understand what authentic means, what a performance is, and how to identify performances that provide evidence of student learning of vital concepts and principles. This is where providing experiences in real-world industry, business, or community organizations helped them transform "theory into action."

Many teachers struggle to distinguish among (1) knowledge, the concepts or principles of a discipline; (2) cognitive skills that transcend all disciplines and learning; and (3) other types of skills, ranging from academic skills (such as reading), the problem-solving process, the organization of information, and beyond that, discipline-specific skills. Of course, there is a fine line between labeling some of these "knowledge" versus "skills." In addition and very importantly, many teachers are not secure in knowing the difference between the knowledge taxonomy of their discipline and the more contextual "curriculum content" within which knowledge or skills can be embedded or taught. For example, teachers may identify computer-aided-design (CAD) software functions as knowledge, whereas mechanical drawing or engineering graphics concepts such as cross-sectional views would be a concept, and the software functions and hardware components of CAD would be technological tools. Another example is from English: a knowledge concept would be figurative or persuasive writing, whereas the novel would be the contextual content within which the concepts and principles of writing are applied. We have often found teachers testing on the novel rather than the knowledge, concepts, and principles involved in writing literature.

Education versus training is something else to consider. The intent of educators is to teach knowledge that can be used across learning (courses or disciplines) or real-world contexts. Use of a concept or principle requiring interpretation, reasoning, practical application, and comprehension at the Bloom's Taxonomy levels of synthesis and evaluation, or the "create" level of the revised Bloom's Taxonomy, takes place through education processes (Anderson & Krathwohl, 2001). Education is often combined with training. For example, education should occur on mechanical drawing knowledge, while training should occur on the CAD software and hardware. An example of training without education is when students use a "template" approach to algebraic formulae but are unable to find a mistake because they have no understanding of the relationships between the factors in the formula.

The standards movement has made it easier to bring teachers to an understanding about what they should be measuring. When teachers understand the critical questions to ask themselves – what standards they want students to achieve, what level of achievement is desired, what the best method of assessing the learning is, and ultimately how to contextualize what is to be learned – they can then move on to other instructional decision making. They begin to understand that performance assessment should be intertwined with learning. Traditional testing is artificial and requires a "time out" for testing memory or comprehension, such as making simple comparisons. Many teachers are striving to infuse more critical thinking into traditional test items; others are rewriting traditional test items to ensure concept attainment when allowing use of technology while taking the test. Authentic and performance-based assessment, however, differs in that often students will not feel that they are being tested but that they are performing while learning and learning while performing. The two are not artificially separated. It is more a culture of achieving outcomes through performance tasks. To us, a complex performance task is one that embeds several performances as a cluster; that cluster is embedded within a real-world scenario and the performance tasks are as authentic as possible. The performances require a range of outcomes, such as the use of knowledge at the upper critical thinking levels and the use of cognitive skills, and may include a requirement that students use academic and other skills within a context to which they can relate. The question of "what" is to be measured and then the alignment of the achievement targets with assessment methods is critical. Chatterji (2003, pp. 96-98) identifies five types of assessments:

- 1a. Written structured-response assessments – usually timed, fixed, or selected response, written exercises
- 1b. Written open-ended assessments – usually timed, constructed response, written exercises
- 2. Behavior-based assessments – behaviors or demonstrations exhibited in natural or structured settings
- 3. Product-based assessments – products, reports, or items created in structured or unstructured situations
- 4. Interview-based assessments – one-on-one verbal (oral) interaction in structured or unstructured situations

5. Portfolios – purposeful collections of behaviors or work samples made over time

Lissitz and Shafer (2002) provide an example of matching targets to methods (Table 1).

Table 12.1 Aligning Achievement Targets to Assessment Methods (Lissitz and Shafer, 2002)

Target to Be Assessed	*Assessment Method*			
	Selected Response	*Essay*	*Performance Assessment*	*Personal Communication*
Knowledge Mastery	Multiple choice, true/false, matching, and fill-in can sample mastery of elements of knowledge	Essay exercises can tap understanding of relationships among elements of knowledge	Not a good choice for this target—three other options preferred	Can ask questions, evaluate answers, and infer mastery—but a time-consuming option
Reasoning Proficiency	Can assess understanding of basic patterns of reasoning	Written descriptions of complex problem solutions can provide a window into reasoning proficiency	Can watch students solve some problems and infer about reasoning proficiency	Can ask student to "think aloud" or can ask follow-up questions to probe reasoning
Skills	Can assess mastery of the prerequisites of skillful performance—but cannot tap the skill itself	Can assess mastery of the prerequisites of skillful performance—but cannot tap the skill itself	Can observe and evaluate skills as they are being performed	Strong match when skill is oral communication proficiency; also can assess mastery of knowledge prerequisite to skillful performance
Ability to Create Products	Can assess mastery of of knowledge prerequisite to the ability to create quality products—but cannot assess the quality of products themselves	Can assess mastery of knowledge prerequisite to the ability to create quality products—but cannot assess the quality of products themselves	A strong match can assess: (a) proficiency in carrying out steps in product development and (b) attributes of the product itself	Can probe procedural knowledge and knowledge of attributes of quality products—but not product quality

Source: Student-Involved Classroom Assessment, 3/e, by R. J. Stiggins, © 2001. REPRINTED BY PERMISSION OF PEARSON EDUCATION, INC., UPPER SADDLE RIVER, NJ 07458.

Wiggins (1998, p. 23) presents the key differences between typical tests and authentic tasks (Table 2). Also important is the question, "To what level of achievement?" Along with the original Bloom's Taxonomy (Table 3) (Bloom, 1956), I use the revised Bloom's Taxonomy in *A Taxonomy for Learning, Teaching, and Assessing* (Anderson & Krathwohl, 2001, p. 100). This schema (Table 4) identifies the types of knowledge and reveals changes in the cognitive process dimension. When using this taxonomy to plan my own teaching and student learning, I may still need the "synthesis" level of the original Bloom's Taxonomy, but "create" as the final category is very appropriate and does inherently require synthesis. Another very useful aspect of *A Taxonomy for Learning, Teaching, and Assessing* is a table comparing the original Bloom's Taxonomy to other multidimensional classification systems.

Table 12.2 Key Differences between Typical Tests and Authentic Tasks (Wiggins, 1998, p. 23)

Typical Tests	*Authentic Tasks*	*Indicators of Authenticity*
Require correct responses only	Require quality product and/or performance, and *justification*.	We assess whether the student can explain, apply, self-adjust, or justify answers, not just the correctness of answers using facts and algorithms.
Must be unknown in advance to ensure validity	Are known as much as possible in advance; involve excelling at predictable demanding and core tasks; are not "gotcha!" experiences.	The tasks, criteria, and standards by which work will be judged are predictable or known—like the recital piece, the play, engine to be fixed, proposal to a client, etc.
Are disconnected from a realistic context and realistic constraints	Require real-world use of knowledge: the student must "do" history, science, etc. in realistic simulations or actual use.	The task is a challenge and a set of constraints that are authentic—likely to be encountered by the professional, citizen or consumer. (Know-how, not plugging in, is required.)
Contain isolated items requiring use or recognition of known answers or skills	Are integrated challenges in which knowledge and judgment must be innovatively used to fashion a quality product or performance.	The task is multifaceted and non-routine, even if there is a "right" answer. It thus requires problem clarification, trial and error, adjustments, adapting to the case or facts at hand, etc.
Are simplified so as to be easy to score reliably	Involve complex and non-arbitrary tasks, criteria, and standards.	The task involves the important aspects of performance and/or core challenges of the field of study, not the easily scored; does not sacrifice validity for reliability.
Are one shot	Are iterative: contain recurring essential tasks, genres, and standards.	The work is designed to reveal whether the student has achieved real versus pseudo mastery, or understanding versus mere familiarity, over time.
Depend on highly technical correlations	Provide direct evidence, involving tasks that have been validated against core adult roles and discipline-based challenges.	The task is valid and fair on its face. It thus evokes student interest and persistence, and seems apt and challenging to students and teachers.
Provide a score	Provide usable, diagnostic (sometimes concurrent) feedback: the student is able to confirm results and self-adjust as needed.	The assessment is designed not merely to audit performance but to improve future performance. The student is seen as the primary "customer" of information.

Table 12.3 Bloom's Ranking of Thinking Skills (Bloom, 1956, p. 100)

Bloom's Ranking of Thinking Skills					
Knowledge	**Comprehension**	**Application**	**Analysis**	**Synthesis**	**Evaluation**
List Name Identify Show Define Recognize Recall State Visualize	Summarize Explain Interpret Describe Compare Paraphrase Differentiate Demonstrate Classify	Solve Illustrate Calculate Use Interpret Relate Manipulate Apply Modify	Analyze Organize Deduce Contrast Compare Distinguish Discuss Plan Devise	Design Hypothesize Support Schematize Write Report Justify	Evaluate Choose Estimate Judge Defend Criticize

Table 12.4 Taxonomy Table (Anderson & Krathwohl, 2001, p. 100)

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge						
C. Procedural knowledge						
D. Meta-cognitive knowledge						

Major Types and Subtypes	Examples
A. Factual knowledge—The basic elements students must know to be acquainted with a discipline or solve problems in it	
AA. Knowledge of terminology	Technical vocabulary, musical symbols
AB. Knowledge of specific details and elements	Major natural resources, reliable sources of information
B. Conceptual knowledge—The interrelationships among the basic elements within a larger structure that enable them to function together	
BA. Knowledge of classifications and categories	Periods of geological time, forms of business ownership
BB. Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
BC. Knowledge of theories, models, and structures	Theory of evolution, structure of Congress
C. Procedural knowledge—How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
CA. Knowledge of subject-specific skills and algorithms	Skills used in painting with watercolors, whole-number division algorithm
CB. Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
CC. Knowledge of criteria for determining when to use appropriate procedures	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D. Metacognitive knowledge—Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
DA. Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a text-book, knowledge of the use of heuristics
DB. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of the types of tests particular teachers administer, knowledge of the cognitive demands of different tasks
DC. Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weak-ness; awareness of one's own knowledge level

Figure 12.4 Major Types and Subtypes of the Knowledge Dimension (Anderson & Krathwohl, 2001)

The Kolb Learning Cycle is also a useful tool. Fry et al. (2003) define experiential learning as "learning by doing" (p. 14). They credit Kolb for the most popular theory of learning from experience. Experiential learning is based on the notion that understanding is not a fixed or unchangeable element of thought but is formed and re-formed through experience, "a continuous process often represented as cyclical, and, being based on experience, implies that we all bring to learning situations our own ideas and beliefs at different levels of elaboration" (p. 14). The Kolb Learning Cycle requires four abilities when learning is successful (p. 15).

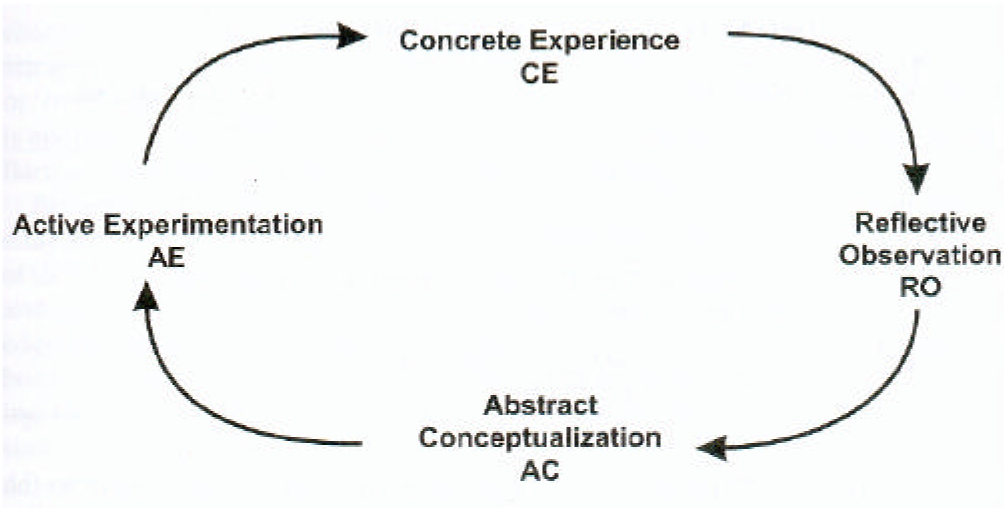

Figure 12.5 Kolb Learning Cycle (Fry et al., 2003, p. 15)

For our purposes, this cycle can be used as a metric, just as the Bloom's and revised Bloom's taxonomies can be, to guide the planning, execution, and evaluation of teaching and learning. This approach makes it possible to deepen learning and broaden understanding and application of knowledge across contexts and produces more authentic learning and deeper learning.

Assessment as Learning

So far, we have mentioned assessment *of* student learning, the dominant type in schools today. Now, let us discuss two other types, assessment *for* learning and assessment *as* learning (Table 5). Assessment *for* learning requires a fundamental shift from summative assessment (evaluative judgment) to formative (ongoing) assessment, where descriptions are created that can guide or inform the next stage of learning:

> [T]eachers collect a wide range of data so that they can modify the learning work for their students. They craft assessment tasks that open a window on what students know and can do already and use the insights that come from the process to design the next steps in instruction…Marking (scoring or grading) is not designed to make comparative judgments among the students but to highlight each student's strengths and weaknesses and provide them with feedback that will further their [individual] learning. (Earl et al., 2003, p. 24)

This changes the teacher's role. Teachers are central in the assessment of learning, but in assessment *for* learning, they use their knowledge of the student and the learning context to determine learning needs. The timing is also different as assessment *for* learning happens throughout learning, usually more than one time, not at the end as with assessment *of* learning. In assessment for learning, teachers interact with students differently and record-keeping is more of the checklist, rubric, and portfolio type, showing a progression of student learning along a continuum (Table 5; Figures 6 and 7).

Assessment *as* learning has been our model, for we believe that teachers and students perform best *while* learning and that assessment activities can *serve as the learning mechanism.* When assessment is effective, the students (in our case the teachers and ultimately their students) become self-motivated and do not wait for the teacher (our program leaders) to "judge" whether their answer or work is correct. Rather, reflection and the construction of meaning enable them to realize, on their own or with team members, when they do not understand something. They then take steps to figure out what they need and where or how to find it. Comparisons *between* individual teachers or students are no longer relevant; rather they compare their own growth or progress with their prior knowledge, skills, or abilities.

When working with teachers, we generally made performing and learning indistinguishable from each other, one driving the other. The teachers presented, discussed, and ultimately owned the goals or standards they achieved. Then they participated in learning activities with the needed integral knowledge and skill development. As they learned, they developed new products, attitudes and behaviors, and processes, or performed using new strategies, models, techniques, or procedures. They were both learning and being assessed, simultaneously.

This is one method of "curriculum embedded assessment" where the traditional test at the end is replaced by the culminating product or performance. Ongoing immediate feedback is critical in this process, but it can be informal as well as formal. Performance-based assessment is usually not arbitrarily separated from learning and is less artificial than tests, which are merely *indicators* of potential performance ability or of "valued real-world performances" (Wolf & Reardon and Linn & Baker, as cited in National Society for the Study of Education, 1996, pp. 19-20, 85).

Table 12.5 Features of Assessment of, for, and as Learning

Approach	*Purpose*	*Reference Points*	*Key Assessor*
Assessment *of* Learning	Judgments about placement, promotion, credentials, etc.	Other students	Teacher
Assessment *for* Learning	Information for teachers' instructional decisions	External standards or expectations	Teacher
Assessment *as* Learning	Self-monitoring and self-correction or adjustment	Personal goals and external standards	Student

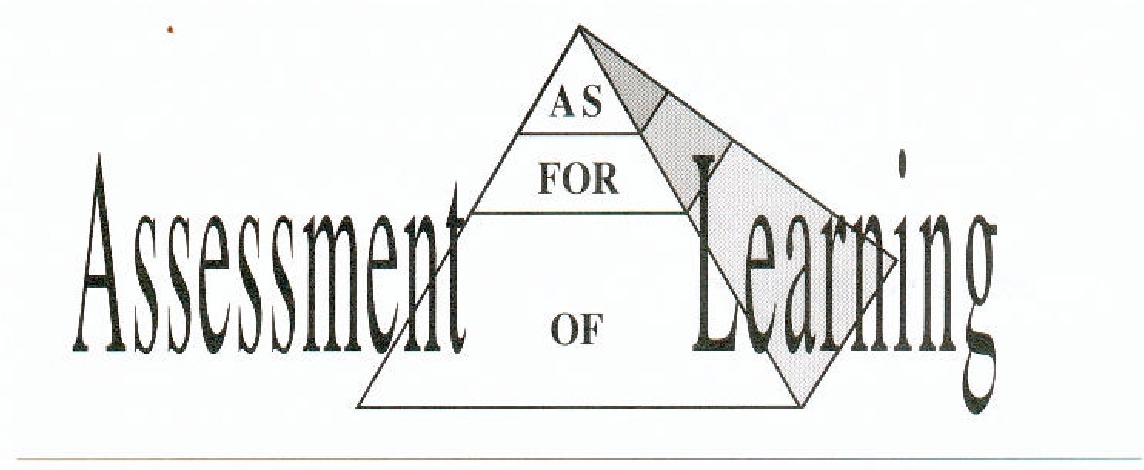

Figure 12.6 Traditional Assessment Pyramid (Marzano et al., 1993, pp. 26-27)

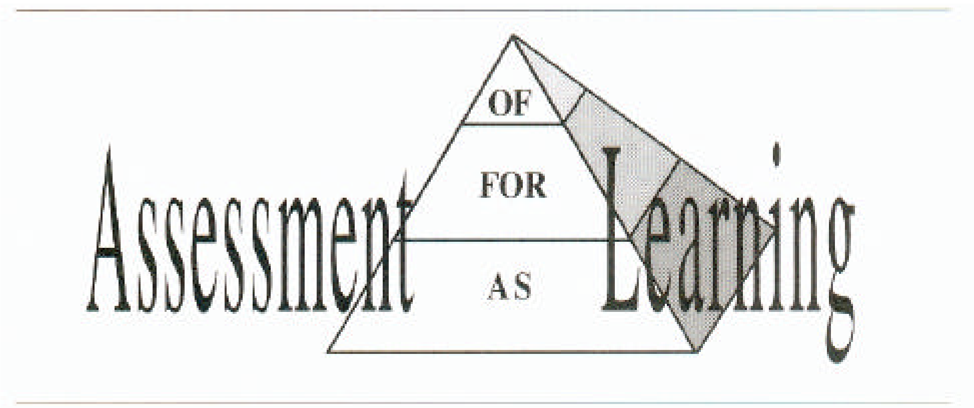

Figure 12.7 Reconfigured Assessment Pyramid (Marzano et al., 1993, pp. 26-27)

Authentic or Performance-Based Assessment

Standardized tests force instruction to focus on the

> accumulation of facts and decontextualized skills. A very different approach is offered by the National Council of Education Standards and Testing, the National Education Goals Panel, the New Standards project, the American Association for the Advancement of Science, the National Councils of Teachers of English and Mathematics, and others. They advocate for curriculum reforms that emphasize reasoning, higher-order thinking skills, and identification and solution of real-world (authentic) problems. Therefore, authentic performance-based assessments are critical and integral to those reforms and considered exemplary instructional practice where assessment and instruction are indistinguishable from each other. (Linn & Baker, as cited in National Society for the Study of Education, 1996, p. 85)

The National Education Goals Panel, in its first report, identifies a need for higher standards related to student assessment. Its authors advise that (authentic) performance-based assessments may be more closely aligned with educational goals than standardized tests (p. 86). They (pp. 87-89) provide the following characteristics for performance-based assessment:

1. Be open-ended. Require the student to construct a response or perform an activity.
2. Involve higher-order, complex skills. These would include formulating and solving problems, reasoning, and communication.
3. Require extended periods of time for performance. Include the collection and analysis of data as well as the preparation of written or oral presentations of results and conclusions.
4. Involve group performance. Students working together may be asked to formulate hypotheses and design experiments.
5. Give student and teacher a choice of tasks. Performance-based assessments often allow some degree of latitude in the choice of tasks.
6. Rely on judgmental scoring. This requires scoring guidelines or rubrics and training.

In addition, there is much to be considered if the desire is to design valid and reliable performance tasks. Content quality, curricular importance, cognitive complexity, linguistic appropriateness, ancillary skills, and the meaningfulness of the tasks for students are all important considerations in the development of performance tasks. Also important are the consequences for students and teachers, fairness when assessing diverse learning groups, the transferability of results, how to compare results over time with confounding cohort differences, and instructional sensitivity to the general intellectual ability of the students. And finally, technical quality is a definite requirement for performance assessments (Linn & Baker, as cited in National Society for the Study of Education, 1996; McMillan et al., 2001).

Wiggins (1998, pp. 139-140) establishes that performance tasks should be:

- *Authentic*: they should have realistic options, constraints, criteria, standards, and audience, and a genuine purpose.
- *Credible:* they should address rigorous content and performance standards.
- *User-friendly:* they should be feasible, appropriate, engaging, and rich in feedback, with rehearsal and revision built in. They should provide a clear and complete set of instructions, guidelines, and models; and troubleshooting should be available.

Wiggins is careful to warn readers that while performance-based and authentic do not mean the same thing, they are often used interchangeably (pp. 140-141):

1. Just because it is a performance task does not mean that it is authentic. Not all performance tasks reflect the real world.
2. A task involving hands-on work is not necessarily authentic. It may not involve the methods and procedures of the real world, or perhaps the answers are already known.
3. A constructed-response task may not be authentic or even a performance task. Performance or production requires the student to plan and execute a new work from scratch and to use good judgment in choosing content and shaping a product.

4. A task that is authentic is not necessarily valid. Validity entails the ability to infer about performance based on an apt sample of work. Many authentic challenges make poor assessment tools because they do not permit easy isolation of performance.
5. Just because a task is inauthentic does not make it invalid.

To support teachers in their development of high-quality assessments and performance tasks, we provided teachers with examples and gave immediate and continuous feedback as they designed and developed their performance tasks. Wiggins (1998) has easy-to-use guidelines; we also used Hart (1994).

Scoring and Grading

Rubrics make public the key criteria that students use in developing, judging, and revising their work. Rubrics hold both the student and teacher accountable. Students know and understand what they have to do to achieve at established levels, and teachers cannot "change the rules" once the rubrics are in the hands of the students. Rubrics also build consistency in scoring or grading, while reducing bias. And most importantly, students are rarely surprised by their scores or grades (Huba & Freed, 2000).

Teachers enthusiastically reported that using rubrics resulted in higher-quality student work, more learning, improved scoring or grading, and better teacher-student relationships. They also felt that the self-assessment integral to the use of rubrics motivated students to achieve at higher levels.

There are all kinds of rubrics. We developed very simple ones for use in scoring the teachers' performance tasks, rubrics, and, ultimately, curricula modules. In considering what good rubrics need, the following elements are important:

- Levels of mastery describe the level the student has achieved.
- Dimensions of quality can be discipline specific or include general education knowledge and skills, cognitive processes, procedural knowledge, etc.
- Organizational groupings are clusters of criteria within a particular grouping.
- Commentaries are the descriptions of each criterion by level.
- Description of consequences is where the teacher reveals the consequences of performing at a given quality level in a real-life setting. A form of feedback encourages students to think about what will happen in a real-world setting. (Huba & Freed, 2000, p. 167)

Rubrics can broadly accomplish two important things: educate students and judge their work. Students learn the expected or optional standards of the discipline or profession, internalize them, and build aspirations for themselves, connecting what they are learning to their real world after graduation. Students also become informed about what constitutes poor, good, and excellent qualities of work or performance. They can use this to self-assess, provide themselves with feedback, and then correct their work before turning it in to the teacher. Teachers asked us for benchmarks or work that exemplified qualities of work that we expected of them. Huba and Freed (2000) have suggested that students examine "ungraded" work across various levels of quality: “When students have an opportunity to examine assignments that differ in quality, they usually find that their own work is enhanced” (p. 170).

There are a variety of styles of rubrics, some with descriptions as in the samples provided below, and others with more simply stated criteria below each standard (Figures 8 through 14 in the appendix; also see examples on the website, www.strategicalliance.niu.edu.).

Rubrics must have prescribed standards and criteria levels for each standard, establishing various levels of achievement possible with a point system. Standards can be absolute or developmental. The absolutes are those exemplary benchmarks established de facto as the best. Developmental standards are established for particular cohorts (e.g., high school versus college), so excellence is determined for each type of cohort. Expectations are different in nature. Expectations reflect patterns or norms for groups; in other words, a student is expected to perform at a particular level because there is a pattern of that result for his or her ability and experience levels. “Students can exceed norms and expectations but still not perform up to standard” because norms have the effect of “hiding how students and teachers are doing when judged against worthy standards” (Wiggins, 1998, pp. 157-158). Good rubrics have a logic and chronology. They also, as with performance tasks, need to be valid in that the appropriateness and validity of the criteria and descriptors for discrimination, or making judgments against, are valid in relation to the tasks. These are holistic and analytic trait rubrics. Criteria are often of five types: impact, craftsmanship, methods, content, and sophistication of performance. One need not use all five all the time; “the challenge is to make sure that we have a feasible set of right criteria and that we have distinguished between genuine criteria and mere indicators or useful behaviors” (p. 168). Weights are important considerations. For example, should processes and results be weighted the same or should the mechanics of writing and the content be equally weighted? Rubric descriptors should address both strengths and errors in the work or performance judged.

Summing up Rubrics

According to Wiggins (1998, pp. 184-185), the best rubrics

1. Are sufficiently generic to relate to general goals beyond an individual performance task, but are specific enough to enable useful and sound inferences about the task.
2. Discriminate among performances validly, not arbitrarily, by assessing the central features of performance, not those that are easiest to see, count, or score.
3. Do not combine independent criteria in one rubric.
4. Are based on analysis of many work samples and on the widest possible range of work samples, including valid exemplars.
5. Rely on descriptive language (what quality or its absence looks like) as opposed to merely comparative or evaluative language, such as “not as thorough as” or “excellent product,” to make a discrimination.
6. Provide useful and apt discrimination that enables sufficiently fine judgments, but do not use so many points on the scale (typically more than six) that reliability is threatened.

7. Use descriptors that are sufficiently rich to enable student performers to verify their scores, accurately self-assess, and self-correct. (Use of indicators makes description less ambiguous, hence more reliable, by providing examples of what to recognize in each level of performance.)
8. Highlight judging the impact of performance (the effect, given the purpose) rather than over-rewarding processes, formats, content, or the good-faith effort made.

According to Wiggins, technical rubrics are

1. Continuous. The change in quality from score point to score point is equal: the degree of difference between a 5 and a 4 is the same as between a 2 and a 1. The descriptors reflect this continuity.
2. Parallel. Each descriptor parallels all the others in terms of the criteria language used in each sentence.
3. Coherent. The rubric focuses on the same criteria throughout. Although the descriptor for each scale point is different from the ones before and after, the changes concern variance of quality for the (fixed) criteria, not language that explicitly or implicitly introduces new criteria or shifts the importance of the various criteria.
4. Aptly weighted. When multiple rubrics are used to assess one event, there is an apt, not arbitrary, weighting of each criterion in reference to the others.
5. Valid. The rubric permits valid inferences about performance to the degree that what is scored is what is central to performance, not what is merely easy to see and score. The proposed differences in quality should reflect task analysis and be based on samples of work across the full range of performance; describe qualitative, not quantitative, differences in performance; and not confuse merely correlative behaviors with actual authentic criteria.
6. Reliable. The rubric enables consistent scoring across judges and time. Rubrics allow reliable scoring to the degree that evaluative language ("excellent," "poor") and comparative language ("better than," "worse than") is transformed into highly descriptive language that helps judges to recognize the salient and distinctive features of each level of performance.

Student assessment fits within the broad context of instructional design. The process begins with an instructional analysis to determine what teachers think they are doing, what they should be doing, their strengths and weaknesses, and what they think they are teaching and measuring. We used the learning standards as part of this process and helped teachers focus on what the state and nation prioritize for students to learn. We arranged this process in a variety of ways. Usually, we engaged teachers in the analysis at the beginning of the professional development program. Later, they followed through when participating in the performance assessment component. We modeled best practice in teaching and learning, and used standards, performance assessment, feedback, and rubrics to score the results. The workshop leader worked with teachers in a reiterative process that required a great deal of patience.

To support our teachers in this process, we gave them reference copies of several different sources. These varied according to the year and included the following: Marzano et al. (1993), *Assessing Student Outcomes, Performance Assessment Using the Dimensions of Learning Model;* McTighe and Arter (2001), *Scoring Rubrics in the Classroom;* Hart (1994), *Authentic Assessment;* Burke (1999) *How to Assess Authentic Learning;* and Bellanca et al. (1994), *Multiple Assessments for Multiple Intelligences*.

Developing teachers to the point where they can devise reasonably good and reliable performance tasks and rubrics means more than just teaching them the process; it requires embedding performance tasks within real-world problems and scenarios. Making this connection is very difficult for most teachers, especially those in mathematics and the sciences. It is much less difficult, and in fact more normal, for those in vocational areas or English disciplines. Therefore, MSTE teams benefited from working together on developing performance tasks and rubrics. Vocational teachers were a great asset when guiding mathematics, science, and English teachers to use and develop these more authentic and performance-based kinds of assessments (Tables 6, 7, and 8).

Table 12.6 Rubric for Assessing the Quality of a Performance Task

<u>Key Components</u>

A properly designed Performance Task must:

a. be based on content standards taken from the *Illinois Learning Standards*

b. describe a "real-life" scenario

c. involve students in complex reasoning processes

d. require students to collect and process information

e. incorporate "habits of mind"

f. require student collaboration and cooperation

g. result in a tangible product or communication activity

I. Component: The Performance Task is based on the *Illinois Learning Standards.*

1. The Performance Task is directly related to and based on Learning Standards.
2. Learning Standards are apparent, but the relation to the task is sketchy or irrelevant.
3. The Performance Task does not appear to be based on Learning Standards.

II. Component: A "Real-Life" scenario is described in the Performance Task.

1. The scenario described in the task accurately mirrors an activity in the community outside the classroom.
2. The scenario described in the task simulates an activity in the community outside the classroom.
3. The scenario described in the task contains some aspects of activity outside the classroom but is largely contrived.
4. The scenario described in the task is an academic exercise that usually takes place only in the context of a school setting.

III. Component: The Performance Task involves students in complex reasoning processes.

1. The task requires students to utilize complex reasoning components, such as induction/deduction, diagnosis, abstracting, experimental inquiry, or problem solving.
2. The task requires students to utilize complex reasoning components, such as comparing, classifying, decision making, or investigation.
3. The task requires students to only recall facts.

IV. Component: The Performance Task requires students to collect and process information.

1. The task incorporates a variety of information gathering techniques and information resources. Students are required to interpret and synthesize information and accurately assess the value of information gathered.
2. The task requires students to gather and synthesize information, but the value of the information gathered is not assessed.
3. The task requires students to gather information but not to interpret it.
4. The task requires no gathering or processing of information.

Table 12.7 Rubric for Assessing the Quality of a Performance Task (continued)

V. Component: The Performance Task incorporates "Habits of Mind."

1. The task requires students to make effective plans, use necessary resources, evaluate effectiveness of own actions, seek accuracy, and engage in activities when answers or solutions are not immediately apparent.
2. The task only requires students to effectively plan or use resources.
3. The task does not require students to engage in self-regulation, critical, or creative thinking.

VI. Component: The Performance Task requires student collaboration and cooperation.

1. The task requires students to use interpersonal skills, work toward the achievement of team goals, and perform a variety of roles within the team.
2. The task requires students to work together in teams, but there are no measures described that ensure collaboration or cooperation among team members.
3. The task is completed largely by students on an individual basis rather than in student teams.

VII. Component: The Performance Task results in a tangible product or communication activity.

1. The task result is a tangible product or communication activity comparable to that commonly produced in business or industry.
2. The task results in a product that is similar to those completed in business or industry but lacks several components that make the product realistic.
3. The task does not result in a product or communication activity.

Table 12.8 Rubric for Assessing the Quality of a Rubric

Key Components

A properly designed Rubric must:
a. Contain a set of key components to be assessed.
b. Include descriptors for each key component.
c. Have descriptors that are indicative of observable student performance.
d. Include appropriate weights for each component and descriptor (optional).

I. Component: The Rubric contains a set of key components to be assessed.

Level	*Descriptors*
1	A complete list of key components is provided.
2	Key components listed are not exhaustive for the performance task.
3	Not all key components describe student outcomes.
4	No key components are listed.

II. Component: The Rubric includes a set of descriptors for each key component.

Level	*Descriptors*
1	Descriptors for each component are arranged in a clear hierarchy from non-achievement to full-achievement.
2	Descriptors are present for each component, but obvious levels in some are missing.
3	Each component does not have an associated set of descriptors.

III. Component: Rubric descriptors are clear and contain observable student behavior.

Level	*Descriptors*
1	All descriptors clearly delineate levels of student performance.
2	Most descriptors clearly delineate levels of student performance.
3	Only a few descriptors clearly define levels of student performance.
4	Descriptors do not describe observable student outcomes.

IV. Optional Component: Appropriate weights are assigned to components and descriptors.

Level	*Descriptors*
1	Components and descriptors are each properly weighed according to instructional emphasis.
2	Weights are assigned, but point values do not reflect proper instructional emphasis in all cases.
3	Weights are assigned to some performance standards and descriptors.

Our teachers had already identified the student learning standards upon which they were going to base their integrated MSTE modules and had spent time with businesses and industries related directly to their modules. We began by reviewing their instructional analyses, the standards they wanted students to achieve, and then working with them on the development of the pretest/posttests, followed by the development of performance tasks. The performance tasks were embedded within real-world problems or scenarios, using their business, industry, and community learning experiences as a basis. After that, they designed their assessment instruments or procedures, including their tasks and rubrics, so that each module had several complex performance tasks (cluster of tasks) and corresponding rubrics. As mentioned above, they had also developed a traditional pretest and posttest that was approved by the program leader and assessment expert.

The workshop covered assessment broadly, and then each type of assessment was explored more deeply, focusing on more authentic performance assessments, the scoring of performance tasks, and the creation of rubrics. The teachers developed the module's pretest and posttest with close assistance from the program leader. Bloom's Taxonomy was reviewed and used as a tool in the development process for all types of assessment. At each stage of this usually week-long course or workshop, the teachers developed assessment-related tools, so they were learning while performing and being simultaneously assessed through an interactive process of teaching, development, feedback, and evaluation between the leader (professor) and teacher.

This process was most effective when done over a four-day span, but we also tried it for five days and three days. Five days ensured greater understanding and skill development; three days was too short. Here is the agenda for a four- or five-day workshop:

Day 1: Assessment Overview. Goal: Gain literacy in assessment and assessment strategies; identify the components of a balanced assessment model.

Day 2: Portfolio Assessment. Goal: Identify the components and uses of portfolios; design a portfolio for the assessment workshop.

Day 3: Traditional Assessment. Goal: Design teacher-made tests that are aimed at higher cognitive levels; build a database of test items to measure learning benchmarks for each content area; develop a team instrument to assess student accomplishment of module objectives (standards).

Day 4: Performance Assessment. Goal: Identify assessment tools; design performance tasks.

Day 5: Designing Rubrics. Goal: Develop skills in writing and using rubrics; design rubrics to assess student accomplishment of performance tasks.

Teachers received reference texts, a notebook with information from the presentations, performance task and rubric examples, the standards and achievement criteria for each one, and a rubric for scoring their performance tasks and rubrics. The leader reviewed the traditional tests for standards-based content validity. Teachers were also required to keep a reflective journal of their development, which had prompts for their responses. They produced an informal mini-portfolio, which provided evidence of their growth in student performance assessment and traditional test development.

Teachers responded extremely well when the workshops were led by a knowledgeable person who could answer their questions and help them make learning and assessment real. This required a leader with experience beyond a traditional classroom and who could use mathematics and science across real-world and other learning contexts. The most successful leaders came from technical disciplines (e.g., industrial technology, engineering technology). We had great success with teams co-led by a professor from engineering technology and a high school master teacher from technology education. However, the workshops were less successful when the program transitioned to the district, where local leaders took over. The traditional tests were not as well conceived or developed, and the performance tasks were less authentic and much more basic, primarily due to lack of experience outside the classroom or with theory in action.

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Appendix

Accurately identifies constraints or obstacles

4 Accurately and thoroughly describes the relevant constraints or obstacles. Addresses obstacles or constraints that are not immediately apparent.

3 Accurately identifies the most important constraints or obstacles.

2 Identifies some constraints or obstacles that are accurate along with some that are not accurate.

1 Omits the most significant constraints or obstacles.

Identifies viable and important alternatives for overcoming the constraints or obstacles.

4 Identifies creative but plausible solutions to the problem under consideration. The solutions address the central difficulties posed by the constraint or obstacle.

3 Proposes alternative solutions that appear plausible and that address the most important constraints or obstacles.

2 Presents alternative solutions for dealing with the obstacles or constraints, but the solutions do not all address the important difficulties.

1 Presents solutions that fail to address critical parts of the problem.

Selects and adequately tries out alternatives.

4 Engages in effective, valid, and exhaustive trials of the selected alternatives. Trials go beyond those required to solve the problem and show a commitment to an in-depth understanding of the problem.

3 Puts the selected alternatives to trials adequate to determine their utility.

2 Tries out the alternatives, but the trials are incomplete and important elements are omitted or ignored.

1 Does not satisfactorily test the selected solutions.

If other alternatives were tried, accurately articulates and supports the reasoning behind the order of their selection and the extent to which each overcame the obstacles or constraints.

4 Provides a clear, comprehensive summary of the reasoning that led to the selection of secondary solutions. The description includes a review of the decisions that produced the order of selection and how each alternative fared as a solution.

3 Describes the process that led to the ordering of secondary solutions. The description offers a clear, defensible rationale for the ordering of the alternatives and the final selection.

2 Describes the process that led to the ordering of secondary solutions. The description does not provide a clear rationale for the ordering of the alternatives, or the student does not address all the alternatives that were tried.

1 Describes an illogical method for determining the relative value of the alternatives. The student does not present a reasonable review of the strengths and weaknesses of the alternative solutions that were tried and abandoned.

(Source: McREL Institute)

Figure 12.8 Problem-Solving Rubric (McRel Institute as cited in Huba & Freed, 2000, p. 191)

Is aware of own thinking.

4 Consistently and accurately explains in detail the sequence of thoughts he or she uses when faced with a task or problem, and provides analyses of how an awareness of own thinking has enhanced his or her performance.

3 Consistently and accurately describes how he or she thinks through tasks or problems and how an awareness of own thinking enhances his or her performance.

2 Sporadically but accurately describes how he or she thinks through tasks or problems and how an awareness of own thinking enhances his or her performance.

1 Rarely, if ever, accurately describes how he or she thinks through tasks or problems or how an awareness of his or her thinking enhances performance.

Is open-minded.

4 Consistently seeks out different and opposing points of view and considers alternative views impartially and rationally.

3 Is consistently aware of points of view that differ from his or her own and always makes a concerted effort to consider alternative views.

2 Is at times aware of points of view that differ from his or her own and sporadically makes an effort to consider alternative views.

1 Rarely, if ever, is aware of points of view that differ from his or her own and seldom makes an effort to consider alternative views.

Restrains impulsivity.

4 Consistently and carefully considers situations to determine if more study is required before acting; when further study is required, engages in detailed investigation before acting.

3 Consistently considers situations to determine whether more study is required before acting; when further study is required, gathers sufficient information before acting.

2 Sporadically considers situations to determine whether more study is required before acting; when further study is required, sometimes gathers sufficient information before acting.

1 Rarely, if ever, considers situations to determine whether more study is required before acting; when further study is required, usually doesn't gather sufficient information before acting.

(Source: McREL Institute)

Figure 12.9 Habits of Mind Rubric (McRel Institute as cited in Huba & Freed, 2000, p. 192)

Criteria	Levels of Achievement			
	Excellent (A) 4 points	Good (B) 3 points	Needs Improvement (C, D) 2 points	Unacceptable (F) 1 point
Formulation of Design Problem				
Formulation and scope of problem	Design problem formulation is clear and well thought out. The problem scope is well defined.	The problem formulation is clear, but the scope is not well defined.	The problem formulation is unclear in some respects and does not appear to be well thought out.	The design problem is not formulated clearly.
Significance	The problem chosen represents a current challenge facing the engine industry. The potential market is large and clearly identified.	The problem represents a current challenge in the engine industry, but the potential market is small or is not clearly identified.	The problem does not represent a current challenge in the engine industry, and the market is small or is not clearly identified.	The problem does not represent a current challenge in the engine industry. There is no explanation about who would be interested in the product or why they should buy it. There is no evidence of the background work (e.g., market analysis) that is needed to design an engine.

Continued

Figure 12.10 Rubric for Engine Design Project (Part 1) (McRel Institute as cited in Huba & Freed, 2000, p. 191)

Criteria	Levels of Achievement			
	Excellent (A) 4 points	Good (B) 3 points	Needs Improvement (C, D) 2 points	Unacceptable (F) 1 point
Engineering Skill Utilization				
Analysis	Engineering analysis is detailed and challenging and is used at every stage of the design process.	The engineering analysis is detailed and challenging, but some steps do not appear to be supported by calculations.	Some analysis is included, but it is not very detailed or challenging. Many steps are not supported by calculations.	Engineering analysis is infrequently used. When used, it appears trivial and leads to obvious conclusions.
Documentation	Documentation is thorough and complete.	There is some missing information in the documentation.	There is a great deal of missing information in the documentation.	Documentation is poor or nonexistent.
Assumptions	All assumptions are stated and justified.	Assumptions are stated, but some are not justified.	Assumptions are stated, but none are justified.	No assumptions are stated.
Extension of Knowledge about Internal Combustion Engines				
	Concepts beyond those in the prerequisite course are frequently used. The professor may have learned something new.	Prerequisite course content is used easily, and some material beyond the course is included.	Prerequisite course content is used, but new and unfamiliar areas are not introduced.	Prerequisite course content is not applied correctly. New areas are not included.

Figure 12.11 Rubric for Engine Design Project (Part 2) (McRel Institute as cited in Huba & Freed, 2000, p. 191)

Team Skills				
Group functioning	The group functions well. Peer review indicates good distribution of effort. All members are challenged and feel their contributions are valued.	The group functions fairly well. Some people in the group believe they are working harder (or less hard) than others, but everyone is contributing.	The group is still functioning, but each individual is doing his/her own work and ignoring the efforts of others. There are frequent episodes where one person's design will not fit with another's due to lack of communication.	The group functions poorly. All work is the product of individual efforts.
Regularity and productivity of meetings	The group meets regularly and the meetings are productive.	The group meets regularly, but meetings are not as productive as they could be. Some members are not prepared.	The group meets irregularly. Meetings are not as productive as they could be because several members are not prepared.	The group does not meet regularly, and when it does, some members are absent and no one is prepared.
Use of group problem-solving techniques	The group makes frequent use of brainstorming and group problem-solving techniques and documents the effect of these sessions.	The group uses brainstorming and group problem-solving techniques but does not always document the effect of these sessions.	Some attempt to use group problem-solving techniques is observed, but decisions are not based on results of problem-solving sessions.	No attempt to use group problem-solving techniques is made. Meetings are worthless.
Written Communication				
Organization	Written work is well organized and easy to understand.	The organization is generally good, but some parts seem out of place.	The organization is unclear.	The report is disorganized to the extent that it prevents understanding of content.
Definition of terms	All new terms are defined.	Some terms are used without definition.	Many terms are used but not defined.	Terms are used without definition to the extent that understanding is inhibited.

Continued

Figure 12.12 Rubric for Engine Design Project (Part 3) (McRel Institute as cited in Huba & Freed, 2000, p. 191)

	Levels of Achievement			
Criteria	Excellent (A) 4 points	Good (B) 3 points	Needs Improvement (C, D) 2 points	Unacceptable (F) 1 point
Integration of writing styles	The team developed a writing style that is uniform throughout the report. There is no indication that the report involved multiple authors.	There is some indication of multiple authors (e.g., different fonts, different paper, etc.).	There is ample indication of multiple authors (e.g., different fonts, different paper, etc.).	Report is clearly the work of multiple authors with different writing styles, margins, printer fonts, and paper types.
Grammar	The work has been thoroughly spell-checked and proofread by everyone in the group.	There are a few spelling and grammatical errors.	There is more than one spelling or grammatical error per page.	There are frequent misspelled words and serious grammatical errors, indicating that time was not taken to spell-check and proofread.
Use of appendices	Information is appropriately placed in either the main text or an appendix. Appendices are documented and referenced in the text.	Information is appropriately placed in either the main text or an appendix. Documentation and referencing in text are somewhat incomplete.	There is some misplacement of information in the text vs. the appendix. Appendices are poorly documented and referenced in text.	Considerable amount of material is misplaced. Appendices are not documented or referenced in text.

Figure 12.13 Rubric for Engine Design Project (Part 4) (McRel Institute as cited in Huba & Freed, 2000, p. 191)

Oral Communication

Interest/ organization	Design presentation is clear, interesting, and well organized. It starts and ends well.	The design presentation is interesting, but some points are unclear. The introduction and/or conclusion are weak.	The design presentation has some interesting points but is difficult to follow. Either the introduction or conclusion is missing.	The design presentation is hard to follow and poorly organized. It appears to be off-the-cuff. There is no introduction or conclusion.
Visual aids	Visual aids are used frequently. They are easy to read and understand, and they are of professional quality.	Visual aids are good, but a few are sloppy or difficult to read.	Most visual aids are sloppy and hard to read.	There are too few visual aids, and those used are carelessly prepared.
Length	The presentation is within the assigned time limits.	The presentation is too short or too long by two minutes or more.	The presentation is too short or too long by five minutes or more.	The presentation is too short or too long by ten minutes or more.
Engineering analysis	Engineering analysis is presented with sufficient detail to be understood, but not so that it insults the audience.	Engineering analysis is poorly explained or so detailed that the audience falls sleep.	Engineering analysis consists of trivial calculations and is poorly explained.	No engineering analysis is presented.

(Van Gerpen, 1999)

Figure 12.14 Rubric for Engine Design Project (Part 5) (McRel Institute as cited in Huba & Freed, 2000, p. 191)

13. Teaching Models

Jenny Parker

All teachers in the project participated in a series of workshops designed to promote experiential education in the classroom. The basic premise of experiential education is that education is an active process through which meaning must be sought and connections must be made (Frank, 2001). To that end, modeling active teaching and learning in each of the workshops was important. The workshops focused on brain research, multiple intelligences, learning styles, teaching models, and teacher expectations and student achievement (TESA). The common thread was the improvement of teaching and learning across content areas. The teachers were introduced to the standards in their content area, and these were then used as a lens through which to view the content of all the workshops in this series.

This chapter is divided into sections that correspond with the workshops offered and the order in which they were provided. Each section begins with an overview, followed by goals for the workshop, a brief description of the theories upon which the workshop was based, a content outline including sample activities and outcomes, and a list of resources. The chapter closes with conversations in which teachers discussed the outcomes of the workshops and tips for successful workshops and reflections on what I learned from this process.

Multiple Intelligences and Learning Styles

The first workshop integrated brain research, multiple intelligences, and learning styles to explore the concept of differentiated instruction (Tomlinson, 1999). After beginning with a theoretical overview, the teachers participated in a variety of activities designed to illustrate the importance of these concepts and how they could be integrated into the curriculum.

Goals

There were three primary goals for this workshop:

- To introduce basic premises of brain research, multiple intelligences, and learning styles.
- To identify preferred learning styles and intelligences.
- To develop an action plan for integrating these concepts, through differentiated instruction, into the classroom.

Theories

Much research has been conducted on how the brain learns and retains information (Caine & Caine, 1991; Jensen, 1998; Kovalik, 1997; Tomlinson, 1999). The brain searches for deep, personal meaning, and responds more efficiently to information that is relevant and connected. It learns best through developing understanding rather than memorizing imposed facts and disjointed information. Kovalik (1997) provides eight brain-compatible elements to include in teaching: absence of threat, meaningful content, choices, adequate time, enriched environment, collaboration, immediate feedback, and mastery.

In 1983, Gardner published a groundbreaking book, *Frames of Mind*, in which he introduced the theory of multiple intelligences. He suggested that we think, learn, and create in different ways and that our potential is affected by connections between what we learn and how we learn. Over the years, Gardner (1983) has identified eight intelligences:

- Verbal/Linguistic: ability to think in words and appreciate complex meaning
- Logical/Mathematical: ability to calculate, quantify, and hypothesize
- Visual/Spatial: ability to think three dimensionally and appreciate images
- Bodily/Kinesthetic: ability to unite body and mind through sensory-motor experiences
- Musical/Rhythmic: ability to be sensitive to pitch, melody, and tone
- Interpersonal: ability to operate primarily through relationships with others
- Intrapersonal: ability to construct an accurate self-perception
- Naturalistic: ability to recognize and appreciate patterns in nature

Gardner's theory allows us to assess each individual as a whole, rather than focus purely on his/her verbal or mathematical skills.

The second part of the workshop focused on learning styles. Of the many learning style theories, this workshop focused on the one provided by Kolb (1984, 1999), which seemed to best fit with the experiential education philosophy. Experience is a great teacher, but by itself is not enough; with it must come reflection, generalization, and application. Kolb (1984) articulates the learning process as four phases of the experiential learning cycle. Each phase corresponds with a particular learning style:

- Divergent (Experience and Reflection): views concrete situations from a variety of viewpoints
- Assimilating (Reflection and Generalizing): takes abstract concepts and organizes concisely and logically
- Converging (Generalizing and Applying): solves problems and makes solution-based decisions
- Accommodating (Applying and Experience): prefers hands-on experiences and challenges

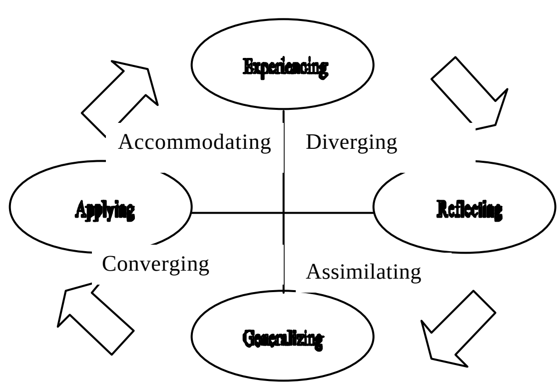

Figure 13.1 Experiential Learning Cycle

Table 13.1 Multiple Intelligences and Learning Styles Workshop Outline

Time	Topics	Sample Activities	Teacher Products
4 hours	Brain Research: How the brain learns Differentiated instruction Integrated thematic instruction Multiple Intelligences: Verbal/Linguistic Logical/Mathematical Visual/Spatial Bodily/Kinesthetic Musical/Rhythmic Interpersonal Intrapersonal Naturalistic	Participants: Engage in novel tasks to illustrate learning process. Create and discuss examples of activities for use in classrooms. Participate in group discussion by discipline, addressing the questions: Which intelligences do you focus on most? How might you integrate others? Complete survey to identify own preferred intelligences and then discuss implications for the team.	Report to group Completed survey
4 hours	Learning Styles: Diverger (Blue) Assimilator (Gold) Converger (Green) Accommodator (Orange) Addressing brain research, multiple intelligences, and learning styles	Complete a survey to identify their preferred learning style. Using 4 quadrants of experiential learning cycle, act out a scene illustrating how members of each quadrant approach the same task differently. Team members read a different but related article.	Completed survey Self-reflection on how learning styles are addressed in classes Report to group Completion of action plan to address intelligences and learning styles in future lessons

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Teaching Models I

The second workshop spanned two days and challenged the teachers to stretch a little further in their endeavors to provide active learning experiences for their students. The intent was to provide a variety of teaching models as alternatives to lecture. To that end, active learning was modeled throughout the workshops and demonstrated in the variety of the teaching models we discussed. This workshop worked best when the two days were broken down into one full day and two half-days to allow planning time.

Goals

The three primary goals of the workshop were:

- To provide and demonstrate a variety of teaching models
- To practice several models in a teaching situation
- To observe colleagues and provide feedback

Theory

Over the last 25 years, much of the research on models of teaching has been conducted by Joyce and Weil (2000). They provide 22 models of teaching, each of which has been shown to affect student learning. Each model represents a holistic approach that combines theory, content, planning, management, learning strategies, and social interaction. According to Joyce and Calhoun (1996), the three underlying tenets for each model are:

- Teachers have an array of approaches to use in teaching.
- Methods make a difference in what is learned as well as how it is learned.

- Students are a powerful part of the learning experience and they react differently to any given teaching method.

The teaching models are categorized into four families: information processing, social, behavioral systems, and personal. A common type of learning and a similar orientation to others identify each model within a family. For example, models in the information-processing family help students learn to process information, whereas models in the personal family focus on the development of self-identity.

The teachers were asked to try unfamiliar models, but inclusion of the more common models gave them the opportunity to share success stories from their classrooms. Of the 22 models provided by Joyce and Weil (2000), the 12 listed below were the main focus. The selection came partly from teacher feedback and partly from the need to balance the novel with the familiar:

- Advanced Organizer: enhances active learning and retention by organizing and conveying information
- Concept Attainment: challenges students to distinguish between concepts through compare and contrast
- Cooperative Learning: focuses on students working together to achieve a common learning goal
- Direct Instruction: focuses on teacher direction and control to maximize learning time
- Inductive Thinking: learns through classifying and hypothesis testing
- Inquiry Training: focuses on scientific inquiry, provides investigative process
- Jurisprudential: promotes systematic thinking and debating skills
- Mnemonics: increases storage and retrieval of information
- Non-directive: focuses on nurturing and facilitation of learning in a counseling-type relationship
- Role Play: explores feelings, values, and attitudes through action
- Simulation: mimics reality with the complexities controlled
- Synectics: uses metaphorical thinking to creatively solve problems

Table 13.2 Teaching Models Workshop Outline

Time	Topics	Sample Activities	Teacher Products
10 hours split over two days	Families of Teaching Models: Information Processing Personal Behavioral Systems Social Teaching Models: Advanced Organizer Concept Attainment Cooperative Learning Direct Instruction Inductive Thinking Inquiry Training Jurisprudential Mnemonics Non-directive Role Play Simulation Synectics	Participants: Discuss each model and identify the family to which it belongs. In teams of four, become experts in a model. List the key points, strengths, weaknesses, and examples of how the model could be used in class. Illustrate how each could be used in a class. For example, when teaching inquiry training, each group of teachers has an object in a sealed envelope. Using the principles of inquiry training they have to hypothesize what is in the envelope and then test their hypotheses (make sure the object is not breakable or obvious!).	Survey models to establish previous experience. Complete chart with families of models. Present to group. Create mind map to illustrate personal connections between models. Commit to teach a lesson using one or two models with which they are not as familiar.
4 hours	Modeling the models	Individually or in pairs, teach a slice of a lesson incorporating one or more of the models. Team members watch them teach and give immediate feedback.	Lesson plan Teaching experience Supervision experience

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Teacher Expectations and Student Achievement

Teacher expectations and student achievement (TESA) was a 15-hour training workshop focused on heightening awareness of how the teacher's perceptions might affect students. It included a two-hour overview of the components of TESA.

Goals

The three primary goals of the workshop were:

- To briefly introduce the 15 TESA strategies
- To discuss how the strategies are implemented in classes
- To complete a simplified observation instrument

Theory

TESA is grounded in expectation theory and is based upon the pioneering work by Brophy and Good (Brophy, 1981; Brophy, 1983; Good, 1981; Good, 1987; Good & Brophy, 1973). Good (1987) defines teacher expectations as "inferences that teachers make about the future behavior or academic achievement of their students, based on what they know about these students now" (p. 33). TESA is concerned with both the quantity and quality of teacher-student interactions and promotes equitable and meaningful interaction with all students.

TESA provides five units of instruction, and each unit addresses the interactions associated with the strands of response opportunities, feedback, and personal regard. Table 3 illustrates the 15 interaction strategies in the TESA program.

Table 13.3 TESA Interaction Strategies

	STRAND A **Response Opportunities**	**STRAND B** **Feedback**	**STRAND C** **Personal Regard**
Unit 1	Equitable Distribution	Affirm/Correct	Proximity
Unit 2	Individual Help	Praise	Courtesy
Unit 3	Latency	Reasons for Praise	Personal Interest and Compliments
Unit 4	Delving	Listening	Touching
Unit 5	Higher-Level Questioning	Accepting Feelings	Desist

Table 13.4 Teacher Expectations and Student Achievement Workshop Outline

Time	Topics	Sample Activities	Teacher Products
2 hours	TESA Equitable Distribution Affirm/Correct Proximity Individual Help Praise Courtesy Latency Reasons for Praise Personal Interest and Comp. Delving Listening Touching Higher-level questioning Accepting Feelings Desist	Participants: Discuss each strategy. Discuss and complete simplified observation instrument. Use video to practice observation.	Complete self-reflection of strengths and areas for further development. Complete observation instrument.

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For TESA training opportunities contact:

Los Angeles County

Office of Education – TESA
9300 Imperial Highway
Downey, CA 90242

Teaching Models II

Teachers who completed Teaching Models I could enroll for an optional two-day workshop the following year. The focus moved from specific teaching models to teaching styles that could be used within the models and concluded with teachers sharing their "best" teaching strategy.

Goals

The three primary goals of the workshop were:

- To demonstrate a variety of teaching styles
- To practice several styles in a teaching situation
- To link styles with teaching models and teaching strategies

Theory

Mosston and Ashworth (1990, 2001) suggest that a single unifying process governs teaching: decision making. The patterns of decision making are teaching styles, and the framework that holds them together is the Spectrum of Teaching Styles. The styles are labeled A-K and lie on a continuum anchored by Command Style (A) at one end and Self-Teaching (K) at the other. As Table 5 illustrates, the continuum moves from left to right and is characterized by whether the objectives focus on the reproduction or production of knowledge and, more specifically, on whether students will need to memorize, discover, or create information.

Each style consists of three sets of decisions – pre-impact (prior to face-to-face interaction), impact (during interaction), and post-impact (evaluation) — that are situated on the continuum according to who makes each set of decisions, the students or the teacher. Teachers select an appropriate style depending upon content (memorization, discovery, or creativity), students, learning environment, and time.

Table 13.5 Spectrum of Teaching Styles

Reproduction					Production					
A	B	C	D	E	F	G	H	I	J	K
Memory					Discovery		Discovery and Creativity			

Table 13.6 Teaching Models II Workshop Outline

Time	Topics	Sample Activities	Teacher Products
8 hours	Spectrum of Teaching Styles: Command (A) Practice (B) Reciprocal (C) Self-Check (D) Inclusion (E) Guided Discovery (F) Convergent Discovery (G) Divergent Production (H) Learner Designed (I) Learner Initiated (J) Self Teaching (K) Lesson planning	Participants: Illustrate how each style could be used in a class. For example, for the reciprocal style of teaching that focuses on social interaction and peer feedback, complete worksheets adapted to encourage appropriate feedback for correct or incorrect responses. Select a style to teach.	Complete worksheet for each style. Present to group.
4 hours	Review of styles Share a strategy	Teach a lesson focusing on one teaching style (not command or practice).	Lesson plan. Teaching experience.

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Conversations with Teachers

Over the years of facilitating workshops, many conversations with teachers have occurred. (This context uses the word conversation very broadly to include actions, written words, and discussions.) The following conversations are personal interactions, but similar conversations take place in most workshops conducted with teachers.

Without exception, the first conversation has been the same and revolves around the relationship between university faculty and teachers in the public schools. I felt trepidation at the beginning of the first workshop – a reaction, I believe, to uncertainty about how it would turn out until I overheard two teachers reminiscing about the hours of lectures they experienced as undergraduates. I realized that it was very important to establish my credibility as a university faculty member when facilitating a workshop with public school teachers. Under the heading "What brought me here?" – I discussed the structure of the workshops and my background as a public school teacher and supervisor of student teachers and clinical students. I followed up this question with "What brought *you* here?" The dialogue began.

After this initial discussion, other conversations fell primarily into four categories: formal evaluation, discussions within the workshops, informal chats, and "let's get it out in the open!" Formal, standardized evaluations were completed by the teachers at the end of each workshop. I made a point of reading the evaluations prior to the next workshop to address any issues and incorporate suggestions. Most of the teachers expressed satisfaction with both the content and structure of the workshops. They noted that the activities were useful for transforming theory into practice and providing something they could use in their classes. Additionally, and perhaps most importantly from my perspective, they appreciated learning from their colleagues and gained many new resources to assist their students. Some asked for additional information, while others requested more discussion time. Some wanted shorter lunch breaks, while others wanted a variety of food available. Some provided their email address and asked for handouts to be sent electronically. This final request led to offering electronic versions of the materials to all workshop participants.

The second category of conversations took place within the workshops themselves. Often the most enlightening and powerful discussions, they usually focused on the real issues of teaching. Frequently raised questions included: How can we justify incorporating multiple intelligences when student success is determined by a standardized paper and pencil test? What is the relationship among multiple intelligences, learning styles, and personality testing? How can we incorporate all these teaching models when students just sit in class and will not participate? Is teacher sarcasm appropriate in class?

Also within this second category were "Yes, but what about (fill in the blank)?" conversations. These allowed teachers to agree with the workshop content while creating reasons why they could not implement the strategy in their particular setting. Initially, my response was to create possible solutions to their individual dilemma; later I asked the group for assistance. There was often another teacher dealing with a similar situation who was willing to share some ideas, and the process of discussion enabled the teachers to learn with each other.

Informal chats, the third conversation category, occurred during lunch break, on the way out to the parking lot, or in an email after the workshop was over. Most involved problem solving specific to a particular class, student, or content area. Often they involved teachers who did not want the information shared with their colleagues but wanted input from another source.

The final type of conversation was "Let's get it out in the open!" While working with such a large and diverse school district over an extended period of time, I realized that there were situations when the success of the workshop could be affected by incidents that happened in the district. Initially, discussion of district business was not included in the workshops, but I came to realize that for most teachers, their only opportunity to talk to each other and be heard came in these workshops. Consequently, we reached an agreement: we would discuss the latest event for 30 minutes and then proceed with the workshop as planned. This arrangement allowed the teachers to talk about what was currently important in their careers. It gave credibility to their concerns, enabled me to gain a new perspective on recent events, and resolved a major distraction.

Tips for Facilitating Workshops

I have learned much from these workshops. My own teaching has improved, and I have been challenged to develop creative activities to promote learning. I have learned that an eight-hour workshop can seem like 50 minutes when participants are engaged in appropriate and relevant activities, or it can seem like a week when the activities do not encourage active involvement. I have learned that teachers, when they are students, will talk, fidget, whisper, and pass notes in class! I have also learned, however, that when treated with respect, courtesy, and appreciation, they will sing, dance, sculpt, and play if they can see how it will benefit their teaching and student learning. I offer the following tips:

- Always have food!
- Include time to chat.
- Have fun!
- Start and end on time.
- Respect experience.
- Listen. I mean really listen.
- Ask early and ask often.
- Encourage the CASE (Copy and Steal Everything) method — with appropriate citations of course!
- Dare to be different (I have used everything from paper airplanes to molding clay to create learning experiences with teachers).

Teaching is complex, rewarding, heartbreaking, and messy. What works in theory often needs tweaking before it can be transformed into successful practice. Perhaps Prather (1970, p. 70) said it best: “Ideas are clean. I can take them out and look at them. They fit nicely in books. They lead me down the narrow way. And in the morning they are there. Ideas are straight. But the world is round, and a messy mortal is my friend. Come walk with me in the mud.”

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14. Teachers and Instructional Technology: New Ways of Teaching, New Ways of Learning

James Lockard

This chapter describes efforts to expand teachers' knowledge and skills in the area of instructional applications of technology. Its sections offer a rationale for instructional technology (IT) training for teachers, present a brief timetable as an overview of this component of the program, detail the goals and evolving content of the IT component over the years, and reflect on achievements observed among the participants, concerns that arose during and after the activities, and lessons learned. These lessons should benefit others who may pursue similar ventures with teachers.

Teaching, Learning, and Technology

In 1997, the International Society for Technology in Education (ISTE) decided to tackle the issue of national standards for technology in education with some modest outside funding. The National Educational Technology Standards for Students (NETS-S) appeared in June 1998 (ISTE, 2003). It is significant that the first standards defined what *students* at all levels, K-12, should be able to do with technology. By starting with student competencies, which were the ultimate goal, one could work backward to determine what was necessary to achieve them, including the knowledge and skills required of teachers. To support NETS-S, ISTE also commissioned and published the book *Connecting Curriculum and Technology* (2000), which provides explicit examples of how teachers can address the NETS-S standards within the curriculum.

ISTE later received more generous funding through the federal Preparing Tomorrow's Teachers to Use Technology program (PT3), and the work accelerated. The National Educational Technology Standards for Teachers (NETS-T) appeared in June 2000 and NETS for Administrators followed in November 2001. Each of these documents laid out in detail, with numerous concrete examples of the knowledge and skills that their respective target audiences should have in order to function effectively in our "different world." NETS-T focused on effective integration of technology into the curriculum, which was possible only if teachers themselves had the fundamental technology skills required of students by NETS-S.

The need to address the technology competence of both pre-service and in-service teachers was widely recognized, and gradually state education departments and organizations such as the National Council for Accreditation of Teacher Education (NCATE) and the Interstate New Teacher Assessment and Support Consortium (INTASC) began to adopt or adapt the NETS standards for their constituencies. As of June 2003, 47 of the 50 states plus the District of Columbia had "adopted, adapted, aligned with, or otherwise referenced at least one set of standards in their state technology plans, certification, licensure, curriculum plans, assessment plans, or other official state documents" (ISTE, 2003). Similarly, NCATE incorporated NETS into its expectations of its member institutions and the INTASC principles correlated directly with NETS standards (see http://cnets.iste.org/ncate/pdf/NETST_INTASC_S.pdf for a correlation matrix).

Let's take Illinois as a specific example. Until 2003, there was no requirement for any exposure to technology as part of teacher certification in the state. Beginning July 2003 (23 Illinois Administrative Code, Chapter 1, Section 24.10), all teacher preparation programs were to meet new standards, among which are Core Technology Standards for All Teachers (www.isbe.net/profprep/CASCDvr/pdfs/24120_coretechnology.pdf). The only other area mandated as a core requirement for all teachers is language arts (see www.isbe.net/profprep/pcstandardrules.htm). The core technology standards readily map to the NETS-S and NETS-T standards (Figure 1).

While the Illinois standards apply to all initial teacher certification candidates, they also include in-service teachers to an extent. Teaching certificate renewal requirements afford opportunities for bringing veteran teachers up to the current standards as well. According to the ISBE Frequently Asked Questions document, "The Illinois Professional Teaching Standards, core Technology Standards, core Language Arts Standards, and the applicable teaching standards of the Content-Area Standards for Educators will guide the continuing professional development of teachers" (www.isbe.net/profprep/CASCDvr/faq.pdf). The Illinois State Board of Education has not released precise enforcement details yet, but many schools districts in the state already are enhancing staff development offerings and expectations to help veteran teachers address the new standards. While the NSF-funded program described in this book long predates the Illinois standards, the instructional technology components in particular were designed to help participants improve their skills and explore ways to enhance their teaching technology.

Session Overview and Timetable

Technology was an integral part of our program from inception, but in the early years, this primarily meant technology as an area of study — CAD, for example— and use of software specific to participants' modules. Other chapters describe those technology components in detail. Program participants received laptop computers and appropriate software so they could develop their lesson plans and modules, access the Internet, and so forth. The process of technology infusion was necessarily gradual, given both district readiness and participants' backgrounds. Broader instructional applications of computer technology became an organized program element in 2001.

The 2001 instructional technology workshops resulted from an initial planning meeting in December 2000. Following that session, program participants were offered four different workshops between February and June 2001. These are described more fully in the "Goals and Content" section of this chapter.

In autumn 2001, organizers decided to increase teacher exposure to instructional technology offerings, in part as a result of favorable evaluations of previous sessions. In January 2002, participants completed a detailed survey of their technology knowledge and skills, which then served as a needs assessment to inform the content of the workshops under development. Between April and June 2002, three of four workshops from the 2001 offerings were updated and delivered, and another was added, as detailed below. In addition, a separate group of teachers from a different project also participated in repeat offerings of three of the workshops in August 2002.

Table 14.1 Correlation of Illinois Core Technology Standards and NETS Standards

Illinois Core Technology Standards	NETS Standards
1. Basic Computer/Technology Operations and Concepts	Basic operations and concepts (NETS-S, 1) *Teachers demonstrate a sound understanding of technology operations and concepts.* (NETS-T, I)
2. Personal and Professional Use of Technology	*Teachers use technology to enhance their productivity and professional practice. (NETS-T, V)*
3. Application of Technology in Instruction	*Teachers plan and design effective learning environments and experiences supported by technology. (NETS-T, II)* *Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning. (NETS-T, III)*
4. Social, Ethical, and Human Issues	Social, ethical, and human issues (NETS-S, 2) *Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice. (NETS-T, VI)*
5. Productivity Tools	Technology productivity tools (NETS-S, 3) *Teachers demonstrate a sound understanding of technology operations and concepts.* (*NETS-T, I)* *Teachers use technology to enhance their productivity and professional practice. (NETS-T, V)*
6. Telecommunications and Information Access	Technology communications tools (NETS-S, 4) *Teachers demonstrate a sound understanding of technology operations and concepts*. (NETS-T, I)
7. Research, Problem Solving, and Product Development	Technology research tools (NETS-S, 5) Technology problem-solving and decision-making tools (NETS-S, 6)
8. Information Literacy Skills	Technology problem-solving and decision-making tools (NETS-S, 6) *Teachers plan and design effective learning environments and experiences supported by technology. (NETS-T, II)*

Sources: Illinois Standards (www.isbe.net/rules/archive/pdfs/24ark.pdf), NETS-S (cnets.iste.org/students/s_stands.html), NETS-T (cnets.iste.org/teachers/t_stands.html)

For 2002-2003, the program expanded again, starting with a revised technology knowledge-and-skills survey in October 2002. The final schedule offered seven discrete sessions between October 2002 and June 2003, incorporating four new workshops and the content of the four previous workshops, effectively "eight days in seven." The series concluded with a much-needed catch-up day, during which teachers could complete work from previous sessions with assistance.

Goals and Content

The 2000-2001 NSF program was already under way when the initial meeting to discuss an instructional technology component took place in December 2000. Teachers already had their laptop computers with Microsoft Office for basic productivity software. Participant experience with the computers and basic software was certain to vary, but basic computer skills were assumed (see Figure 1, Illinois Core Standard 1). Internet connectivity was also in place, both in individual schools and at the high school where the technology sessions met.

In planning specific content for three sessions, the primary goal was to assist teachers in developing practical technology skills through activities that could become part of their modules, which they would teach the following year. These skills addressed primarily Core Standards 2 and 5 through 7, which relate to the technologies themselves, and concurrently Standard 3, their application to instruction. Topics selected were visual literacy (how to take advantage of the power of visual materials to communicate), WebQuests (how to use the Web effectively and efficiently for student problem solving), and basic Web page development (how to establish one's own Web presence to support instruction).

Another broad goal of the total program was to enhance collaboration among teachers. The online collaboration tool LiveText was available to support that goal. This tool became the basis for the WebQuest and Web page development sessions offered that year.

For 2001-2002, a number of changes occurred. The visual literacy session had not fit programmatically as well as anticipated, and it was eliminated. The WebQuest and basic Web page development sessions remained. Additions to the program built on the base of those two retained sessions by adding a workshop on enhancing the pages with multimedia elements and another on creating virtual tours. The latter served to integrate the participants' industry visits into their modules by creating a means for students to experience sites vicariously. In addition, the series of four sessions, all built around some form of Web page development, offered participants who elected to take multiple workshops the chance to develop stronger skills, rather than each session involving a different tool.

It was necessary to rewrite all materials from each session from the 2000-2001 programs because the LiveText tool proved to be unsatisfactory. Instead, teachers learned to work on each type of Web application using MS Word, with which they already had some familiarity, and to a limited extent Netscape Composer. Both are functional for the purpose, but neither is highly desirable. However, they did not involve costs for new software, and learning new Web techniques became relatively easy extensions of familiar software, which minimized the learning curve. The new workshops also relied primarily on Word. Collaboration support shifted to Microsoft SharePoint, which integrates with the basic Microsoft productivity tools, so the potential for electronic collaboration remained beyond LiveText.

The extra preparation necessitated by the change in software paid off further when it became possible, in August 2002, to offer three days of workshops on WebQuests and Web page development for a small additional group of teachers from rural schools. This experience also demonstrated clearly the impact of group size on the learning process. The NSF-supported sessions were mostly quite large, while the August sessions involved fewer teachers, whose achievements far exceeded the norm in the larger groups.

The 2002-2003 program brought significant change to the IT sessions as well. Four new workshops, consisting of a three-part series on electronic portfolios and one session on computer animation, joined the WebQuest, Web page, and virtual tour offerings. Again, a survey of knowledge and skills guided workshop planning.

The first portfolio sessions laid the conceptual foundations for electronic portfolios (October 2002) and provided technical skills for developing electronic artifacts for a portfolio (November 2002). The third session, in April 2003, aimed to create a sample portfolio (based on work during and after the previous sessions) and to post it on the district server. The WebQuest workshop occurred in March 2003; sessions on personal Web pages, virtual tours, and animation followed on successive days in June. One final day without new content offered participants the opportunity to polish their work from other sessions.

As had been the case the previous year, changes in the program necessitated rewriting all the materials as well as those for the new sessions. The driving force was the decision to extend teacher technology skills into a “hot” new area, namely animation. Animation has become a popular technology tool that is highly appealing to students. Including it in the program had two goals – to excite teachers with a fun new tool and to prepare them to expand their views of possible alternative ways in which students could demonstrate their learning.

Until the addition of animation to the program, existing software was adequate, if not ideal, for all of the IT offerings. However, no package already in the teachers’ hands supported animation, and learning to work with any animation software would likely be the greatest challenge participants would face within the IT workshops. After much consideration of options, the clear choice was Macromedia Flash. This necessitated a major software purchase, and it quickly became clear that it made sense economically to acquire the entire Macromedia Studio MX software suite. This gave teachers a much more sophisticated Web page development tool in Dreamweaver as well as Flash for animation. While it was hardly necessary to shift other workshops to Dreamweaver, it was logical to do so because similarities in the Macromedia products would allow much reinforcement of operating procedures and avoid an abrupt change and steep learning curve just for the animation session.

Achievements

The best illustrations of achievements are the individual modules produced by the teachers each year. Just as the technology backgrounds of the teachers varied widely, so did their products. The following examples serve to illustrate points of particular note.

One benchmark was the significant number of participants who elected instructional technology sessions for the second or third year. Most of the workshops were not required components, yet there were many familiar faces in the second-year sessions, and a number from the first year returned for the third time in the final year. The usual reason given for electing IT workshops was to reinforce and extend what they had enjoyed learning the year before. It is particularly rewarding to be able to observe the increase in skills that occurs only over time.

Returning participants reported positive outcomes in their classes from using their materials. Because so many of the workshops occurred after the end of the school year in June, only returning participants had had the opportunity to use their creations. In some cases, teachers also reported student uses of technology that they were now prepared to encourage and support but that they would not have been able to do prior to their own learning.

Another achievement of the final year was the introduction of real-world software beyond Microsoft Office. An unspoken goal of the workshops was to help teachers develop positive attitudes toward the unending challenge of learning new software, whether because of version upgrades or entirely new packages. Personal experience has shown that teachers tend to become comfortable with routine technology uses and may hesitate to take on new programs on their own. The heavy reliance on Macromedia products in the final year confronted the participants with an entirely different software paradigm. The success of participants in tackling an admittedly complex set of tools should increase the likelihood that they will become more adventurous in adopting new software in the future.

While the focus of the sessions was on using software to develop products to aid learning, opportunities to consider hardware did arise. This was particularly true during the second and third sessions on e-portfolios, as it is commonly necessary to convert existing documents and other artifacts into digital form. Use of scanners, digital cameras, digital recording using the computer's sound card, and even digital camcorders became topics of discussion. One of the more observable impacts of even brief attention to hardware is the case of USB flash drives, small solid state devices that can store the equivalent of roughly 45 to 180 floppy disks on a unit that can be used as the fob on a set of keys. Most of the participants made regular use of floppy diskettes and had a sense of their limited capacity. Teachers learned about these new USB devices as a very small part of one IT workshop. Several asked for detailed information on where to obtain the devices and, indeed, at the next workshop a number of teachers had made the investment from their own funds. This is a good example of how individuals were willing to support their own needs when the benefit was clear and the cost reasonable.

Finally, several participants initiated discussions about further study of instructional technology at Northern Illinois University. The workshops reached deeply enough into the pedagogical thinking of some participants to interest them in further opportunities to learn. Thus far a few have enrolled and more have indicated their hope to enroll.

Challenges

It is tempting to focus on achievements, but they offer little that is truly new to those who work with in-service teachers to enhance their teaching with technology. More informative, and hence treated in greater detail, are the many challenges that occurred within the workshop offerings. This discussion groups them into three categories: challenges related to participants, to the technology, and to the program structure.

Participants

The single greatest challenge was the disparity of skills within each workshop cohort. Participants varied from moderately skilled in basic use of computers to barely able to turn on their computer. Early on, it became obvious that group instruction could not work beyond the conceptual level. Individual differences meant there could be nothing close to a standard pace for any session when it was time for hands-on work. Thus, it was necessary to try to develop documentation that would be essentially self-instructional. Preparing such materials is, of course, extremely time consuming.

No matter the care that went into producing the detailed handouts, a significant number of participants in each session needed substantial individual help. That is a problem only in the sense that it becomes frustrating for participant and instructor alike when someone does not receive needed assistance very quickly. The magnitude of the problem obviously related to the number of participants per session. For the larger groups, it was often possible to have an assistant along with the instructor, but even two individuals were generally unable to keep up with the need for help. The more knowledgeable participants were gracious in trying to help their colleagues when staff could not respond quickly enough.

Varied participant preparation for sessions posed another challenge. Certain sessions, for instance the third on e-portfolios, were designed to build on the previous sessions and the materials that were to be gathered following them. Perhaps because of the long time between sessions, a sizable number of participants came to the third session without the expected materials. Most seemed chagrined that they had forgotten, while a few said that they had no obligation to do work on their own between sessions.

Technology

Technology-related issues are discussed under the headings of technical problems and the environment.

<u>Technical Problems</u>

Every session was dependent on district technology-support personnel who were available only at the beginning of the day and occasionally not at all. Although there were many different kinds of technical problems, by far the most common was getting the Internet connections to work. Initially the cause appeared to be the need to change configurations when moving from the home school to the high school. Teachers from the high school did not experience the same problems as did those from other buildings. Since the Internet was a fundamental tool most of the time in most sessions, workshops could not begin until nearly everyone had made a connection. In the first year, the problems sometimes delayed the start of a session by as much as an hour, thus costing participants valuable learning and exploration time.

Fortunately, in the second year, the connectivity problem declined noticeably for unknown reasons. By year three, most participants were able to achieve a connection without assistance or significant delay, which was fortunate as support was also less frequently available. Whether the district changed to an automated connection system or the teachers slowly learned to make the necessary changes was never clear.

There were two notable exceptions to the improved technical environment, both server related. Most IT sessions did not depend heavily on the district server, and some not at all. Workshop materials resided on an NIU server, minimizing reliance on the district. However, the district provided space on its server for teachers to post their Web creations. For the first two years, no problems arose other than the expected participant learning curve. As always, in the third year, the instructor tested the district server regularly, especially prior to workshops that would involve teachers posting their work, and found no problems. Written materials explained in detail how to connect and upload files to the server. Thus, it was a rude surprise when, near the end of the first session that involved posting, the directions provided did not work. Some of the more knowledgeable teachers indicated they had discovered the problem before and, like the instructor, were easily able to access the server from other locations, just not from within the high school. Thus, teachers could not complete the final step of the work in that session.

Resolving the issue with district personnel took several weeks, stretching beyond the next workshop, during which teachers were again unable to post their work, into a two-month period before the following session. Revised instructions explained new procedures that differed depending on where one was physically when trying to connect to the server. However, posting was again possible.

The second exception related to electronic collaboration and only indirectly affected the IT workshops. As previously explained, efforts were made in year one to foster collaboration with LiveText. Although teachers learned LiveText well enough to develop WebQuests and personal Web pages, the very compact timetable for the workshops did not lend itself to requiring participants to share their work with one another. They struggled to complete their projects in the available time without concern for feedback or input from others. The concept of electronic sharing seemed unclear to most participants, and the mechanics of sharing within LiveText were confusing to those who seemed interested. There was also some resistance to LiveText when teachers learned that there was no way to download or save their work from that environment to their own computers. The system was totally Web-based and lacked provision for local copies of work. This made every aspect of the work dependent on a system that was no longer available after that year.

Efforts to promote electronic collaboration shifted to Microsoft SharePoint in years two and three. Clearly, it would have been desirable to reinforce the value of collaboration throughout the program and certainly within the IT offerings to reinforce this use of technology; however, problems in year two began with many of the teacher laptops still having versions of Microsoft Office that were too old to fully support SharePoint. Since only some of the teachers could use it, it was not practical to demand use, and teachers who did have the technology seemed disinterested. In year three, there appeared to be fewer problems with software compatibility, but when I asked the teachers how they were using it, they said they were not. They reported that the district server had been down the day of the SharePoint training. They expressed concern that the system was not reliable and were unwilling to trust it with the results of their countless hours of work. Therefore, the IT sessions again did not incorporate electronic collaboration.

Environment

Environment is the descriptor used to indicate all of those issues that relate to working conditions for the workshops.

Environmental issues centered on teacher hardware. Participants came from many schools within the district and were involved with the program for varying lengths of time. Depending on when they joined the program, they might have a very new laptop or a much older one. Comments indicated a level of jealousy among those whose equipment was older, not an unexpected reaction. More significant, however, was the fact that the laptops varied in their version of the Windows operating system, which required extra care in preparing the workshops. In the world of computer hardware, even a year's difference in the age of two computers usually means a large difference in operating speed and hard drive space. Newer machines are typically more stable and less prone to crash, further increasing the disparity in productivity among the participants. Differences in hard drive space became important only in the third year, when some of the computers did not have enough available space to install the Macromedia software needed for the workshops without first removing other software.

Site-related environmental issues concerned the physical space and the technology available. The primary meeting space was a large room known as the Atrium, which was the only space available in the district with the necessary number of seats and Internet connections. The Atrium was less than ideal for a number of reasons. First, it was a difficult room in which to teach using projected computer images because of a large amount of glass that made the room quite bright at all times. The projection screen was too small to permit an image of the size that would be necessary for individuals in the back to see readily. Furthermore, the room was L-shaped and individuals at the right front (in the far "base" of the L) necessarily sat at a bad viewing angle to the screen, hampering their ability to see clearly. From the very first session, it was obvious that sessions could not depend on demonstrations alone, least of all demonstrations that participants might follow on their own computers, as is common practice when teaching in a computer lab. Workshop presentations had to be limited to conceptual and descriptive content presented using PowerPoint with very large type and only minimal demonstration of actual software use. Handouts had to be sufficiently detailed to allow participants to explore the software step by step in lieu of demonstrations.

Some environmental issues may have stemmed from the district and its commitment to the program and to technology applications in the schools. Concerns were most evident when teachers had problems with their laptops. There seemed to be no clear pattern of responsibility for maintaining them, or perhaps the teachers were unaware of how to obtain service help. In addition there were many complaints about the lack of support for technology in the district, including the lack of consistency from one building to another in how networking was set up and system changes that were implemented without warning or directions. This may be illustrated best by the change in means to access the server to post participants' work in the third year. Only the facilitator seemed surprised that the written procedures, which had worked previously and from sites outside the high school, did not work within the high school.

Program structure

The most significant programmatic challenge was the apparent lack of understanding among many participants as to how their work in IT (and, according to some participants, other components as well) related to the larger module. To some participants, the sessions did not appear to connect explicitly to other parts of the year's work. Many participants clearly made the connections and produced appropriate learning materials, but some did not. Furthermore, many seemed not to feel any responsibility for completing the projects begun in the sessions.

Another programmatic issue stemmed from workshop scheduling and prerequisite skills. The range of sessions, especially in the third year, was not necessarily treated as a group with a sequence. Rather, participants chose sessions as if making selections from a menu. The electronic portfolio series did, indeed, work as a series, and no one attended a later session without having participated in the previous sessions. The same was not true of later sessions. Although this was according to plan, an unanticipated consequence was a need to start virtually every session with software installation, since there were always new participants who had not previously received the Macromedia package. This also meant that some had prior experience with the software, while others did not, which further necessitated the self-instructional approach as group instruction truly was not feasible.

A final program issue was overlapping content within the program. Within some IT sessions, some participants reported that they had also worked with, say, Web page development in sessions that were not part of the IT series. Because participants had variations in their activities over a year, this did not occur uniformly. Nonetheless, the overlap in content caused some frustrations because the software and expectations differed among the workshops. Participants rightly perceived that there are multiple means to most technology goals, but because they often lacked experience and confidence in their computer skills, multiple approaches tended to confuse them. A standard approach and expectations would have better served these teachers.

Lessons Learned

From any experience such as this, one of the key outcomes must be lessons learned that could improve future efforts of this type. Here, then, are specific suggestions that could enhance programs of this nature. They are grouped into the areas of program integration, basic skills, and support.

Program integration

First and foremost, integrate any instructional technology component fully into the program from the start. Only experience will help most teachers recognize the best opportunities to enhance the learning experiences of their students with technology. Technology sessions should begin at the start of the program, with skill development as the main focus. If teachers understand technology capabilities in the early stages of module development, they will have a much greater potential to incorporate technology elements into their evolving module. Several participants clearly indicated that, while they could envision applications of what they were learning in the IT workshops, the understanding came too late for them to do much in fact. In each of the three years, many of the sessions came very close to the end of the program year, by which time the module was so well developed as to have little room left for modifications, however desirable they might seem.

In turn, it would have been very helpful to define expectations from the workshops more clearly, that is, to establish actual accountability for learning and incorporating technologies. Comments and observations of the work of some participants made it clear that they felt no obligation to produce anything useful at all.

Further, participants would benefit from the integration of instructional technology throughout the program, rather than in specific workshops. The arguments parallel those in discussions of how best to implement technology training into pre-service teacher education (Lockard & Abrams, 2000, pp. 341-349). The goal is the incorporation of technology as a natural part of learning activities in schools. This is only possible when teachers first have solid competence to use the technologies; that is, they cannot integrate something they do not understand and that they cannot themselves do on at least a basic level. Skill development precedes integration. Thus, skill-oriented sessions ideally should come early in any program. Integration into the module then could benefit from coordination among instructional-technology facilitators and content-area facilitators. This would necessitate meetings and joint planning sessions. The result would be clear plans for supporting content areas with technology as appropriate. Participants would then benefit from further guidance and reinforcement of their developing technology skills within the broader context of the total program. This approach would do much to demonstrate the desired connections, rather than leaving it to novice technology users to discover them.

A side benefit of greater integration should be improved sequencing of offerings, which would minimize the disparities among participants and allow greater progress from session to session. It should be possible to cluster skills development sessions early in the program year, without long gaps, so that reinforcement occurs more naturally. Additional sessions scattered throughout the year would help bridge possible gaps between expectations in content areas and participant skills. The final sessions of the year could then focus on completing technology activities and projects, rather than being the point of introduction of new techniques.

Basic skills

One of the greatest challenges of all was the result of highly varied basic technology skills. Each workshop had a set of goals and expected outcomes that assumed that participants had basic computer skills. There was insufficient time to teach file management, folder creation and use, and so on, and still hope to reach the larger goals. However, it became painfully evident in many sessions that a significant number of participants lacked those fundamental skills. One need not be a computer whiz to integrate technology into learning activities, but a teacher without the basics is like a bicycle rider who is unaware that the cycle has gears or brakes. They can still ride, but it is needlessly difficult and sometimes unpredictable. Just providing equipment such as laptop computers to teachers is not enough if they are to benefit fully from the technology. It would be best to establish requirements for participation in the program with remediation opportunities for those who lack the most basic skills.

Support

Support means adequate personnel at each session to assure, first, that the technology is working correctly and then to assist throughout the workshop during individual work time. Teachers who are willing to develop technology integration materials and plans can lose their enthusiasm quickly when faced with even minor glitches. Prompt, effective troubleshooting is key to maintaining the momentum that presumably brought the participants into the workshops in the first place.

Recommendations

The following recommendations may assist other groups or organizations that seek to create comparable programs:

- Base all instructional technology elements on applicable national, state, and local standards. This provides the essential rationale and context for the offerings.
- Integrate the IT elements into the program thoroughly from the start of planning. If a program is already under way, integrate IT into the structure as completely as possible; avoid a separate entity that requires the participants to make the connections between IT and their other responsibilities. Clearly define the expectations to incorporate technology components into larger program outcomes such as an instructional module. Provide key training sessions early enough in the program for participants to incorporate new technology applications into their evolving instructional units. Optimize the sequence of sessions so that skills grow steadily with the minimum possible loss due to time gaps.
- Assure that all participants have basic computer skills (e.g., file management, terminology, mouse skills). Too much workshop time is non-productive if basic skill deficiencies hamper new content presentation and learning. Consider a required prerequisite workshop on fundamental computer concepts and techniques.
- Do not underestimate the level of support the participants will need. Experience suggests that teachers expect and need a lot of direct, one-on-one assistance when learning to use new technologies.
- Assure that the infrastructure exists to support the IT elements, starting with appropriate physical space. Technical support staff should be readily accessible, if not constantly available, and issues of Internet connections, server access and storage, printing, and availability of specialized hardware such as scanners need to be addressed.

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15. Communication Across the Curriculum

Bradley Peters

This chapter explores a communication across the curriculum (CAC) initiative that involved a university, a community college, and an urban school district. CAC focuses on developing writing, reading, and speaking lessons in mathematics, science, and technology, as well as English, classrooms. This initiative, funded in part by the National Science Foundation, was unusual because it included English. The inclusion of English validated: (1) students' writing as the primary method of gauging learning, (2) teachers' communicating across the curriculum as a method of creating integrated instructional modules, and (3) workshop facilitators' demonstrating cross-curricular activities in writing, reading, and speaking as methods of defining mathematical, scientific, and technological literacy.

The following pages review essential principles and practices of sound CAC pedagogy, emphasizing the kinds of communication strategies, especially writing, that generally help teachers obtain evidence of learning among elementary, middle, and high school students. Then the discussion places CAC in the wider programmatic context of the initiative, indicating where teachers experienced the development of their own communication skills. A summary of results indicates how the CAC activities helped sustain curricular integration for participants in the initiative. Finally, there are specific suggestions for future initiatives.

CAC-Related Principles and Strategies

Scholars in CAC have long known that the overall development of successful reading and speaking skills depends on good writing instruction (Barr, 1995; Della Croce & Everett, 1999; Dunn, 1998; Flynn, Remlinger & Bulleit 1997; Hain & Louth, 1999; Quinn, 1995; Tchudi & Lafer 1996). Above all, "writing also affects reading comprehension," the National Assessment of Educational Progress notes in a 1998 reading report card for primary and secondary schools. Students in grades four, eight, and twelve "who said they wrote long answers" to their reading assignments in various subject areas on a weekly basis scored higher than those who said they never or hardly ever did so (National Writing Project & Nagin, 2003a, p. 12; see also S. Andrews, 1997; Freidman, 1997).

The often repeated mantra in CAC is that "writing promotes learning: what we learn through writing we are more likely to retain and more likely to understand" (Law, 2003, p. 4). Although CAC got its start in English studies and spread throughout the humanities (R. Andrews, 1998; Bohan & Davis, 1998; Haust, 1998; Kumar, 1999; Perkins & Kervick 1999; Tucker, 1998), research shows that good writing instruction also yields strong evidence of learning in many of the disciplines known as "hard" or "empirical," such as mathematics (Bolte, 1998; Burton, 1996; Hayden, 1997; Isaacs, 1997; Mazur, 1999; Mower, 1996; Russek, 1998; Taylor, 1999), the sciences (Becker, 1995; Burnham & French, 1999; Chabot & Tomkiewicz, 1998; English, 1997; Jacobs & Moore, 1998; Keys, 1999; Klein, 1999; Moore, 1993; Rorrer, 1996; Sherwood & Kovac, 1999; Winchell & Elder, 1992), and technology (Drexel & Andrews, 1998; Hirt, 1999; Ramey & Hudgins, 1999; Sorenson, 1999; Watkins-Goffman & Dunston, 1994). The multifarious uses of writing instruction include "writing as problem solving; writing as critical thinking, writing within pragmatic contexts rather than [stand alone, i.e., belletristic] themes; writing as a way to individualize instruction for a multicultural and multilingual student body" (Maimon, 2001, p. x).

Advocates of CAC know, too, that improvement in all communication skills only occurs for students when they receive systematically *sustained* "instruction and guidance while they are working on pieces of writing within the context of a specific discipline" (Law, 2003, p. 4). Without such sustained practice, which obtains the best results when connections to students' cultural backgrounds are addressed as well, reading skills *especially* will not advance (see Applebee, 1993). Yet "national studies and assessments of writing over the past three decades repeatedly show that students spend too little time writing in and out of school" at all levels, primary through postsecondary, a situation that profoundly affects the development of reading skills not only in English but in mathematics, the sciences, technology, and other disciplines (National Writing Project & Nagin, 2003a, p.13).

To illustrate, one of the high schools involved in this initiative had a strong grasp of the importance of writing. School administrators advised teachers that they must participate in a program that would target all secondary levels – grades 9 through 12 – requiring students to have practice writing paragraph-length pieces that served many purposes, such as concept summaries, class minutes, correspondence, definitions, creative solutions to problems, directions or "how to" processes, and prediction. Teachers had to get students to understand how real-world writing functioned: to inform, clarify, explain, justify, or persuade. Teachers would evaluate the written work with a rubric that included clearly defined criteria for focus, support, organization, and grammatical conventions.

However, the school's administrators advised teachers to require students to write a 150-200 word paragraph *once a month*, with no attention to the kind of instruction that engages all the complex processes of writing: "rumination, investigation, consultation with others, drafting, feedback, [rereading,] revision, and perfecting" (National Writing Project & Nagin, 2003a, p. 11). Moreover, despite their concern about the concurrent development of reading skills, the administrators did not mention (let alone emphasize) writing-about-reading. Instead, they emphasized that the monthly paragraph writing must help students improve scores in the writing component of the Prairie State Tests. Such an impoverished, test-driven approach to CAC – despite its well-articulated premises – was bound to fail. Teachers got the message that no further writing or reading instruction was necessary. Some could not figure out how to make the writing exercises connect meaningfully to course work in their subject areas. Students saw the exercises as repetitive busy-work. No increase in test scores took place.

Moreover, in most classrooms nationwide, two common but fallacious reasons for inadequate instruction in writing recur among teachers in all disciplines (*including* English): (1) teachers often feel that time spent on writing instruction takes away from time needed to cover course material and (2) teachers often feel unqualified to teach writing. This kind of reasoning undermines the development of good reading skills as well because it ignores the reading-writing connection.

To address these problems, teachers need sustained opportunities for professional development that, according to Maimon's (1992, p.x) "Carlton Plan,"

- Provide writing-about-reading workshops to "create a nonhierarchical setting for real dialogue across the disciplines"
- Encourage curriculum change that emerges from "intellectual exchange among faculty members"
- Offer "a sense of [teacher] ownership" rather than obedience to top-down executive orders or teach-to-the-test imperatives
- Promote collaboration "among faculty members and among students"
- Involve students "in commenting on [their] work-in-progress" at faculty workshops, thereby affording students "a leadership role" in teachers' professional development
- Define "writing as a complex process closely related to thinking"
- Establish that well-informed writing-about-reading instruction "helps students learn subject matter as well as to improve fluency in writing"

As the above principles imply, writing-about-reading workshops for teachers become the vehicle for an emergent "CAC culture."

What follows is a description of writing-about-reading strategies that the mathematics, science, technology, and English teachers in this initiative actually tried. These kinds of strategies promote ongoing development of a CAC culture – although building a strong CAC culture that enjoys the participation of a significant number of cross-curricular faculty still takes a minimum of three to five *continuous* years, and often as many as 10 (National Writing Project & Nagin, 2003a, p. 93). The strategies described here emphasize the high level of interaction and engagement in very specific, classroom-adaptable practices that are crucial to successful professional development in CAC. The strategies include reading challenging texts, experimenting with textual formats, designing and responding to cross-disciplinary assignments, conducting written discussions online, planning and scheduling multiple-stage assignments, accommodating cultural rhetorics, publishing student writing, writing as a means of classroom management, and using and evaluating portfolios of written work.

Reading challenging texts

Teachers read an excerpt from Ricoeur's (1981) *Hermeneutics and the Human Sciences*. A CAC facilitator gave them an objective test that required them to provide answers to multiple choice and true-false questions, after which they immediately received the correct answers and scored their understanding of Ricoeur. Next, a second CAC facilitator asked teachers to read an excerpt from Ragland-Sullivan's (1986) *Jacques Lacan and the Philosophy of Psychoanalysis*. This time, the workshop facilitator provided definitions to several key terms, explained the context from which the excerpt was taken and talked about how Ragland-Sullivan's excerpt applied to his own research. The facilitator then asked the teachers to read the excerpt, encouraging them to underline passages that caught their attention, write brief informal notes about points they felt they understood, and locate parts of the text that confused them. Afterwards, the teachers got together in groups to share what they had written. In a general discussion, the teachers identified which reading activity most resembled the way they taught texts in their own courses. The teachers recalled how they felt at the beginning and middle of reading each excerpt, identified excerpts they found difficult and strategies they used to make sense of the excerpts, and described what the workshop facilitators did (or could have done) to make the reading experiences easier.

Experimenting with textual formats

Teachers read through a selection of cross-disciplinary excerpts taken from books on how to prepare for the Graduate Equivalency Exam and the Standard Achievement Test. They identified features of the excerpts that would make the reading difficult for their students. Then the CAC facilitator asked the teachers to write informally about an important concept in their discipline, using language they felt their students could grasp. After that, the teachers wrote about the concept in another – perhaps nontraditional – format, such as notes that "talk back" or question the author of a text, a reading log entry, a summary/response paragraph, an interview, a poem, an autobiography, a dialogue, a news release, an advertisement, multiple-choice or short-essay questions, a picture, a scene from a play, or a paraphrase (maybe in a different dialect). Teachers shared what they had written in small groups, and then each group chose someone to perform his or her written work for the whole group.

Designing and responding to cross-disciplinary assignments

Teachers selected or wrote a passage about another important concept in their discipline, this time making an effort to exemplify "textbook language." Then they listed different reading strategies they felt students would need to understand the passage, paying special attention to features of the language. After that, they wrote instructions for a writing activity that they believed would teach a key strategy to help students read their passage (e.g., asking students to define vocabulary, explain how they would teach the concept to other students, design an experiment, compare the concept to a similar or different one, cite a real-world application, speculate about problems the concept would address). Next, the teachers exchanged their instructions with another teacher who taught a different subject. Each responded in writing to his or her partner's instructions. When finished, they evaluated each other's written performances, citing their reasons for evaluating what their partner had done. Teachers volunteered insights about what they learned about making connections between the processes of reading and writing, "decoding" the kind of language textbooks are written in, and designing activities as well as writing clear instructions to assist students in reading comprehension.

Conducting written discussions online

Teachers did a Web search for sites they believed would be useful for their students to access and study for the courses they taught. The teachers copied and pasted the URLs into a WebBoard conference, annotated them, and explained what they thought students might learn from reading and exploring each website. WebBoard is an online writing software that permits a high degree of interactivity among online writers. (BlackBoard and WebCT provide similar electronic writing environments.) Next, teachers accessed one another's annotated URLs and websites and offered their own impressions of how useful they might be. They also discussed what they had learned from writing about the websites rather than talking about them to one another.

Planning and scheduling multiple-stage assignments

Teachers looked at an online syllabus for a first-year college-level writing course. They examined, in particular, two assignments that required students to find and choose their own books belonging to a specified genre (e.g., autobiography and career-related). The assignment required students to write several practice pieces in stages, first identifying an important topic in the book, then researching and evaluating several sources relevant to that topic and doing textual analysis and, finally, making connections to the sources that amplified their understanding of the topic. They synthesized their work into a 6-8 page essay. The teachers studied how the assignment stages built on one another and targeted different types of writing-about-reading strategies. They then discussed the kinds of reading and writing assignments included in their own syllabi. They compared their assignments with the multistaged ones in the first-year writing course.

Accommodating cultural rhetorics

Teachers looked at lists of rhetorical techniques employed by writers from different cultural backgrounds, such as American deaf culture (Anderson, 1998; Davis, 1995), African American (Balester, 1993; Gilyard, 1991; Gilyard & Richardson, 2001; Smitherman, 1994, 1997; Troutman, 1997); Chinese, Japanese, Middle Eastern, and Spanish (Leki, 1992); and Native American (Lesko, 1996; Raimes, 2003). The teachers speculated about the kinds of difficulties they thought students with different cultural rhetorics might have with reading and writing about American texts in their own disciplines. The teachers attempted to write about a concept in their own discipline, emulating a different cultural rhetoric. A few of them volunteered to read their pieces aloud, while others tried to guess the cultural rhetoric the volunteers were imitating. They discussed the difficulties of reading and writing in another rhetorical tradition. Finally, they examined an assignment calling for the analysis and comparison of two arguments. They read an Afghani student's written response to the assignment. The teachers identified where the student's rhetorical practices differed from those most highly regarded in American academic rhetoric (Crowley, 1994) and debated what written guidelines they would give the student to help him revise.

Publishing student writing

Teachers read work by students who had reviewed books on Amazon.com, students who had evaluated websites in an exercise posted on a WebBoard conference, and students who had published personal essays in a textbook used for a first-year writing course. The teachers discussed how they thought these forms of public writing might have been affected by the students' awareness of a larger reading audience. Then the teachers posted their own ideas on the

WebBoard, brainstorming assignments that would invite students to publish written work in courses they taught. They reviewed what ideas they and their colleagues had written.

Writing as a means of classroom management

Teachers described a class they had recently taught in lecture format. Then they revised it by introducing written activities. The teachers shared their alternative plans with one another, explaining their rationales for designing the activities and justifying the amount of time they allotted to writing. Written activities included students (1) reviewing the most important points about a previous class, (2) responding to a mini-lecture, (3) commenting on a reading assignment, (4) preparing questions for a class discussion, (5) reflecting on newly introduced material, (6) explaining contributions to a small group activity, (7) appraising or interacting with another student's piece of writing, (8) arriving at a consensus or articulating reasons for disagreement on a controversial issue, (9) suggesting how to apply an important concept to a real-world situation, and (10) forming an hypothesis. The teachers talked over the ways that they thought the class might have turned out if they had tried these exercises. They speculated about how they would evaluate such writing.

Using and evaluating portfolios of written work

Teachers reviewed directions for students to assemble a portfolio of their best work in a biology class. Then the teachers read generic directions that could be adapted for students to assemble a portfolio in a course they taught. As follow-up, the teachers read through a collection of student work in an online portfolio, comparing the changes among drafts. Then the teachers discussed revision as a neglected kind of reading skill. Applying a rubric that had been designed for a first-year writing program, the teachers ranked the online portfolio.

We employed these strategies in several different venues: (1) daylong workshops held in an atrium at a high school, where cross-disciplinary participants brought their own laptops; (2) breakout sessions in daylong conferences at the university or a community college, where small groups of cross-disciplinary participants went to a computer lab; (3) daylong or half-day workshops held in a networked research facility at the university, where only middle and high school English teachers consulted with the CAC facilitator and other professorial writing faculty.

All strategies emphasized how CAC pedagogy helps teachers to address writing and reading skills that transfer across content areas. That is to say, none of the strategies gave more weight to specific course content in English or any other discipline. We expected that if teachers could augment their classroom techniques to help students discover how to learn through writing and reading, mastery of specific course content would follow.

CAC in Programmatic Context

Our initiative drew CAC into its professional development plan at a time when CAC took hold as a program in the partnering university. The director of this initiative asked the university's CAC coordinator, *not* the same person who helped organize and facilitate the writing-about-reading activities described above, to help the teachers build and reinforce literacy broadly. The director felt that it was a strategic necessity to encourage English teachers from the target school district to participate in the initiative because they could: (1) reiterate the convention that writing generates valid evidence of learning, (2) provide additional peer support in the workshops where teachers designed modules, and (3) bring their knowledge of instruction in reading, writing, and speaking into the purview of developing mathematical, scientific, and technological literacy.

During a two-year pilot program funded by the state, forerunner of the NSF-funded initiative, this CAC coordinator introduced teachers to the theoretical principles of CAC and encouraged them to apply the principles to instruction that resonated with real-world practices in the teachers' respective disciplines. The teachers readily accepted the CAC principles, but many (including a number of English teachers) struggled to translate the principles into classroom practices. The director of the initiative identified teachers who successfully implemented CAC in their instruction and asked them to join her core team. Then the CAC-savvy team held focused workshops to help the other teachers develop the writing, reading, and information-retrieving skills that they needed to design effective performance tasks for their modules. The pilot program identified a proven, effective model for professional development: *teachers teaching teachers*.

Unfortunately, around the time the two-year pilot program ended, the university CAC coordinator moved on to another institution. A two-year interval occurred before CAC again entered the picture. On the other hand, the director and her team discovered that the efforts to introduce and implement CAC had not been wasted. When the sponsoring university hired a new CAC coordinator, the director invited him into the initiative, along with other university English faculty. These new facilitators found that many teachers who had been introduced to CAC had not forgotten or discarded what they learned. Building upon the earlier CAC foundations, the new coordinator and other English faculty facilitated writing-about-reading workshops that expanded upon what many teachers knew as they continued to participate at higher program levels. These experienced teachers were then able, to a certain extent, to pass along and reinforce the principles that guided what the CAC strategies again brought to the initiative.

A surprising side note: except for the new CAC coordinator and the university facilitators from English, hardly any cross-disciplinary facilitators (in mathematics, the sciences, or technology) expressed familiarity with CAC.

CAC re-entered the initiative when a principal from one of the participating high schools invited the CAC facilitators to meet with cross-disciplinary teachers for an in-service day. The schedule included two breakout sessions: one that outlined how to set up a high school writing center and one that featured many of the workshop strategies described above. Following this in-service, the same school hosted another daylong writing-about-reading workshop for cross-disciplinary teachers from other schools in the district. Many cross-disciplinary teachers participated in the fully dedicated CAC "refresher" workshops.

On other occasions, the full assembly of participating teachers heard CAC briefly mentioned during cross-disciplinary seminars on (1) state standards, (2) university requirements and expectations, (3) and profession-related requirements and expectations in industry, business, medicine, and civic service. However, only English teachers went on to participate in sustained workshops with the CAC facilitators, because the initiative then scheduled sessions for teachers in each discipline to spend intensive time with the university facilitators from their respective disciplines.

A cautionary observation: in settings such as this, cross-disciplinary teachers *may* get the impression that CAC is an English concern and that English teachers should take the primary responsibility for writing or reading instruction, while teachers in other disciplines should focus on helping students master content. However, the mathematics, science, and technology teachers in the initiative did *not* succumb to this false impression. The pilot program had laid too firm a foundation, and CAC received ongoing validation at important moments.

Moreover, the whole cross-curricular endeavor remained intensive in reading, writing, and speaking. The teachers searched and read extensively for new information that they could teach, and they infused their teaching modules with reading beyond the textbooks that the district supplied. Teachers individually practiced a process of writing-about-reading as they wrote lesson plans, developed lesson materials, and made choices in teaching strategies, including assignment-specific rubrics. Throughout the preparation of the teaching modules, the teachers inevitably engaged in a prolonged discussion on four crucial levels: (1) students' need to master diverse writing and reading tasks, (2) teachers' need to build common expectations for good writing and reading, (3) schools' need to develop fair and authentic writing and reading assessments, and (4) administrators' need to accept multiple approaches to teaching writing and reading (National Writing Project & Nagin, 2003a, pp.13-16).

The initiative also gave the English teachers opportunities to develop vision and leadership by working with CAC facilitators to:

- Debate what kinds of "long-term plans for improving writing" might be most useful, vis-à-vis reading
- Learn about policy statements that "articulate a rationale for why writing matters and why improving it should be a focus of the entire school community," vis-à-vis reading
- Discuss "the status of writing and of teaching it in [their] individual schools," vis-à-vis reading
- Train more intensively as reading instructors and as "advocates for improving the teaching of writing in all classrooms"
- Devote time to learning about necessary resources and "research-proven classroom strategies" (National Writing Project & Nagin, 2003a, p. 88)

Teachers could not always apply what they learned. They spent much time discussing the considerable impediments they faced – including, in some cases, no encouragement to put their leadership training in CAC into practice, unreliable access to technology, inflexible faculty, administrative attitudes and administrative structures that resisted change, and distrust from the school community.

Results and Inroads to Curricular Integration

Teachers of mathematics, science, and technology infused their teaching modules with many opportunities to sustain course-relevant practice in writing, reading, and speaking. English teachers, on the other hand, had a more formal, conscious understanding of CAC's potential to make a significant impact on the overall curriculum.

For instance, a visit to a sixth-grade classroom in a middle school revealed students at work on a unit in careers, after they had read about some unusual jobs (e.g., a woman who did a promotional drive across the United States for the Maxwell Briscoe Motor Company in 1909). Students were preparing to interview professionals in careers that interested them. They did two practice interviews – one with the school principal and one with the CAC coordinator – to see how they might approach other professionals to ask about duties, educational preparation, salary expectations, and so forth. The teacher asked the students to compose suitable interview questions beforehand, conduct the interviews, write a report on their interviews, and then write an application letter in response to a similar job opening that they had to find advertised in the newspaper, on the Internet, or elsewhere.

Visits to a ninth-grade classroom yielded even more compelling evidence of CAC implementation. Students reading Dickens's *Great Expectations* had prepared and mounted flowcharts documenting events that influenced the development of characters in the novel. They were in the process of scripting and planning commercials that they would videotape to urge other classes to read the novel. The teacher also arranged for the students to correspond by email with an overseas business expert to understand some of the economic conditions that influenced English society at the time the novel was written.

Later, the teacher of this same class had the students read Shakespeare's *Romeo and Juliet* and set up a trial to determine if the lovers' parents had any legal culpability for their deaths. Students vied for the roles of prosecuting and defending lawyers, criminal investigators, psychologists, defendants, witnesses, and so forth. A criminal lawyer came into the classroom to inform students how such a trial and its investigation were conducted. A judge later came in to preside over the trial, with a jury composed of the school librarian, another English teacher, and the university CAC coordinator. The jury determined whether the parents were guilty and the type of sentence.

An eleventh-grade teacher in another school decided to set up a pilot writing center. After discussing the experiment with administrators and members of his department, he consulted with the CAC coordinator about recruiting and training peer tutors among the students he taught. Once the teacher had assembled and trained his staff, the CAC coordinator brought in peer tutors from the University Writing Center, who helped the high school tutors review student writing samples from various disciplines. The two groups of tutors exchanged ideas about helping the writers improve their work in classes where the formats and conventions of writing varied significantly. The teacher then arranged periods during the week when the high school peer tutors would be available to assist students from two specific classes – both English – whose teachers had expressed interest in supporting the experiment. At the end of the semester, all teachers and students involved in the experiment were pleased with the impact that the tutors had made on students' writing, but the high school administrators decided to abandon the idea because they wanted to use the space where the writing center had been set up for a study hall instead. No other space was apparently available.

This same teacher set up an electronic correspondence between students in one of his high school classes and students in a professor's English education class. The two classes exchanged information about their assignments, course materials, and actual written work. They used the interactive electronic writing environment of WebBoard, also an extensive exercise in technological pedagogy. High school students received the opportunity to receive commentary on their drafts from advanced composition students in college, and the college students could exercise what they had learned about effective writing.

Additional evidence of a sustained impact of CAC resides in two important outcomes. First, many of the performance-based teaching modules in mathematics, science, and technology demonstrated similar implementations of CAC. For example, a science teaching module on the toxicity of the river that ran through the school district's city required students to read about what kinds of tests should be conducted. The students then gathered data, drafted a lab report, and composed a "results" document that would persuade a board of city directors to act. The students had to rehearse such a presentation. Like the activities the English teachers designed, these performance-based, real-world tasks yielded solid evidence that students (1) learned content, (2) found the experience relevant and fun, and (3) achieved an understanding of how to apply interdisciplinary concepts and integrate communication skills across mathematics, science, technology, and English.

A second outcome involved further collaboration with the ninth-grade teacher mentioned above. The teacher told the CAC coordinator about the administration's recent decision to launch a district-wide CAC initiative in response to repercussions from the federal Leave No Child Behind legislation. The school district was conforming with the rest of the state, according to a highly regarded study of writing assessment in five states: Illinois, Kentucky, New York, Oregon, and Texas (Hillocks, 2002). That is, the district's students had 40 minutes in a standardized test to produce a "stand-alone" essay not related to any course, whereas by contrast, students in the most competitive state, Kentucky, had a full year to produce course-related drafts for a portfolio. Assessment scores had no impact at all on the students' academic progress, whereas by contrast, low scores in two of the other states (New York and Texas) prevented students from graduating. Many teachers (70% statewide in Illinois) were pressured by the nature of the 40-minute test to instruct students in a form of writing that only engendered "vacuous writing" unconnected to disciplinary reading and conducive only to low standards for teaching (National Writing Project & Nagin, 2003a, p. 75-76). Therefore, the district's administration was eager to find ways to focus on teachers' professional development in writing-about-reading instruction.

At the same time, the CAC coordinator and other university faculty in English were working with the state coordinator of the National Writing Project (NWP) to set up a regional site. The NWP is a professional development organization that has trained "more than 100,000 teachers, grades K-16, in all disciplines" at more than 175 sites in 50 states, and it does a strong job of addressing the reading-writing connection (National Writing Project & Nagin, 2003a, p. xi). The NWP also insists upon a teachers-teaching-teachers model, where participants demonstrate and discuss their expertise in classroom practices, read research, and become immersed in writing. Afterwards, participants return to their home institutions and offer workshops for colleagues. Inverness Research Associates (2002), an independent reviewer, found that NWP-trained teachers outperformed others in terms of effective classroom practices, and the Academy for Educational Development discovered that high percentages of third- and fourth-grade students (73-89%) taught by NWP-trained teachers showed consistently strong achievement in persuasive writing and strong control of usage, mechanics, and spelling.

The ninth-grade teacher and the CAC coordinator notified the school district administrators that they would organize a demonstration workshop led by NWP representatives and jointly sponsored by the NWP and the university. Some 26 participants showed up, mostly English teachers, although the NWP aggressively encourages involvement among teachers from *all* disciplines. After the workshop, all agreed that they wanted to see a regional NWP site established. They nominated the ninth-grade teacher as one of the first co-directors. The CAC coordinator later met with the director of the district's reading and writing department, instructional specialists, and instructional council to inform them of plans to bring the NWP to the region. If all goes well, the first summer NWP institute – a four-to-five-week intensive program that the U.S. Department of Education funds – will take place in 2005, and at least two more interim workshops will occur beforehand.

Based on evidence of the initiative's implementation and impact, the following suggestions would enhance the inclusion of CAC in future initiatives and assure improved results:

- Thoroughly inform all participants – especially university facilitators – about up-to-date CAC theories, research, and pedagogy, perhaps through distributing and using a resource such as *Because Writing Matters*, by the NWP and Nagin.
- Hold a minimum of one or two workshops on CAC, where well-informed university facilitators from specific disciplines work with teachers in those *same* disciplines, offering reading and writing activities that transfer to the classroom and relate to the formats and conventions *of those particular disciplines.*
- Invite teachers who have had time to develop and implement material they have learned from the initiative's seminars and workshops to provide teaching demonstrations at follow-up seminars.
- Invite students whose trained teachers have introduced them to new materials to join seminars and workshops and describe their work in progress.
- Hold a CAC workshop on designing forms of assessment in writing and reading that can fill the learning gaps that commonly used standard exams do not address.
- Provide exemplary teachers the opportunity to publish studies on the impact that participation in an initiative such as this has made on their classroom practices. The reflectivity involved in such a writing exercise would show that *teachers' efforts and voices count.*

In conclusion, an initiative that targets professional development for teachers in mathematics, science, technology, and English should not emphasize new content material without suggesting as well the pedagogical strategies that will most effectively convey the content material to students (and teachers). CAC strategies prove by far the most effective because of CAC's intense integration of reading, writing, and speaking practices that lead to salient, writing-based outcomes. Teachers may agree with CAC strategies in principle, but unless they experience those strategies themselves as readers, writers, and speakers, they may not acquire the confidence to incorporate them into their lesson plans and teaching modules. Including English teachers with their colleagues in mathematics, science, and technology opens the door for collaboration and the emergence of peer leadership in CAC. Not only students but also teachers benefit when teachers implement writing-about-reading and performance tasks that provide students with the opportunity to apply what they have learned from their exposure to new concepts, knowledge, and information. CAC strategies yield outcomes that compensate for the significant assessment gaps that standardized tests simply cannot fill because written outcomes tend to be more valid, reliable, and *authentic*.

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16. Mathematics: University / Secondary

Richard Blecksmith and David Rusin

Recently, Paul Sally wrote an editorial opinion in the *Notices of the American Mathematical Society* (Sally, 2003, p. 437). It is a call to arms asking mathematicians to undertake outreach to local schools. Schools face monumental challenges, and problems with mathematics education are certainly among them. When we first became involved with this initiative, we hoped to help the schools respond to these challenges, as Sally suggests.

What We Found in the Schools When We Began

We are mathematicians with no professional training in secondary mathematics education or any prior direct contact with the Rockford Public Schools. However, our department is heavily involved in the preparation of future secondary-school mathematics teachers, and we both have worked closely with our mathematics education students. We have also been personally involved with local school districts and with the institutional process of bringing high school students up to university-level mathematics work. We thought we were prepared to help the teachers in much the same way that we help college students prepare to become teachers.

It is fair to say, however, that we were unprepared for the situation we encountered in the schools, and especially in this school district. Some sobering realizations dampened our hopes of making quick contributions:

- It is painful to remember that the *weakest* incoming college is roughly the *average* high school student. Our admission policy requires incoming freshmen to be in the upper half of their graduating class; thus half of the public school population is less motivated or less equipped than the college first-year student with whom we are most frustrated.
- School districts lack the option of screening their students. University faculty have the luxury of inviting uninterested students to leave rather than disrupt class; high school teachers do not. Nor can public school teachers simply declare that a student's needs are below the level they believe should be taught in their school.
- University courses are increasingly subject to assessment review and the strictures of accrediting agencies. But these are much less confining than the standards and high-stakes testing that govern the high school curriculum.
- The deficiencies we see in college students accumulate in high school. The weaknesses in high school students are often already present in the middle grades, so middle school is an important level where we should devote attention. But as university faculty, we have only the faintest memory of what the middle school curriculum is like, and middle school students themselves are, to us, very mysterious creatures.

- The high school and middle school mathematics classroom is *not* primarily a link in the chain to the college mathematics classroom; it is a component of the K-12 school structure. It is a completely different environment to which we had to adapt. No mathematician, for example, seems to know what Bloom's Taxonomy means, whereas every K-12 teacher does. The K-12 teacher's mind is not as much on mathematics as on classroom management, mainstreaming, state standards, and technology – issues foreign to us.

These issues affect all large school districts. Rockford's problems from recent years, including expensive legal action over racial imbalances and financial woes more acute than in most other cities, have led to some other obstacles:

1. Internal regulatory issues tend to undermine teachers' activities. In particular, teachers reported that the school district had decreed that every high school student was ready for algebra; there was essentially no way to mark students as failing in a way that would keep them out of the next course in a sequence. Student access to the computers, *which the schools had already purchased*, was restricted.
2. The school district had virtually no resources for the teachers. Books were in short supply, as were classroom manipulatives, classroom calculators, and so on. Dedicated teachers need resources and consumable supplies to try to reach all types of learners.
3. The school district had no real resources to hire and retain qualified teachers. Some of the teachers in the district are excellent, working hard in an impoverished environment to make a contribution to the city. But such teachers as our university helps educate – properly trained and certified in the discipline – are in short supply in RPS. New teachers have little incentive to go to disadvantaged districts when wealthier districts are also hiring.

These issues create a climate antithetical to learning mathematics. Apart from a minority of people who like the subject, most people will learn mathematics only under some programmatic pressure or under the tutelage of a particularly inspiring and competent teacher. Given a situation in which the students know that they may safely drift to graduation and in which the teachers are at the limits of the mathematics that they know well, it is easy to see why students' mastery of the subject tends to be poor.

The university can do nothing substantial to resolve the issues listed above. But to do nothing at all is *not* really an option. So how can some outsider mathematicians offer anything at all to the teachers on the front lines? We considered a few promising courses of action:

1. Since we are already in the business of teaching mathematics to adult students who wish to teach, we naturally thought we could teach mathematics to those teachers already in the classroom.
2. We have a chance every day to pursue the subject matter that delights us; we believe it makes us enthusiastic about the discipline, and we hope to have that enthusiasm rub off on the teachers.

3. Being higher on the educational food chain, we have a clearer perspective of how the parts of school mathematics will later tie together to prepare students for college-level work in fields that use mathematics. In particular, we can help the teachers at all levels see the value of the skills and understanding they give their students for subsequent schoolwork and careers.
4. Our university has a variety of resources for use in the preparation of future teachers. We can share these resources with the Rockford teachers – exposure to various textbook series, classroom technology, instructional videos, websites, etc.
5. We can interact directly with the RPS students: we might take a simplified lecture from the college classroom and present it in the schools or simply show up for a school visit and stir up interest in our discipline and the careers for which it is necessary.

We tried all of these ideas in our meetings with the teachers over three years.

Activities

The overall structure of the program worked well. We met with teachers at full-day Saturday workshops throughout the school year. Usually we worked only with small groups: sometimes one for the whole day, and sometimes rotating several groups that would meet with us and with faculty in other disciplines.

Paths to careers

The intent of these sessions was to give the teachers – of all subjects, not just mathematics – a response to the students' whine, "When am I ever going to have to use this?" We know that mathematics study is important for students to succeed in technical careers; we wanted to make sure the teachers understood that too.

However, this is tricky. How can we convince students that they need to learn the quadratic formula for their careers? Engineers really do need it because they will have to compute partial-fraction decompositions in calculus so they can later compute Laplace Transforms in their engineering-mathematics classes. But this means nothing to students whose career visions are focused on being a roofer or a baker, and we cannot truthfully claim they will need the quadratic formula to succeed in those careers. Moreover, an audience of, say, middle school English teachers has little more inkling of these real applications than the student does.

Our illustrations of the uses of mathematics in the working world tended to be merely suggestive of the real applications and arranged to use only grade-school mathematics. We measured temperatures in a cup of cooling water and plotted a few points, remarking only at the end that more sophisticated mathematical equations model heat flow in other media, which, for example, is important in the design of delicate electronic circuitry: an accessible but not very informative display of how mathematics is really used. The teachers responded with enthusiasm.

Let's look at one of these workshops in detail. The career link was to the uses of mathematics in encryption.

We met with three separate groups of high school teachers and discussed a handout, "Computers, Codes, and Pails of Water." Our main objectives were to

1. introduce binary numbers and parity check bits
2. explain a simple way to use parity check bits to find and correct errors in transmitting data in binary form (which explains why scratched CDs can still play correctly)
3. discuss the Pails of Water problem. An example is to obtain exactly one quart of water with two pails of capacity 5 and 7 quarts each. The solution is to fill the 5-quart pail three times and empty it into the 7-quart pail twice, since 3 x 5 – 2 x 7 = 1.
4. introduce clock arithmetic and the "mod" function
5. explain the "31" code, and show by example how to encode simple text messages by first converting the letters to numbers, then scrambling these numbers by multiplying by an encoding number, and then finding the remainder of the product modulo 31
6. explain how to decode scrambled messages to read the original message
7. relate our encoding/decoding system to the Pails of Water problem
8. let participants work in groups on worksheets requiring them to decode the punch lines to a collection of jokes. For example, a mathematics teacher was found in an Iraqi school with a straightedge and compass in his pocket. Later the White House announced the finding of *instruments of mathematics construction*.

This code is also described in Childs (1979), "Chapter 10: Secret Codes I." The more secure and sophisticated RSA code can be found in Silverman (1997), "Chapter 18: Powers, Roots, and 'Unbreakable' Codes." For a general and popular account of secret codes, see Singh (2000). Recently, an 18-year-old girl, Sarah Flannery (2001), made a surprising contribution to encryption that she explains in her delightful and inspiring book *In Code*.

The material on secret codes was almost universally well received. The teachers felt they got a glimpse into just how much mathematics and technology have pervaded the mysterious world of espionage and data security. It surprised them to discover that the only mathematics they need to understand the basic concepts of data correction and encryption is what they learned in the seventh grade. Finally, the worksheet asking them to decode jokes is ideally suited to group work. The encryption worksheets were so successful that we used shortened versions of them for later Discipline Update days.

Module development

The initiative directors included several activities focused on the preparation of modules for classroom instruction. (A module here means a collection of lesson plans, classroom activities, and assessment tools, all related to one topic.) We had been encouraged to prepare classroom modules of our own for use in the schools. One of us prepared a module for high school trigonometry students, using music and acoustics as a hook to motivate the study of the trig functions and their properties. This did not go very well. The differences between college teaching and high school teaching seemed daunting: the need to tie activities to prescribed state standards and to specific tested outcomes and the attention to classroom management issues proved too difficult for an academic who is accustomed to a focus just on the details of the subject material.

Much more successful was a later workshop in which the faculty served as consultants to teachers who had already begun the preparation of modules. The teachers' enthusiasm for the topics they had chosen was evident, and they were already proficient at the design of modules. Our job was only to suggest aspects of mathematics they could reinforce as part of the module, and this skill comes naturally for us. Some sample topics:

1. Tabulating statistics for an ongoing student/parent survey
2. Statistics relating to the Holocaust
3. Earthquakes (measuring intensity using logarithms)
4. Studying the moisture level of soil in new suburban development sites
5. Tracing butterfly migration

Information-technology specialists refer to "push versus pull" models, according to whether information delivery is organized primarily by the provider or the client. This last workshop was definitely of the pull variety, and it worked well. The teachers came with their ideas partly developed and with questions they really wanted answered. Our push formats – when we presented programs developed in advance – sometimes failed because the material fell upon deaf ears.

Discipline updates – middle school, level I

In the discipline-update workshops, faculty met with one group of teachers – in our case, only mathematics teachers – for several full days. Participants were all teaching at the same level (middle school or high school) and had all been in the program equally long. ("Level I" means first-year participants and so on.) The intent was to help this homogeneous audience see more advanced parts of their discipline that would give more depth to the topics they were teaching.

Here is a typical day's schedule for one of these workshops:

1. Building rafts. Compute the volume and surface area of rafts built using *n* 1-by-1-by-10 logs for small values of *n*. Find general formulas involving the variable *n.* Later we showed a tape of sixth graders working in teams on the raft problem. (Video: *Building Rafts*)
2. Algebra Blocks. We looked at geometric explanations of sample algebraic multiplication and factoring problems, using a four-quadrant grid and pieces of dimensions 1 by 1, 1 by x, and x by x. Typical questions: (1) use the algebra blocks to draw (-x-1)(x+2), and (2) given that -x2+5x-6 is the area of a rectangle, what are its two factors (length and width)?
3. Videos. We watched tapes produced by the National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) on learning communities and mathematical discovery. We compared what we saw to what participating teachers experience. (Videos: *Mathematics: Making the Connection* and *You're Gonna Need Those Numbers*)

4. Technology. We shared online sources of information, such as AskEric, enc.org, nctm.org, comap.com, forum.swarthmore.edu, and a website of the second author, math-atlas.org. Teachers themselves brought and shared software they found useful.

Some features shown here were repeated on other Discipline Update days. We tried to present topics similar to what the teachers themselves might present in class. We also incorporated professional materials aimed at teachers and supported by research in the mathematics education community.

Discipline update – middle school, level II.

We continued the patterns shown above. Since the teachers had now been with us longer, these sessions tended to be more a meeting of peers. We might take time for roundtable discussions about the difficulties of teaching mathematics, or the teachers might share examples of technology that actually helped in the classroom. Here is a sample Level II day:

1. We looked at sample questions from the mathematics part of the fifth- and eighth-grade sample ISAT tests (a standardized test taken by all students in Illinois in those grades). For at least 10 questions, we explored further material relating to the concept being tested. For example, the solution to one ISAT question was based on the fact that the areas of similar figures change by the square of the ratios of their lengths. What happens to volumes in our 3-D world when length is altered by a fixed ratio?
2. Videos are helpful as a change of pace. Several good series are available from the Annenberg/CPB Mathematics and Science Collection, the MAA, the NCTM, and Project Mathematics at Cal Tech. We watched two tapes from this last series, designed by Tom Apostol, on *The Theorem of Pythagoras* and *Similarity.*
3. We distributed copies of notes and examples on how to make daily and weekly lesson plans.

The seeming emphasis on middle school was the consequence of a larger number of middle schools feeding into the four Rockford high schools. This enabled us to work with high school teachers in a smaller group format. The high school teachers' work affects us more immediately at the university level, and high school mathematics is more similar to university-level mathematics.

Green chemistry

On interdisciplinary days, our audience included teachers from all fields, so we had to keep the mathematics straightforward. Two of these days centered on environmental topics, so we presented mathematics with that focus:

1. Lake Pollution. We used a discrete version of a mathematical model to compute changes in the level of pollution over time in a lake with a fixed proportion of runoff. The original model, designed for second-year mathematics majors at Northern Illinois University, requires solving a first-order linear differential equation. The discrete

version calculates the percentage of pollution from year to year, and its solution involved logarithms.
2. Catch and Release. For middle school teachers, we included a study of the "count and recount" method for estimating wildlife population in a natural preserve.
3. Two-Lake Systems. For high school teachers, we explored the two-lake scenario of the lake pollution problems where runoff from one lake enters a second lake.
4. Mathematical models related to weather. A 30-slide PowerPoint presentation, complete with several worksheets, explained why deserts form on the leeward side of mountains and how smog gets trapped in low valleys.

The topics were accessible, and the mathematics portions of these days were short enough so that the workshops went fairly well. Indeed, the high school science teachers seemed quite happy to see the mathematics used to quantify a descriptive scientific analysis.

Navigation

Another interdisciplinary day focused on navigation, historically a significant part of mathematics. We picked a few mathematical topics to present:

1. There are three types of geometry – Euclidean, spherical, and hyperbolic – distinguished by the following count: given a line L and a point P not on L, how many lines through P are parallel to L? The three answers – (1) exactly one, (2) none, and (3) more than one – lead, respectively, to (1) Euclidean, (2) spherical, and (3) hyperbolic geometry. Terrestrial navigation involves (1) and (2), of course, but we illustrated (3) with the Devils and Angels drawing of M. C. Escher.
2. Exploration of spherical geometry on the surface of the earth. The Longitude Prize of 1714 promised a sum of £20,000 for a solution to the problem of determining the exact longitude of a ship at sea. We distributed handouts on how to determine longitude from an exact knowledge of the time at the port of departure. We also asked participants to compute the amount of error (in miles) if a clock is off by 3 seconds a day on a 30-day voyage. Accurate pendulum clocks existed in the early 1700s, but they were ill suited for travel at sea. Celestial solutions to the longitude problem were explored, based on the work of notable scientists and astronomers. After a long battle with the astronomers, the watchmaker John Harrison won the prize with his series of extraordinarily accurate chronometers.
3. How to locate a position in space, such as your favorite fishing spot in a lake, so that you can come back to it next time. The idea is to take measurements from two different points on the shore. The same idea applied to three dimensions explains the mathematics behind global positioning satellites.

The teachers seemed to enjoy the hands-on material more than the straightforward lecture about the longitude problem and the invention of early chronometers.

Teacher Case Studies

We found the participating teachers to be a very interesting group. Their backgrounds varied considerably, as did their needs as teachers. We present some of their stories here to give a sense of what was happening in the classroom and to see how well our workshops went for them. (All names have been changed.)

Carol taught sixth- and seventh-grade mathematics in a Rockford middle school. She had no mathematics background from college outside of a standard core competency course and possibly a methods course for education majors. She was obviously uncomfortable with the subject. She told us that, at the beginning of the semester, she always asked for a show of hands of everyone who liked mathematics, then she asked those who did not. She would raise her hand with the second group, saying, “I'm with you guys. I've never liked math, but I've come to realize that it's important, so I'll help you get through this class.” Her rather startling confession gains the sympathy of many of her students, but sends a troubling message to others. When asked about the technology available in her classroom, Carol listed an electric fan, an overhead projector, and an electric pencil sharpener, which, she was quick to point out, was paid for from the money the class made by selling candy. Carol was attentive and willing to try many of the group activities planned for each session. Unfortunately, her math anxiety often kept her from completing tasks. We suggested she take a look at Tobias' (1993) highly readable and insightful book, *Overcoming Math Anxiety.*

Mike taught at a school that had been deemed underprivileged. He had graphing calculators for each student in his class, three different brands, along with several computers and software. After the first week of the semester, his students had broken a half dozen of the calculators. To stop them from abusing more equipment, he collected all calculators and stored them in a box for the rest of the semester. He was teaching a general-purpose mathematics class for non-college-prep students. Mike was the participant most interested in the material on secret codes. He asked for further references, which we gave him (Childs, 1979; Flannery, 2001; Singh, 2000).

Susan had a degree in education, but did not specialize in mathematics. Though not as math-phobic as Carol, she obviously did not enjoy the subject. Our session with ISAT questions was in response to her telling us that the principal of her school was putting tremendous pressure on the teachers to improve results on these standardized tests. She asked us if we knew any ways to do this. So we were surprised to watch her spend all morning of the session involving the ISAT questions grading papers. When encouraged to participate in group activities or answer questions, she responded that she was way behind in her paperwork and would not participate right then.

Andy was an elementary teacher pressed into service teaching middle school mathematics. His highest mathematics course was college algebra. He had some mathematical misconceptions. For example he showed one of us how to draw an ellipse with a straightedge and compass – an impossible task. His solution, however, belonged in the category of good attempts; the final drawing actually looked like an ellipse. Andy did not lack in confidence and was willing to experiment and try new things.

Mary had a degree in mathematics education. She taught a class of gifted middle school students and thus did not encounter many of the discipline problems of the other teachers. She was looking for new ways to challenge and interest her students. She asked excellent questions and was willing to participate in the daylong activities. She was the first person to crack the secret codes and to figure out how to place the algebra blocks correctly.

Ron was a high school mathematics teacher, but his university training was in the social sciences, though he was comfortable with the material he taught. One of us had an opportunity to visit his classroom and found a high degree of mutual respect between him and his students. He was interested in smoothing the transition to university mathematics for his college-bound students, but he also tried to find ways to help those whose formal education would end at, or before, high school graduation. He was able to keep alive the interest of a student who wanted to know about Mersenne prime numbers; at the same time, he understood why students could be talking rudely at the back of another teacher's class – they had already figured out that it made no difference whether they failed a class with an average grade of 59% or 0%. They had quit trying by March but were required to be in class every day.

Assessment of Our Activities

What did we accomplish by participating in this initiative, and what did we learn from it? Our goals in working with the Rockford teachers were:

1. listen to their experiences and stories, both successes and complaints
2. provide enrichment by looking at some substantial mathematical concepts and questions
3. explain why rather than just how
4. give them activities and ideas for use in the classroom

How well did we do in each of these areas?

1. *Listening to the teachers*. Perhaps these talk sessions were our biggest success. The teachers face problems foreign to us. It is difficult to teach the FOIL rule to a 13-year-old student who has just discovered she is pregnant. We are mathematicians, not social workers, but we could offer a sympathetic ear. The teachers seemed pleased that university faculty would take an interest in the job they were doing.
2. *Enrichment*. One of the important uses of mathematics is to develop critical thinking skills. We were keener on this than the participants. After all, we thought, what could be better than spending a Saturday talking about interesting mathematics problems? Apparently the rest of the world does not always share our excitement.
3. *Why versus how*. Everyone enjoyed the manipulatives such as the algebra blocks. The session on building rafts was also well received. They asked some excellent

questions, such as, “What happens if you have n=0 rafts?” or “What about fractions such as half a raft?”

4. *Things to try in their own* classes. Here we failed miserably. We obviously do not know of a magic potion to make middle school students interested in mathematics or to make them do well on standardized tests.

As for an overall assessment, we cannot say. Mathematicians are task-oriented people trained to work on technical projects requiring great precision and abstraction. We know at the end with some certainty whether we have achieved something. Education reform, by contrast, deals with difficult-to-measure qualities. This is part of the cultural divide that we have found frustrating on several occasions during this initiative.

Conclusion

Although we were not as successful as we had hoped to be, we encourage others to continue such initiatives. More successful models may be developed for working with mathematics teachers, and surely the schools will benefit to know that we take a keen interest in their work. We learned a lot from the many conscientious and hardworking teachers we met. Understanding the problems public school teachers face will help make us better teachers in our own university classes, especially the ones aimed at education and mathematics education majors. Thinking of ways to stimulate the participants of this initiative – and the hundreds of public school students they teach – is a challenge that we recommend to others in the sheltered world of the university.

Videos Used in Workshops

Building rafts with rods (tape 3). Teaching Math: A Video Library. The Annenberg/CPB Mathematics and Science Collection.

Mathematics: Making the connection. National Council of Teachers of Mathematics.

Similarity. (1990). *Project mathematics*. California Institute of Technology,.

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17. Mathematics: Community College / Secondary

Paul McCombs

In spring 2002, I was asked to present a workshop on integrating technology and mathematics for teachers of Rockford's district. The participants were from varying backgrounds, including biology, earth science, counseling, and other areas of middle and high school.

I created the workshop "When Am I Ever Going to Use This Stuff?" to introduce interactive mathematics into the classroom and to show the significance of mathematics in everyday life. The session combined lecture, a PowerPoint presentation, and an instructor-directed use of technology to simplify real-life mathematical applications. Discussion also focused on possible careers in an effort to promote the importance of mathematics in the educational realm. I also participated in an articulation seminar designed to stimulate dialogue between educators and industry representatives about the expected skill level of graduates and potential employees. Middle school, high school, community college, and university faculty members discussed student preparation expectations.

Mathematics Workshop

I started with a short lecture concerning linear regression. Participants were shown an example of a small town whose population was growing. We looked at the population numbers over a time span and identified a linear model. Then I showed how we could determine the best fit line for the data and how we could calculate the best fit line and make predictions using traditional methods. I gave them another example dealing with *Kelly Blue Book* values for automobiles. Here we looked at the value of a car compared with its mileage. We looked at basically the same type of problem, but instead of working through all the tedious formulas and doing multiple levels of calculations, everyone used a TI-83 graphing calculator.

The problems gave participants an appreciation for the use of technology. They were able to see the overwhelming calculations replaced by technology and also the power that technology brings to the classroom to do real-world problems. I selected the problems to show that real-world data does not always work nicely and that technology can help solve the more complicated problems. The participants were all pleased to see these examples and enjoyed learning for themselves.

Career Workshop

We discussed job opportunities and salary ranges from the *Occupational Outlook Handbook* and online resources. We broke the discussion into two categories: jobs in mathematics, like teacher or researcher, and jobs that use mathematics, like engineer or doctor. I finished by asking, "What job can you have where you do not use math?"

Articulation

At the articulation meeting, we met with industry representatives to discuss what they look for in students entering the workforce. The representatives emphasized that they wanted people who could communicate effectively and be problem solvers. They stressed the importance of the sorts of logical thinking and problem solving that could be learned in a mathematics or science class.

We broke into subject/discipline groups and discussed gaps between middle schools, high schools, community colleges, and universities. Our group concluded that:

A. Access to technology varied greatly. Some participants had limited technology resources, while others had an abundance. This was a surprise to some of the college faculty members, who expect students to have learned how to use graphing-capable calculators prior to coming to college.
B. Some teachers were not really mathematics instructors but were needed to teach mathematics. That was a big difference compared to college and university levels where professors are trained to teach in their discipline.
C. Textbooks were used differently at the different levels of education. Once a text was adopted in the middle and high schools, it must be used for an extensive amount of time. The college instructor may switch the text as desired.
D. At the lower levels, students learned computational skills and basic facts, but when they arrived at the university, they were expected to have more critical thinking skills.
E. Mathematics was that rare subject where a lot of redundant concepts were taught and the subsequent material continued to build on itself.
F. The learning process of the students was hindered by having instructors conduct so much review at the start of each new class.
G. Many students were exposed to the procedures and learned a few basic calculations by rote memorization but had little chance to apply them.
H. Middle and high schools focused on holding the teachers responsible for the students' education, whereas at the community college and university levels, the emphasis was put on the students themselves.
I. Some teachers may cover certain topics, while some may not; it depended on the teacher and the class.
J. Some schools were concerned with improving the skills of lower-level students and keeping the school off a watch list as opposed to teaching the content necessary for the next level of courses.
K. Grading differences existed at the different levels. Where many of the middle and high schools placed the emphasis on attendance, homework, and participation, the community college and university placed the emphasis on exams.

Closing Comments and Lessons Learned

The articulation meetings were very beneficial for all. The college and university professors were able to relate what they expected of incoming students, while middle and high school teachers were able to convey the problems they had preparing the students. Additionally, it was noted that middle and high school teachers were expected to keep attendance, take care of discipline problems, and be consistently interrupted by announcements, all of which disrupted learning. At times their days were interrupted by assemblies and other school-related activities that also detracted from learning. This was different than the college and university level, where professors specialized in their fields do not have to deal with as many distractions and put more emphasis on exam grades instead of attendance, homework, and participation.

The workshops were successful, with glowing comments that many of the teachers left with new information and mathematics-related activities they could share with their students. In addition to mathematics instructors, there were teachers from diverse disciplines. One biology instructor related that he would like to work with me on some projects (in particular a presentation on rates of radioactive decay) in his classroom that would incorporate more mathematics.

Before I wrote this I contacted one of the middle school teachers in the articulation group and asked her what she got out of the whole experience. She related she particularly enjoyed meeting the college professors and instructors and was able to relate to her students the importance of certain mathematics topics and how important mathematics and sciences are to their future success. She mentioned that she stresses more mathematics concepts now than she did before and reminds her students of what she learned by attending these events. She relates to her students what the professors will expect in college, as well as what the industries will be looking for. She hopes that she can better prepare her students for the future.

I am now better able to relate to my college level students what industries are looking for. More importantly, I am more aware of the background of some of my students. Before I had thought most students had the same opportunities, but I now have to keep in mind some students come from less technologically advanced school systems. Based on these experiences, I feel it is very beneficial to keep an open relationship between all levels of the educational process in each discipline.

18. Equipment Construction

Augden Windelborn

A workshop that is sorely needed but seldom offered to teachers is one dedicated to the construction and use of lab demonstration equipment. By constructing their own equipment from inexpensive parts, teachers acquire useful teaching tools and a better understanding of the concepts involved in experimenting and in the development of science. This type of workshop was conducted several times throughout the initiative for both middle school and high school teachers.

Problems

In several workshops, teachers told me they were unable to use a piece of equipment because the instructions were lost. Most of those teachers had no idea what the equipment could be used for because they had no knowledge of the topic it was designed to demonstrate and no practical experience with putting equipment together. If the teachers cannot recognize the parts of something, it is doubtful that they can recognize the function of the whole; therefore, learning to construct the equipment helps them recognize parts and functions. Further, the cost of demonstration equipment purchased through an educational supply house is often so high that teachers cannot afford to buy much, and certain items are simply too expensive, so being able to construct their own equipment saves money. Teachers who construct equipment for classroom use usually pay for the necessary materials themselves so that they can take the item with them if they change jobs. Very seldom do the teachers ever ask for support from their schools or districts.

The workshops usually follow a session that displays and demonstrates easily constructed equipment for classroom use. Many of the people teaching science classes do not have access to the wood and metal shops that make construction of equipment easier. It helps to have someone available who has built the equipment. Once teachers see what can be done, they are eager to build their own equipment. They are also more likely to perform a demonstration with equipment they have built than using equipment they may not fully understand. Teachers who have been teaching for a while and know the topics that need demonstrating are ready for equipment construction workshops. Those just beginning to teach will possibly benefit because science and mathematics principles are reinforced and often better understood through this process.

Justification

Students learn best from doing an activity themselves. If constructing the equipment allows the teachers to have enough sets for every student, the construction is justified. However, teachers also need the opportunity to learn, just as students do. As the teachers build a piece of equipment, they generally learn more about the theory involved in making it work. The opportunity to learn how to construct equipment occurs best in the proper setting: an equipment construction workshop. Thus two objectives are accomplished, developing skills in working with equipment and acquiring knowledge of concepts.

Expecting a teacher to be able to select the "right" piece of expensive demonstration equipment from a catalog and then make it work successfully is usually asking too much of many teachers. Further, districts need ways to acquire resources without unnecessarily large expenditures. Often technology teachers are asked to help fabricate equipment, but this does not always work if neither the technology teacher nor the science teacher really knows how the demonstration is supposed to work or what principles and concepts are supported by the demonstration. Technology teachers have their own projects on which they need to spend time, and if they build the equipment, then every time it needs repair or adjustment, the equipment will probably have to go back to them, which is not feasible. If teachers build their own equipment, they are much more likely to fix it themselves when there is a problem. The learning experience becomes a coordination of efforts. One must guard against technology teachers becoming the school techs for others. However, because they are often skilled in design and technical processes, very often a partnership can result in expanded and integrated joint efforts that will benefit both students and programs. The technology teachers can also lead workshops for a variety of types of teachers to design and build equipment, but clearly the leadership, knowledge, and skills should be acknowledged.

Assumptions

We assumed participating teachers had more access to computer equipment than to shop facilities and someone to show them how to make the equipment they needed, and that they knew what they wanted to build and how they would use it. We also assumed that they were aware of the basic concepts involved and could follow instructions or diagrams. However, supervision and instruction in the proper use of some equipment was usually necessary with those who had not worked with tools often.

Safety was an important consideration. Teachers may forget exactly how to use the equipment between when it is constructed and the next time it is used in a classroom. They were strongly encouraged to write their own set of ideas for using the equipment to help them in the future. Further, if a demonstration is really effective, the students in the class will want to try it. They should be allowed to do so, and thus the equipment should be safe.

The teaching environment can be significantly improved by having materials related to the topics being taught. It should be obvious what subject is taught in any classroom by simply looking at the room, and a science classroom will benefit by having demonstration equipment. Students who come to class early should be allowed to try the equipment once they have learned how to use it safely. I have never had students break a piece of equipment.

Keep demonstration equipment simple and readily controllable. The use of sophisticated equipment often hides the way things work from students. "High tech" equipment can be fun, and sometimes it is the only way to demonstrate certain effects, but it should not be used if a simpler method is possible and available.

Workshops

Part of the workshop content was the technique used in construction, along with the actual item constructed. The construction process also illuminated many mathematics and science principles. The teacher who constructs an item from scratch gains a better understanding of how it works. Therefore, one of the major aspects of this type of workshop was to decrease the level of technology used. The highest level of technology was to access online plans or pictures.

A partial list of the equipment that was built in recent workshop sessions includes standing-wave generators, pulse cannons, laser image generators, trebuchets, hovercraft, pressure cannons, center-of-mass demonstrators, mass sets, sundials, solar observatories, air tracks, pinhole cameras, solar cookers, circuit testers, hydroponics gardens, and motors.

Modeling

A section of the Illinois Science Core standards that is not always well addressed is the one dealing with technological design. Seldom are students (or teachers) asked to identify a real problem, propose a design solution, and implement, evaluate, and revise it. This process is exactly what the teachers did in the equipment construction workshop. Thus the entire workshop was a modeling of the standard related to technological design.

Did it work? How well? Can it be made to work better? As the participants proceeded through the workshop and answered these questions, they demonstrated their knowledge. The teachers did a much better and more rigorous job of self-assessment than I did of assessing them. As they tinkered with their items, they showed their knowledge of science. A teacher who makes a piece of demonstration equipment is more likely to use it and deepen their scientific and technological knowledge, skills, and abilities.

Results

Participants were asked to respond to five statements about the workshop. They had to state whether they strongly agreed (5), agreed, had no opinion, somewhat disagreed, or strongly disagreed (1) with each one. A point value from 5 to 1 was assigned to the answers, and an average response was found. The statements, with their average responses, are:

- This activity increased my knowledge and skills in my areas of certification, endorsement or teaching assignment. (5.0)
- The relevance of this activity to ISBE teaching standards was clear. (5.0)
- It was clear that the activity was presented by persons with education and experience in the subject matter. (5.0)
- The material was presented in an organized, easily understood manner. (5.0)
- This activity included discussion, critique, or application of what was presented, observed, learned, or demonstrated. (5. 0)

Some of the attendees had the basic skills but wanted support. Those who most benefited lacked the skills and needed to improve their knowledge of concepts.

Sustainability

There are three methods for sustaining outreach. One is to permit teachers to come to use the university's shop facilities or get advice. This is not an excessive burden on the university. The problem with this type of program is that it rarely reaches new teachers. The second method is to schedule days when our former pre-service candidates can return to use the shop facilities or get advice. They have a relationship with us that may make them feel that they can return for help and perhaps bring colleagues along. A third method would be to have someone from the university visit the schools and locate nonfunctioning equipment and have it repaired.

The difficulty with these ideas is making teachers aware of the opportunities for partnering. The second method would be the easiest because the teachers could be involved while they are student teaching and hopefully continue the partnership as they enter the teaching profession. The third method will be attempted by advertising on the ISTA listserv and on a website supporting the project. Each of these methods would require a change in teacher activities. Faculty involved in such projects would spend a lot of time supporting the effort, with probably little recognition from their university.

Recommendations

Many university science departments are becoming more separated from the technical shops that support them. I seldom see faculty in our shop constructing a piece of equipment. If it does not happen at the university, where equipment, supplies, and expertise are available, how can we expect it to happen at 6-12? Where does the expertise reside to prepare teachers to construct and maintain their equipment? Often the best support comes from the school or district technicians. Unfortunately, these people, even though they are the most qualified, are not allowed to work with the teachers.

School districts would benefit if they counted time spent on equipment maintenance or repair as part of an institute day. Instead of having an "expert" attend an institute to make a presentation, a technician could be brought in to help with equipment and show the teachers how to use it. Districts should make shop facilities available to teachers. Teachers should also have either an open account at a local hardware store or the ability to be reimbursed for materials purchased. The idea of allowing teachers to buy materials only through approved "educational suppliers" can lead to unnecessary cost and a very limited amount of equipment.

19. Lasers

Augden Windelborn

The goal of these workshops was to help teachers understand the theory underpinning laser technology through projects such as making holograms; therefore, the teachers needed to be introduced to the basic concepts of optics and waves. The teachers had little idea of what was involved in successfully making holograms. However, all participants did have the necessary skills to make holograms and attempted three during the workshop. Every teacher successfully made at least two holograms. The teachers were also provided with equipment and materials for making holograms with their students. Participants included both middle and high school teachers from diverse backgrounds. Of those who were science teachers, very few participants had ever had a science course that dealt with optics, waves, or lasers.

Justification

Working with lasers and holograms can expose students to scientific principles and concepts, as well as the application of mathematics and science; however, very few of the teachers in this initiative had any prior knowledge of optics and waves. During the first session of the workshop, participants were asked what they wanted to learn, and one of the most common responses was about the use of laser technology in particular careers. That response was addressed at the second session.

Assumptions and Changes

We assumed that the teachers wanted to learn how to make holograms and would be able to apply what they had learned in their curriculum. As in most initiatives, there was a range of participant motivations, and although there was great interest in applying mathematics and science through laser technology, teachers were unsure about having access to appropriate facilities in their schools. We also assumed that all the teachers had access to the Internet, and we created a website for the workshop that included the material (with links) covered in the workshops, as well as a full list of resources and additional lesson ideas and other resources for them to access later.

Furthermore, once work began with the teachers, it was necessary to move more slowly when introducing new concepts. Also we found that teachers had little prior knowledge of the science and mathematics foundations to laser technology; therefore, we had to incorporate changes in the content and process. Because of this, we found we needed more time.

Workshops

The content covered during the first session of the workshop was organized historically. Topics included the properties of light, reflection, refraction, diffraction, and interference. During the second session, time was spent on types of lasers, laser safety, holograms, and the process of making a hologram. We devoted most of the second session to making holograms. The secondary science teachers had definite plans on how they would use lasers and holograms in their curricula.

Four of the state science goals were built into the workshop:

State Standard 11a:	Know and apply the concepts and principles of scientific inquiry.
State Standard 12b:	Know and apply concepts that describe how living things interact with each other and with their environment.
12c:	Know and apply concepts that describe properties of matter and energy and the interaction between them.
State Standard 13a:	Know and apply concepts that describe the interaction between science, technology, and society.

We employed three different teaching strategies: directed instruction, activity-based learning, and cooperative learning.

Evaluations revealed that all the teachers increased their knowledge base while having fun during the workshops. This is an important result because science is often intimidating. The workshop did teach the participants some optics, and the fact that all the participants were able to successfully make a hologram also improved their confidence. Participants were asked to respond to five statements about the workshop, indicating whether they strongly agreed, agreed, had no opinion, somewhat disagreed or strongly disagreed with each statement. A point value from 5 (strongly agreed) to 1 (strongly disagreed) was assigned to the answers, and an average response was found. The statements and the average response are as follows:

- This activity increased my knowledge and skills in my areas of certification, endorsement, or teaching assignment. (4.83)
- The relevance of this activity to ISBE teaching standards was clear. (4.78)
- It was clear that the activity was presented by persons with education and experience in the subject matter. (5.0)
- The material was presented in an organized, easily understood manner. (4.94)
- This activity included discussion, critique, or application of what was presented, observed, learned, or demonstrated. (5.0)

Lessons Learned

Teachers in the workshops seemed to be split between two levels of capability; therefore, some teachers needed more assistance on the side of mathematics and science foundations, while a few others could have handled a higher level. If we were to do this again, we would suggest that there be a level one and a level two, with the first level offering scientific and mathematical foundations and the second level incorporating more advanced theory. For teachers to teach mathematics and science through holography, they need to acquire a thorough understanding of the mathematical, scientific, and technological concepts.

A workshop on holography can be extremely valuable for attracting teachers (and students) and creating an interest in science. It would be especially appropriate when offered initially as an introduction to optics and subsequently by working with teachers to gain the concepts and skills to actually teach holography and its underpinning mathematics, science, and technology theory. Finally important to note is the cost of making holograms. If it is not possible to afford within the formal science curricula, then it can be offered as a "special" activity for a science club, or teachers can seek external partners to help with the funding.

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20. Astronomy and Navigation

Augden Windelborn

Astronomy, it can be argued, was the first of the sciences. It can be introduced at the simplest level, requiring no special mathematics skills or equipment. It will develop observation, data gathering, and predicting skills. Even if the school is located in an urban area, observations of the sun and moon are still possible.

During the three years of the Rockford project, the sessions explored astronomy and a related topic, navigation, and included brief presentations on the observatory and other resources available at Northern Illinois University. One of the goals of the sessions was to provide participants with a general knowledge of astronomy and how it could be used in their classes. Activities were used whenever possible to model possible teaching methods. Participants were introduced to Web resources that would enable them to continue their exploration after the sessions were over.

Teachers are usually very interested in astronomy, and the topic is included in most middle school science programs because it is part of the science content standards. Unfortunately, the topic is not included in the science courses that most students take as they prepare to certify as teachers. Few of the teachers in my workshops had ever looked through a telescope or even viewed the pictures of space available on the Web. By the conclusion of the workshops, however, teachers were able to predict what constellations would be visible at specific times and where they would appear. They had also gained access to teaching resources and developed some ideas of how to use those resources in their classrooms.

Assumptions and Limitations

Generally, teachers have difficulty verbalizing their needs, so we try to provide a combination of knowledge about astronomy and ideas on how to teach it. Schools rarely provide instructional funds for astronomy, but occasionally a school will underwrite rental of a StarLab Dome, an indoor planetarium. The students are usually an extremely mixed group. Because the topic is most often taught at the middle school level before any tracking (official or unofficial) takes place, students of all ability levels will be involved.

Originally, most of the sessions were to be devoted to the use of astronomy in navigation, but the teachers wanted information on compasses and maps. They did not know how compasses worked or how they could be used to navigate.

Strategies and Modeling

We employed teaching strategies that teachers should use in their classrooms, mainly cooperative learning, directed instruction, and engaged learning through projects. We kept the materials simple, readily available, and inexpensive. We created a Web page for every topic in the workshop, with links to lesson plans and activities that others have developed.

The state standards affected the content of the workshops. Material directly related to the standards was included to guarantee that teachers understood the concepts and could justify using them. Teachers had to answer questions, perform actions or simple measurements, and share their results. Their ability to do these tasks gave us feedback on how well they understood the topics being presented.

We included a wide range of examples for using technology in teaching astronomy. The examples included online programs for simulating the night sky from different points on earth at a specified date and time, websites with pictures and programs related to space exploration, and demonstrations of the use of a StarLab in teaching astronomy.

Results

Teachers responded to five statements about the workshop. For each statement the teachers were asked to respond whether they strongly agreed (5), agreed, had no opinion, somewhat disagreed, or strongly disagreed (1), and an average response was found. The statements and the average responses are as follows:

- This activity increased my knowledge and skills in my areas of certification, endorsement or teaching assignment. (4.43)
- The relevance of this activity to ISBE teaching standards was clear. (4.35)
- It was clear that the activity was presented by persons with education and experience in the subject matter. (4.93)
- The material was presented in an organized, easily understood manner. (4.31)
- This activity included discussion, critique, or application of what was presented, observed, learned, or demonstrated. (4.50)

The lowest response, to the fourth statement, was due to the fact that four different faculty members presented at the session. Four different methods of presenting and four different subject areas made the session flow somewhat varied. The same argument could be applied to the second statement.

Sustainability of Outreach

There are a couple of obvious ways for sustaining the outreach started in the initiative. The workshop Web pages are maintained indefinitely. The StarLab is available for use by teachers I have trained in its operation. Over the years, this has resulted in thousands of students (and often their parents) having an introduction to astronomy. The practice of loaning the StarLab has made me feel as if I am partner in the learning that is taking place at schools, even though I may not have been there myself.

Recommendations

The biggest problem in offering a workshop on astronomy, as always, is a lack of time because to do more than briefly touch on the topics takes much more than a day. One way of improving the workshop would be to extend its length. If possible, multiple sessions, held a month or so apart, would allow the teachers to make night observations between sessions and share their observations and conclusions. Also we could have students cooperating across all levels: middle school to high school to university.

21. Life Sciences

Karen Messley

During the NSF-funded project, Rock Valley College (RVC) faculty worked each year with faculty from Northern Illinois University and the teachers of the Rockford district to examine articulation from high school to college (either directly to the university or first to the community college and then to the university). Additionally, two sessions were held each year involving faculty representatives from RVC and the teachers. The first of these was a discipline update and the second involved a hands-on workshop.

Articulation Workshop

The goal of the workshop was to compare middle school, high school, and college science instruction. This was to include an examination of

- knowledge, competencies, and skills taught
- content and procedures of assessments
- technology use by student and teacher
- teaching pedagogy
- Illinois state learning standards

We identified no significant gaps in curriculum content, but there were significant gaps in student performance from one level to the next. Ideally, the intrinsic redundancy of knowledge and skills would work to reinforce content from one education level to the next and enable quickly moving to a deeper examination of the material. Unfortunately, this is not always seen because teachers at all levels feel that they must re-teach the basics. The gap between taught and demonstrated knowledge in introductory college science courses can be attributed to the time between taking the comparable high school course and the introductory college course.

The community college and university instructors felt that incoming students often lacked critical thinking skills and believed that all that was needed to succeed in a college science course was to memorize definitions of terms. Related comments from the articulation sheets include:

- We are often trying to teach higher-order skills, but assessing lower-order skills.
- We do need to design assessment tools that will assess the higher-order skills.
- We do a good job of assessing content.

It is *assumed* that students have mastered the previous level prior to moving on to a higher level. However, 20% of first-year college biology students will fail; only 15% will earn an

A. Therefore, we, as a group, wanted to stress an overall focus on reading, science, and study skills, at all levels.

The articulation sessions could not pinpoint specific weaknesses at any level. They were, however, able to highlight the common goals and the limitations all encounter in developing student learning and thinking to the desired level. This discussion also provided the college instructors with a chance to hear firsthand many of the challenges of the middle and high school teachers: the amount of time that must be spent on non-learning activities, the lack of technology and equipment in many schools, the lack of time to set up (and clean up after) a laboratory experiment, and the necessity to cover all of the material dictated by the Illinois learning standards.

Discipline Update

The life science discipline update was an informal exchange of information. The foundation of the discussions was the preceding week's local newspaper and national magazines (such as *Time, Newsweek,* and *Discover*). We discussed the science behind the reporting. This facilitated an examination of the method of scientific inquiry, the technology being applied, the characteristics of any organism (viral, bacterial, animal, or plant) involved, and the bioethical questions raised by many scientific advancements.

A number of non-biology middle and high school faculty were present during these sessions. The questions they raised were excellent springboards to further discussion and exchange of ideas. It appeared that all, both biology and non-biology instructors, enjoyed the ability to explore these advances in a relaxed intellectual discussion.

Workshops

During each of the three years of the project, we offered "Meet the Microbes" as a three-hour session. The goals of the workshop were to:

- Provide Rockford teachers with easily conducted experiments that required minimal supplies and could be used to introduce students to the microbial world
- Illustrate how microorganisms could be used to reveal characteristics of living things
- Increase awareness about the role microorganisms play in our daily lives
- Provide participants with resource materials
- Relate activities with both National Science Educational Standards and New Standards™ Student Performance Standards
- Relate microbiology and literature through the display of fiction and non-fiction books based on microbial actions
- Provide interdisciplinary resources related to bioterrorism
- Develop an awareness of resources available at Rock Valley College that teachers could use in their instruction.

Each exercise was tied to both the National Science Educational Standards and the New Standards™ Student Performance Standards. Some of the experiments came from *Meet the Microbes through the MicrobeWorld Activities,* developed by the National Association of

Biology Teachers, with funding from the National Science Foundation, the Department of Energy, and the American Society for Microbiology. Several of these experiments had been performed by the workshop presenter with middle school girls as a part of the pilot study prior to publication. (These experiments are also available at www.microbeworld.org/home.htm.) Additional experiments came from *Science and Our Food Supply*, written by the U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition and the National Science Teachers Association, available at www.cfsan.fda.gov/~dms/tchcuric.html. During the second and third years of our project, material related to bioterrorism was made available to participants.

Workshop participants also included non-science teachers. Even so, all were expected to take part in several hands-on experiments that used readily available resources in an investigation of sugar and sugar substitutes in gas and calorie production. Experiments included investigating microbes as they affect human lives, the ubiquity of microorganisms, and the transmission of microorganisms and resulting diseases. The workshops moved from general background to specific concepts, while maintaining a comfort level for the participants, to show that many microbiological studies could be performed without a lot of equipment and apply in a multitude of disciplines.

Each participant received a manual of the performed experiments and resources. All exercises available on the Web were linked; the remaining resources were written by me and are available from me. Each of the exercises was tied to National Science Educational Standards and New Standards™ Student Performance Standards.

Outcomes

The collaboration led to better understanding of the general science curriculum at all levels and increased the interaction between the Rockford teachers and RVC faculty. Further, an RVC faculty member made presentations to several middle school science classes, discussed the content of an elective microbiology course she was developing with a high school science teacher, shared bacterial cultures with a high school biology teacher, discussed providing a dual-credit anatomy and physiology course in the local high schools, and renewed discussions between the biology faculties of Northern Illinois University and RVC, resulting in greater use of NIU graduate students as adjuncts in the Life Science Division at RVC.

Recommendations

I would make the following recommendations:

- Continue the learning team made up of Rockford teachers and RVC faculty. This would provide the teachers with a point person for collaboration, foster understanding of the depth of content taught at each level, and build bridges between the two faculties.
- Continue to provide a workshop day where participants would be encouraged to participate in activities outside their own discipline. Much was gained by the interaction of science and non-science teachers during the workshops. This also opens the door to interdisciplinary projects and assignments.

- Conduct the workshop in two sessions, one week apart. This would allow more time for cultures to grow and results to be more observable, thereby reinforcing the need to understand microorganisms. The changed format would also allow more flexibility for preparation and discussion.

22. Biological Sciences

Laszlo Hanzely

Workshops on human genetics and dendrochronology were presented as introductions to biological processes that are fundamental to growth yet poorly understood by laypersons. The following supports the learning of particular Illinois state biology standards.

Human Genetics

The inheritance of genetically determined characteristics or traits, especially in humans, is an interesting topic for both middle and high school students. Several examples, involving both autosomal as well as sex-linked characteristics or traits, can be examined and analyzed in a classroom situation. Tracing the origin of a set of easily identifiable phenotypes (observable physical traits) through parents, grandparents, and great grandparents often creates a fun-filled and exciting adventure for students.

Genetically, normal human beings possess 46 chromosomes within their somatic (body) cells. Of these, two will involve the presence of two X chromosomes in females and a Y and X chromosome in males. In both females and males, the Y and X chromosomes are commonly referred to as the sex chromosomes. In general, sex-linked inheritance refers to the inheritance of those genes that are located only on the X chromosome. The Y chromosome, when present, determines maleness and is passed from males to males.

Workshops

In a classroom setting, one can easily demonstrate the inheritance of a particular trait by examining the student population. The occurrence of a widow's peak (determined by a dominant allele) can be established easily among male students by examining their hairlines. Another frequently studied trait involves the occurrence of attached earlobes (a recessive trait). If students know their blood types, teachers can determine the frequency of the four recognized blood types among students and use the information to explain multiple allelism involved in the inheritance of the ABO blood type in humans.

Once such traits have been identified and properly analyzed, students can assemble a very simple pedigree chart based on an examination of their immediate family members. Tracing the origin of a given inherited characteristic can also lead to classroom projects involving household pets such as dogs, cats, guinea pigs, or gerbils. In addition, one may create a wide variety of hypothetical genetic problems for students to explore. Such simple exercises seem to be of great interest to students at all levels; they can be an important tool when students are exposed to the basic principles of Mendelian genetics.

Understanding the transmission and inheritance of sex-linked genes in humans is more difficult. Once again, students should be reminded that sex-linked genes are located on the X chromosome of both females and males. Consequently, the male will pass his X-chromosome-linked genes to his daughters, while the female will pass her X-chromosome-linked genes to her daughters and sons. The most often studied sex-linked genes in humans are those responsible for hemophilia and colorblindness (Atherly, Girton & McDonald, 1999). Establishing the occurrence of colorblindness can be done in the classroom through the use of slides depicting different color-coded numbers. Colorblind individuals will always see an entirely different set of numbers than the others. Such an exercise is always fun for students and will be of assistance to them in understanding the unique features of sex-linked inheritance.

Students can also examine the occurrence and inheritance of several unique genetic disorders in the human population. Such disorders are always associated with changes in the sequence of the nucleotides in DNA (the genetic material of organisms) and are frequently induced by an exposure to mutagenic agents, many of them chemicals commonly present in the environment. Among the genetic disorders, several are relatively common and have serious effects. Sickle cell anemia, for example, which affects approximately one out of 400 African Americans, is caused by the substitution of a single amino acid in the hemoglobin protein molecule of red blood cells, also known as erythrocytes (Becker, Kleinsmith & Hardin, 2003). In a sample of blood taken from such individuals, a given percentage of the erythrocytes will be sickle-shaped when examined under a light microscope (Campbell & Reece, 2000). Individuals afflicted with sickle cell anemia often reveal signs of fatigue and are incapable of performing tasks that require strenuous physical activity.

Mutations targeting the DNA molecule can also be caused by ultraviolet radiation. Since sunlight is an excellent source of ultraviolet radiation, and students of all ages love to acquire a deep and lasting tan, the formation of ultraviolet-induced pyrimidine dimers (usually two thymines) in DNA, and the association of such dimers with the possible onset of skin cancer, will generate an immediate interest. Showing and explaining to students the formation of thymine dimers in DNA will also facilitate their understanding of the chemical makeup of DNA and the way the nucleotides are arranged. Additionally, students will better appreciate the advice given to them regarding the skin-cancer risks associated with excessive and cumulative exposure to sunlight. Coverage of this topic may also incorporate the importance of the ozone layer in protecting organisms, including humans, from the harmful effects of ultraviolet radiation. Students should be made aware of the fact that emission of chlorofluorocarbons (CFCs) from such sources as refrigerants and propellants in spray cans can greatly damage the ozone layer. A continued release of CFCs from industrial sources would eventually cause a thinning or depletion of the ozone layer, allowing more ultraviolet radiation to reach our planet's surface. This, in turn, would significantly increase radiation-induced mutation rates in all living organisms, including humans.

Dendrochronology

Dendrochronology involves the study of secondary xylem (wood) produced by woody plants (Schweingruber, 1988). Typically, all elements of the secondary xylem are derived from a lateral meristem called the vascular cambium. The secondary xylem consists of two distinct regions, heartwood and sapwood (Northington & Schneider, 1996). The heartwood is centrally located and is generally dark colored, while the sapwood surrounds the heartwood and is light colored.

In general, the width of the heartwood significantly exceeds the width of the sapwood. For example, if a tree is determined to be 50 years old, roughly the first 38 to 40 years of annual growth would make up the heartwood, while the most recent growth of roughly the last 10 to 12 years would make up the sapwood. As a tree ages, the innermost annual rings of sapwood eventually become heartwood. When a tree is cut down, concentric rings (termed annual rings) can be observed in the secondary xylem. Every annual ring (representing a given year's growth) of both heartwood and sapwood is made up of the spring (early) wood and summer (late) wood. Since the spring (early) wood is deposited first during a given growing season, it will be situated toward the center of the tree, while the summer (late) wood will be situated toward the periphery within each formed annual ring (Mauseth, 1991).

Students can examine and analyze wood samples of living and even fossilized trees and acquire basic knowledge concerning the unique growth patterns of woody plants. The examination of a cross-section or a thin core of secondary xylem can reveal the age of a tree, distinguish seasonal variations in precipitation, establish the occurrence and frequency of fires, determine competition from adjacent trees, and provide information on soil fertility. Additionally, analysis of wood samples of markedly different tree species gives students a hands-on opportunity to compare variations in structural and growth characteristics from year to year. Anthropologists and crime investigators often obtain important information from the examination of wood samples.

Results

Teachers attending the biology workshops were very favorably impressed with the content of the presentations on human genetics and dendrochronology. Participants requested and received copies of the slides testing for colorblindness and reported that the test was ideal for the teaching units on genetics and inheritance. They were very interested in the analysis of annual rings in wood, which was a relatively inexpensive way to involve students in understanding growth and development in plants.

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23. Ground and Surface Waters

C. Patrick Ervin & Paul R. Stoddard

As an integrative discipline that uses all other sciences, the earth sciences are logical vehicles for inducting students into the scientific world. Students are naturally interested in the world that they see and experience. This interest gets their attention and willing participation by pursuing answers to questions about the Earth and its environment. Mathematics and the basic sciences can be naturally and unobtrusively introduced in the process, often without the students even being aware that they are studying anything but the Earth. Because middle school science tends to be integrative in nature, the earth sciences are the natural bridge that connects the curriculum. However, this is also true at the high school level, especially if the school uses earth science as an introductory or science-literacy course.

Participation

Because Rockford does not have an earth science curriculum at the high school level, we worked primarily with middle school personnel.

We participated in several aspects of the program, but here we focus on only two of those: the Educational Pathways to Careers workshops and the content-area workshops. In the former, we hosted rotating groups of middle and high school teachers in their first year of the development program.

The content, or discipline-update, workshops involved only middle school teachers. During the first year of our participation, the workshop was only open to public school teachers who were participating for the first time. In the second year, the content workshop was restricted to the same cohort of teachers, but we did not require them to have attended our first-year workshop. Therefore, our second-year participants included teachers with whom we had worked the previous year and others who were with us for the first time.

Objectives

An objective of the pathways workshops was to provide the teachers with accurate information for advising students who might have an interest in the geosciences. A second was to encourage them to speak positively about earth science to their students, to include geoscience topics in their classroom, and to induce them to consider participating in a later workshop to acquire greater knowledge of the subject.

The first content workshop was a three-day experience distributed across all areas of science, with fluids as the theme. Physics and geology worked together for 1.5 of those days, with the first day being led by physics and devoted to exploring flow in its various aspects. Only one morning was devoted exclusively to earth science. The objective for this half-day was limited to developing a concept introduced in the pathways workshop. The second content workshop introduced a variety of activities related to the goals and standards developed by the

Rockford school district for middle grades. We planned the workshop based on discussions with the prospective teacher participants.

Rationale and Motivation

Most middle grade teachers hold elementary certificates and usually have only a modest number of credit hours in any one content area. Science hours are often primarily in life sciences, with some exposure to chemistry. However, middle school curriculum generally attempts to follow an interdisciplinary, although not usually integrated, approach to science. The teacher is, therefore, responsible for teaching all areas of science and often for interrelating that science to concurrent curriculum in social studies, English, or mathematics.

Earth science, by its nature, is an integrative science that uses the other sciences, and in this respect is the ideal vehicle for teaching science in the middle grades. Students easily relate to many aspects of earth science because they encounter them daily. For example, they experience rain, observe water running off the surface, and know that water soaks into the ground. Second, pursuing topics in earth science requires the application of principles from chemistry, physics, and the life sciences. Hence, in the process of learning about something that has relevance to them, they also learn the other sciences in context.

We wanted to show teachers the advantage of using the earth sciences in this context and to provide them with activities they could take into their classrooms. Most teachers have limited resources for their classrooms. Consequently, it is always our objective to present activities that are scientifically sound and can be done at little cost. Our chosen hook was the action of water on and below the surface of the land.

Educational Pathways to Careers

The teachers received these workshops well. The plenary sessions are discussed elsewhere in this volume, so we will address only the earth science sessions, which were conducted in three successive years. Each session was divided into a discussion of career opportunities and program requirements and an introduction to selected activities that the teachers might take back to the classroom.

The teachers enjoyed discussing career opportunities and learning about the program requirements that their students would need to meet if they wished to major in the earth sciences. Because Northern Illinois University has a leading-edge approach to the preparation of secondary teachers, participants were especially interested in talking about the department's teacher education program. In most sessions, this part of the program consumed about two-thirds of the allotted time.

For the second part of the session, we chose running water as the theme. We presented activities that spanned grades 6-12 and focused on streams and their properties. These ranged from a very simple experiment requiring only a short piece of rain gutter and a plastic milk bottle to a more complex, commercially built stream table. Participants explored the relationships between water discharge, velocity, and slope and looked at erosion caused by raindrop impact and running water. Most of these activities were taken from published sources. In general, the participants were most interested in the stream table demonstration and the interesting activities to augment the career discussion.

Content workshop 1

This workshop was open to middle school teachers who were first-year participants in the Rockford program. This was a three-day session with fluids as the theme. Physics, with support from us, led the first day and explored many properties of fluids. We subsequently led a half-day session that was divided into two parts. One part expanded the first day's study of fluids with an introduction to the influence of water and its properties on geologic processes. Magma, another fluid, plays a significant role in geology that is highly dependent on viscosity, so we next investigated that property. Experiments involved flows of water and syrup, including laminar and turbulent flow, done in a section of rain gutter.

Content workshop 2

Offered the following year, this one-day workshop involved only the earth sciences. It was open to the same group of middle school teachers as were eligible for the previous workshop. Although most of the participants had taken part in one of our pathways sessions, many had not been in the first workshop. Most were teaching curricula that incorporated the topics of water and soils to varying extents.

For this session, we generalized the theme slightly and used the fundamental states of matter as the connecting thread, although the emphasis continued to be on the fluid state. Using the school district's website, we aligned the workshop material with its goals and standards for grades 6-8. This articulation was then noted at appropriate points during the workshop.

The Rockford school district has defined goals that are the same for grades 6, 7, and 8. Activities in the workshop primarily addressed goals 11 (Inquiry: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems) and 12 (Concepts: Understand the fundamental concepts, principles, and interconnections of the life, physical and earth/space sciences). The district defines several standards within each goal, each with specific indicators. For example, within goal 12, two standards that we especially addressed were standards C (Know and apply concepts that describe properties of matter and energy and the interactions between them) and E (Know and apply concepts that describe the features and processes of the Earth and its resources). "Describe the process of the water cycle" and "Formulate a hypothesis that can be tested by collecting data" are examples of indicators within these standards.

When designing the workshop, our goals were to increase the teachers' knowledge in the content area, enhance their skills in using that knowledge, convey the concept that both process and product are important in earth science, provide motivation to incorporate the material into the classroom by relating it to district standards, suggest strategies for making content accessible to students, and demonstrate that activity-based instruction can often be accomplished with low-cost resources.

Morning session

Most of the morning session was devoted to the fluid state, specifically to running water in the form of streams and ground water. We again started with properties, with activities focusing on surface tension, cohesion, adhesion, and capillary action. The impact of these on geologic processes was always emphasized. A brief discussion of viscosity was also included as a link back to its introduction in Workshop 1 and forward to the afternoon session.

With the basic properties established, we turned to a discussion of ground water. After *defining* the water table, activities focused on porosity, permeability, and liquefaction. Again, these were related to district standards and were placed in a geologic context, including discussions of such geologic hazards as slope failure and the effects of ground water mining.

We concluded the fluid/water portion with concepts and activities associated with surface runoff, both sheet flow and stream flow. Activities related to stream load (sediment) logically led to the topic of erosion and transportation. At this point, the participants used one of the stream tables that had been constructed in Workshop 1 to investigate the interaction between streams and sediments under varying conditions.

Afternoon session

The afternoon session shifted to matter in the solid state, with a focus on deformation of solid materials, specifically elastic, plastic, and rupture. Plastic flow in the mantle served as the transitional link from the morning's discussions of fluid flow. One of the geologic consequences of deforming rock materials (tectonics) is the occurrence of earthquakes.

We pursued this topic with a discussion of where, when, and how earthquakes occur and of their consequences in terms of seismic vibrations and their impact on society. Discussion and activities addressed elastic strain accumulation and release, characteristics of wave propagation, epicenter location, geologic associations, and data presentation and analysis (graphing opportunities that support standards objectives, such as computing velocity from a time vs. distance plot).

Our final segment addressed the possibility of predicting and mitigating earthquakes. Participants divided into teams charged with designing and building structures to withstand an earthquake. Materials for the structures consisted of blocks of florist foam to use as a base, sheets of foam for the buildings, and a large supply of toothpicks with which to affix the pieces. The integrity of the structures was then tested by imposing a static load. While not strictly analogous to earthquake-imposed stress, the exercise conveyed the concept.

Closing Thoughts

The teachers were responsive and enthusiastic, especially in the content workshops, and they had positive assessments. From our perspective, the experience was quite useful. We perceive the following benefits to ourselves:

- A better understanding of our colleagues working at a different stage in the educational endeavor and of the problems that they face.
- An enhanced recognition of the need to relate to district standards, establish coherent program goals, and set objectives in our own teaching.
- A greater awareness of the pedagogical need to address different learning styles in our classes and to actively engage students in their own education.

Recommendations

Programs like this are worthwhile for both the public school and university faculty. We encourage university faculty to become involved in providing professional development opportunities. However, preparing and delivering these events takes considerable time and effort. Simply delivering a content lecture, too often the mode of instruction at the university level, will not be effective.

Public school teachers are practically oriented and will respond positively if the content is presented in a mode that is appropriate to their classrooms and addresses their needs in terms of district and state standards. Content must include activities appropriate to students at the grade level being addressed, and the teacher must be able to transfer them, with only minor modification, to the classroom.

University faculty often lament about the level of preparation exhibited by incoming students. Taking the long perspective, the most effective way to upgrade the entering students is to become actively involved in assisting their middle and high school teachers develop their own skills in the subject area.

Career-Related Websites

Association for Women Geoscientists: www.awg.org/
Careers, maintained by the American Geological Institute: www.agiweb.org/career/
Openings and links to other lists: www.geosociety.org/science/careers.htm
Resume writing, current job listings: www.geo.mtu.edu/geojobs/
Scholarship listings by organization: pangea.stanford.edu/EEGS/scholarships.html
Women and science literacy: www.aacu-edu.org/Initiatives/scilit.html

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24. Agriculture: Internet Resources for Educators

K. A. Rosentrater

Two workshops exposed secondary school teachers to the multidisciplinary domain of agriculture and to new opportunities to revitalize their mathematics and science curricula. These workshops were centered on an Internet-based platform and provided participants structured, as well as unstructured, activities. This approach worked well in terms of introducing the subject of agriculture to many who had never been exposed prior to attending the workshops, as well as providing insights about incorporating these ideas into current or new classroom materials. This chapter provides my reflections on these workshops and includes feedback from participants. Furthermore, to make this approach accessible to an audience greater than the domain of the workshop participants, it also provides a resource for educators by offering an extensive list of websites that can be used to investigate agricultural concepts.

Most participants began the sessions with a perception that agriculture entailed only grain production and livestock rearing. They soon discovered, however, that production farming was only a small sector of the much larger agribusiness foundation upon which our entire society actually rests.

Justification

Educators who participated in the two workshops were interested in developing innovative classroom materials and felt that agriculture, while unknown territory for most, might prove to be fertile ground for these endeavors. Specifically, they needed to bolster their efforts to improve the mathematics, science, technology, and communication skills of their students and hoped to gain information and applications that could be integrated into their own materials and teaching modules.

Workshops

The eight-hour workshops introduced secondary educators to agriculture and provided them with a fresh resource base from which they could build innovative teaching materials. Each workshop used a three-step approach. Following the online agenda, I introduced a specific topic with a short, directed discussion. Then participants were directed to several Internet sites to learn more about that topic. Participants could freely browse the Internet for related information. After approximately 30 minutes of online research, a class discussion ensued where participants shared information and useful website addresses.

What Is Agriculture?

Traditional agriculture, at least in the United States, has typically entailed grain and livestock farming. While modern agriculture still includes these primary activities, it encompasses a much greater range, and comprises all aspects of the food, feed, and fiber industries that nourish and clothe our population. Thus, agriculture can include diverse disciplines such as:

- Accounting
- Agronomy and soil science
- Animal science
- Biology
- Biosystems and biomedical research
- Building structures, construction, and environmental design
- Business and management
- Chemistry
- Economics
- Ecology
- Electronics and instrumentation
- Engineering
- Environmental systems and natural resources
- Food science and processing
- Genetic engineering and biotechnology
- Law
- Machine design and manufacturing
- Mathematics
- Modeling and simulation
- Physics
- Plant breeding and pathology
- Statistics
- Surveying
- Veterinary sciences

This list, however, provides only a small sampling of the broad scope of contemporary agriculture. Table 1 lists websites for exploration of the extent to which agriculture has expanded beyond the confines of traditional farming. (Tables listing the websites are in the appendices at the end of this chapter.)

Careers in agriculture

Because agriculture encompasses more than just the traditional occupation of farming, career possibilities for college graduates, even those who did not study agriculture while in school, are numerous. Table 2 provides several websites to explore some of these opportunities.

History of agriculture

In 1840, Daniel Webster said, "When tillage begins, other arts follow. The farmers, therefore, are the founders of civilization." His statement was quite true. Civilization began when hunting and gathering tribes settled near rivers to cultivate grain and domesticate livestock. Agricultural history can offer a bountiful harvest of educational possibilities for classrooms (Table 3).

Agricultural technologies and innovations

Modern agriculture, like other segments of our society, is heavily influenced by technological innovations and inventions. A few examples include agricultural production, agricultural processing, flowcharting, modeling and simulation, biotechnology, and geographic information systems, all of which will be discussed in more depth.

Agricultural production

The United States is one of the world's foremost food producing nations. Production is the first step in the food supply chain (Figure 1). In traditional agricultural settings, this has generally entailed only grain and livestock farming. Today, however, it includes all aspects of production that provide raw material inputs into the commercial market stream, including grain, meat, fruit, vegetable, fiber, and pulp. Raw products require processing before they can be consumed or used. Table 4 provides websites that can be used to examine modern agricultural production techniques, processes, and practices.

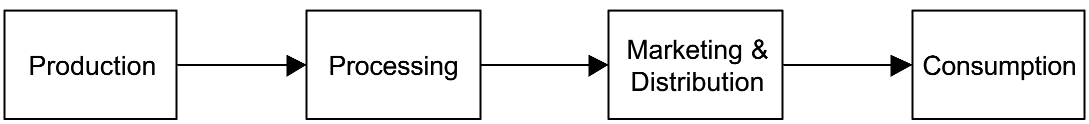


Figure 24.1 Food Supply Chain

Agricultural processing

Processing is the second step in the supply chain (Figure 1). It entails the conversion of raw materials into partially finished products, which become input for other manufacturing and processing steps, or completely finished goods ready for the consumer. Table 5 provides websites that can be used to explore processing strategies and techniques.

Flowcharting

Flowcharts, also known as flow diagrams, use graphic symbols to depict the nature and flow of steps, materials, or information in processes. Flowcharts are used extensively in agricultural and food production and in processing industries (especially during engineering and design stages), but are not limited to agricultural enterprises. Any process, in fact, can be deconstructed and described using this methodology.

Flowcharts can be constructed by several means: sketching, drawing with a template, or using computer tools. They may be simple (Figures 2 and 3) or complex (Figure 4).

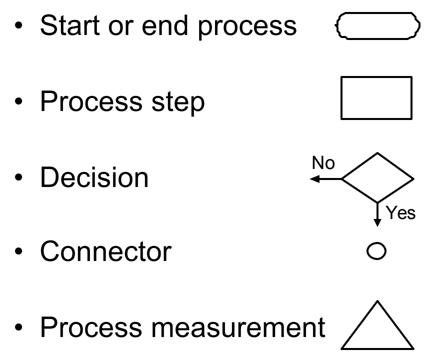


Figure 24.2 Fundamental Shapes Used to Construct Simple Flowcharts

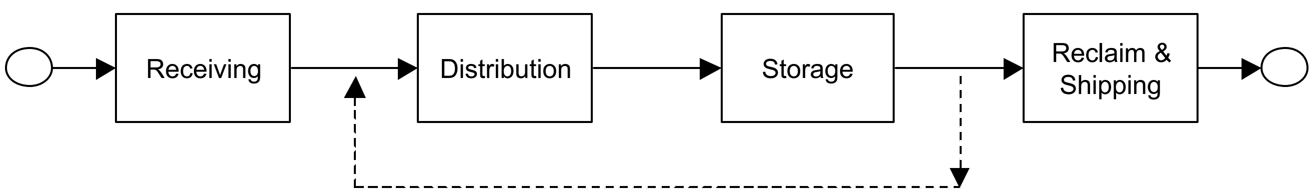


Figure 24.3 Simple Flowchart Depicting a Typical Grain Storage Facility

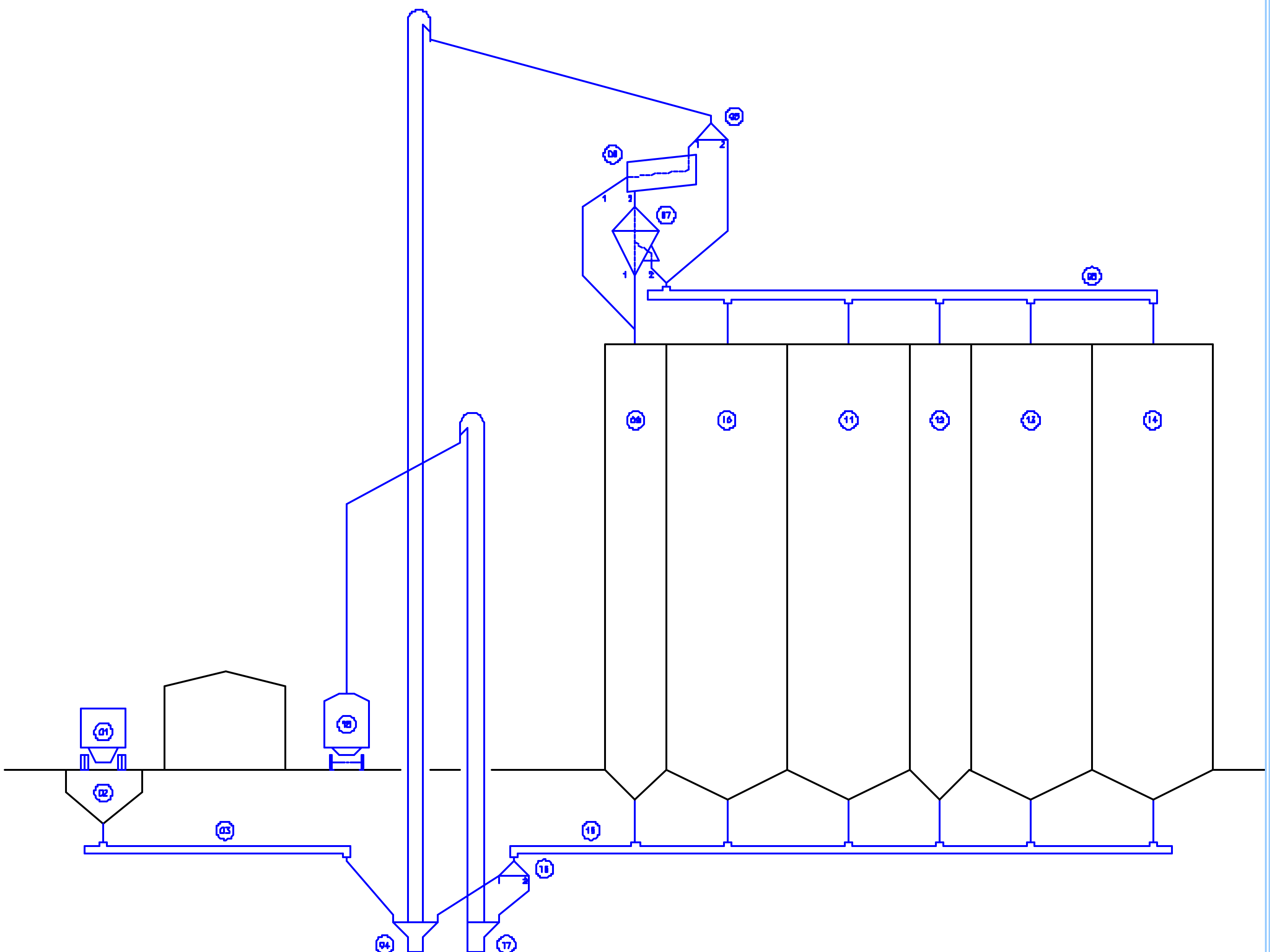


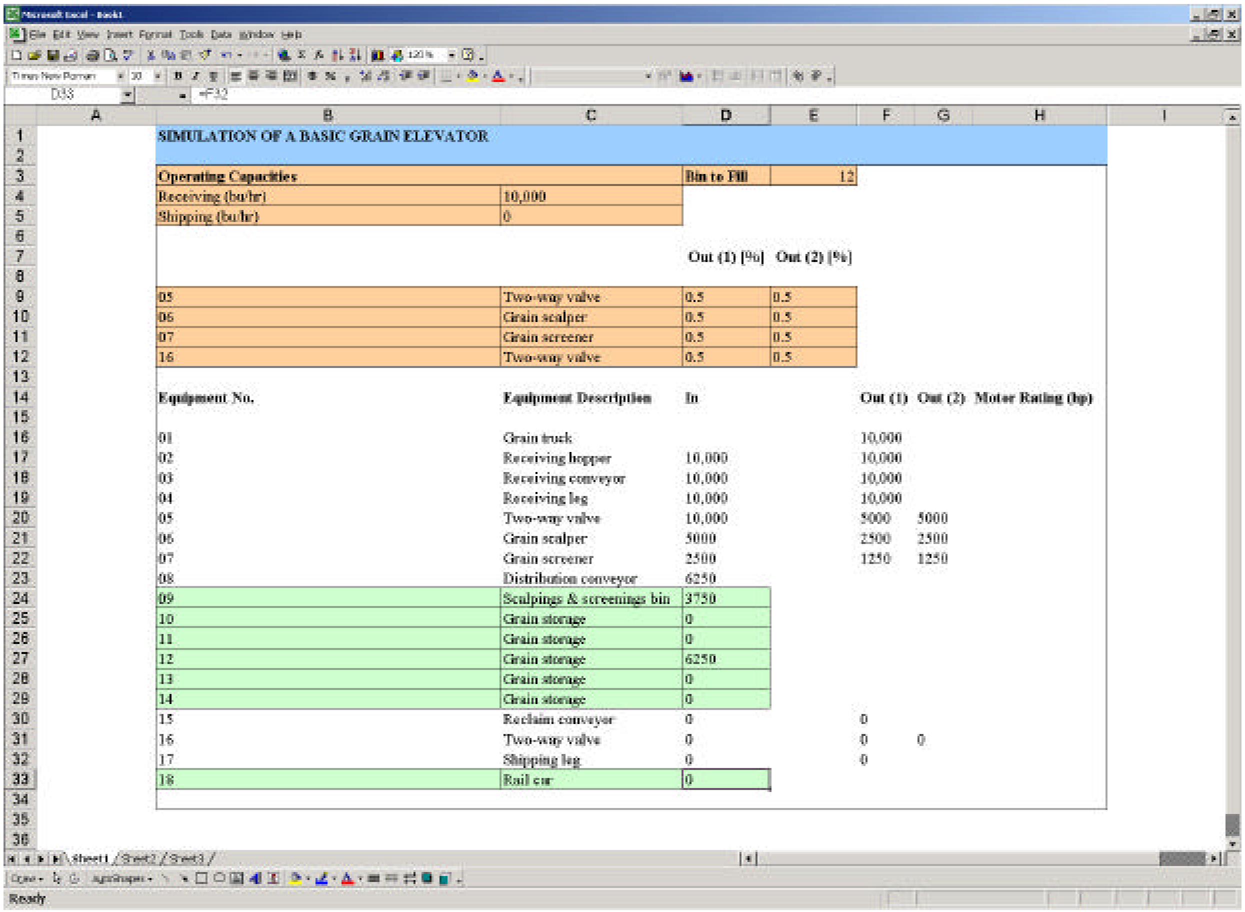
Figure 24.4 Complex Flowchart Depicting Typical Grain Storage Facility

After the Internet exploration phase of the session, we devoted a short applications session to train participants to make a flowchart. Table 6 provides websites that can be used to explore flowcharting techniques and strategies.

Modeling and simulation

Modeling and simulation are tools and techniques that use mathematical equations to quantify and represent systems, processes, and the flow of materials and information. This type of analysis can show how altering one step, several steps, the relationships between these steps, or process inputs can affect the behavior and performance of the entire system under investigation. It is used extensively to examine agricultural production and processing environments. Any system or process can be modeled and simulated, especially those that have been decomposed and depicted using flowcharts.

Many computer programs are available to accomplish this task, but an electronic spreadsheet can be used very effectively to construct relatively straightforward simulation models (Figure 5) by applying simple algebraic expressions to describe flow through the system. This methodology can be used for any system or discipline and can range from relatively simple to very complex in nature. Table 7 provides websites that discuss modeling and simulation in more depth.



SIMULATION OF A BASIC GRAIN ELEVATOR						
Operating Capacities		Bin to Fill	12			
Receiving (bu/hr)	10,000					
Shipping (bu/hr)	0					
		Out (1) [%]	Out (2) [%]			
05	Two-way valve	0.5	0.5			
06	Grain scalper	0.5	0.5			
07	Grain screener	0.5	0.5			
16	Two-way valve	0.5	0.5			
Equipment No.	Equipment Description	In		Out (1)	Out (2)	Motor Rating (hp)
01	Grain truck			10,000		
02	Receiving hopper	10,000		10,000		
03	Receiving conveyor	10,000		10,000		
04	Receiving leg	10,000		10,000		
05	Two-way valve	10,000		5000	5000	
06	Grain scalper	5000		2500	2500	
07	Grain screener	2500		1250	1250	
08	Distribution conveyor	6250				
09	Scalpings & screenings bin	3750				
10	Grain storage	0				
11	Grain storage	0				
12	Grain storage	6250				
13	Grain storage	0				
14	Grain storage	0				
15	Reclaim conveyor	0		0		
16	Two-way valve	0		0	0	
17	Shipping leg	0		0		
18	Rail car	0				

Figure 24.5 Simulation Model Developed in an Electronic Spreadsheet for a Typical Grain Storage Facility

Biotechnology

More than a decade ago, scientists envisioned the development of foods and crops that incorporated the techniques of modern biotechnology. Human intervention could lead to improvements of these biological materials and could include foods with new and desirable characteristics, such as insect and herbicide resistance, or added value from enhanced nutritional and end-use properties, such as modified vitamin, oil, starch, or even pharmaceutical components.

We now have a number of such products in the marketplace. Food and grain producers have readily adopted these new products in the hope that they may help overcome problems associated with a weak agricultural economy. The public, on the other hand, has met these novel biological materials with skepticism and resistance, arising mainly out of concern over the safe application of this new technology and the unknown side effects of gene manipulation. However, the large multinational corporations that have developed these products can allocate significant resources for research and development and see the overarching potential of these materials. What is the future of biotechnology? The debate over genetic modification will continue for several years, and the outcome may significantly affect the global food supply. To explore the controversies surrounding the use of biotechnology, workshop participants conducted a formal debate based on their own findings from their Internet explorations.

Table 8 lists websites that offer information regarding biotechnology, its impacts on society, consumer perceptions, and future directions and applications for this cutting-edge scientific discipline.

Geographic Information Systems

Geographic Information Systems (GIS) are software tools used for mapping and analyzing objects on the surface of the Earth, such as agricultural fields, forests, urban landscapes, building locations, and earthquake fault lines. GIS technologies integrate powerful database capabilities with the unique visual perspective of traditional maps. GIS can be applied to a wide range of public and private enterprises, especially for planning, designing, engineering, reducing costs, or making informed decisions.

In agriculture, GIS is used with global-positioning-system (GPS) satellites to examine field conditions. This allows farmers to apply specific amounts of fertilizer and chemicals to specific locations, which helps them implement efficient and cost-effective production practices. Additionally, farmers are able to determine crop yield at each point in a field, so that management decisions regarding fertilizer and chemical treatment can be specifically targeted the following year. The use of GIS for these purposes is known as precision agriculture. Table 9 provides websites that offer information for precision agriculture and GIS systems.

Augmenting Classrooms with Agriculture

Agriculture is a fertile but often unplowed resource for growing innovative teaching materials. Creative discussion materials, examples, display materials, and even homework and examination problems can provide abundant applications for science, mathematics, and communications-building exercises. Table 10 provides online examples of potential strategies for infusing agricultural concepts into curriculum materials.

Modeling

Workshop implementation hinged on a Web-based delivery platform. Each day’s agenda was placed online, and each participant could access it from a computer in the laboratory where the session was conducted. Each agenda item provided a link to background information, discussion questions, and hyperlinks to additional sources of information on the Internet. After a formal, structured discussion to introduce each activity, participants were directed to explore the Web addresses. After a given amount of time, participants were encouraged to explore the Internet for additional information that could help them develop their own curriculum materials. Participants were then refocused for a group discussion of what each found. They found this helpful, not only because they garnered new ideas and websites from others, but also because it gave them the opportunity to reflect on important concepts to which they had been exposed during their exploration activities.

Upon completion of the workshops, many participants decided to incorporate agricultural ideas and concepts into their curriculum materials. They organized their assignments and modules according to the Illinois State Board of Education learning standards, including:

- Know and apply the concepts, principles and processes of scientific inquiry. (11A)
- Know and apply the concepts, principles and processes of technological design. (11B)
- Know and apply concepts that explain how living things function, adapt and change. (12A)
- Know and apply concepts that describe how living things interact with each other and with their environment. (12B)
- Know and apply concepts that describe the interaction between science, technology and society. (13B)

The standards that were most appropriate to incorporating agriculture into mathematics education included:

- Describe numerical relationships using variables and patterns. (8A)
- Interpret and describe numerical relationships using tables, graphs, and symbols. (8B)
- Solve problems using systems of numbers and their properties. (8C)
- Use algebraic concepts and procedures to represent and solve problems. (8D)
- Organize, describe, and make predictions from existing data. (10A)
- Formulate questions, design data collection methods, gather and analyze data and communicate findings. (10B)

The standards that were most appropriate to infusing agriculture into writing education included:

- Compose well-organized and coherent writing for specific purposes and audiences. (3B)
- Communicate ideas in writing to accomplish a variety of purposes. (3C)

Results

After completing both workshops, participants attained an understanding of the overarching scope and breadth of agriculture. Several of the feedback comments reflected this:

- "Informative and thought provoking."
- "Will implement many ideas in biology and chemistry classes."
- "This was an excellent workshop. It gave me so many good ideas that it will be difficult to pare down everything I would like to try. I found many worthwhile websites because of the presentation."

- "This workshop was nothing like I expected. I expected tractors and farming and found agriculture covers so much more! The websites and information will be easily used in a unit."

The formal results from the structured evaluation questions also display the confluence of participant attitude. Out of 24 total participants during the two workshops, 83-96% were very well pleased with the time spent, while 4-8% were only somewhat pleased (see Figure 6).

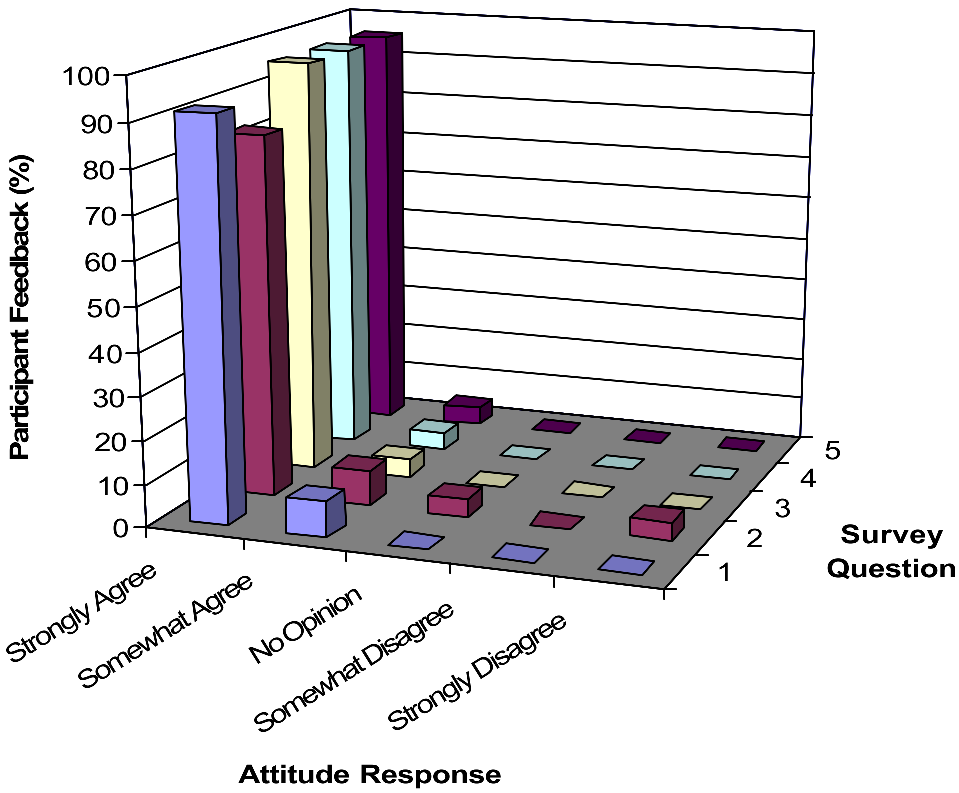


Figure 24.6 Ex Post Facto Workshop Evaluation Results

Many participants either planned to incorporate agricultural concepts into modules that they were developing or planned to construct new teaching modules dedicated to agricultural information garnered from their workshop experiences. Examples of planned curriculum activities included:

- Biology and chemistry exercises examining food processing operations
- Biology and chemistry exercises examining food production
- Examples and homework problems relating to nutrition, food, and organic chemistry
- Flowcharts to describe and solve mathematics problems
- Interactive games to teach disabled children about nutrition
- Mathematics story problems based on food processing systems

- Research papers on agricultural and food practices in various countries
- Research papers on agriculture, food, technology, and human development throughout history
- Research papers on food, economics, politics, environmentalism, and world hunger

The greatest benefit for many participants was the realization that agriculture is an unexplored, multidisciplinary resource for their teaching.

Side Payments

Developing and presenting these workshops benefited both the participants and the professor. The primary side payment was an effective, hands-on, Internet-centered delivery model for workshops that can be used as a paradigm for future endeavors. It worked well for classroom instruction and interaction and provided immediate, easily updated outreach materials for use in the classroom. I have incorporated several content areas initially developed for use during the workshops into my own teaching materials.

Lessons Learned

Several lessons were garnered from developing and presenting these agricultural workshops. First, secondary-level teachers are very interested in gaining new ways of finding instructional materials, examples, applications, and homework problems, especially in terms of reading, writing, science, and mathematics skills. Workshop participants concluded that agriculture, although a nontraditional subject for many, could indeed provide an exciting avenue because of its multidisciplinary scope and depth. Interestingly, the applications initiated by participants were as varied as the field of agriculture itself. Second, an Internet-based workshop with an interactive agenda and hands-on, Web-based activities worked well for delivering content and interactivity.

Outreach Sustainability

At the conclusion of the workshops, participants said that they desired continued access to both materials and information as the basis for incorporating various concepts into their teaching modules. The Web-based nature of the workshops made it easy to furnish materials after the sessions; the workshop pages have been indefinitely posted to the Internet and participants have the URLs.

Recommendations

Teachers and administrators concerned about curriculum development, at both the secondary and the university levels, could reap many benefits by examining agriculture. Potential dividends are new discussion materials, new sample or display materials, new examples, and even new homework and examination problems (especially story problems). Because of the breadth and the scope of agriculture, many innovative classroom materials could be developed that simultaneously address traditional issues in mathematics, science, and communication skills.

Literature Review

Agriculture encompasses a varied spectrum of disciplines and has the potential for developing educational and instructional materials. This potential is particularly extensive in science education (Dreyfus, 1986) at both the secondary and elementary levels (Trexler & Suvedi, 1998) because agriculture involves the use and modification of biological materials. Biology teachers have been among the first to infuse their curriculums with agricultural concepts (Balschweid, 2002; Jungwirth & Dreyfus, 1973). Rao and Pritchard (1984a; 1984b) provide many resources and strategies to achieve these ends. Unfortunately, the literature has not provided examples of integrating agriculture into mathematics or other scientific disciplines.

This lack of information warrants an examination of mathematics and science education in agriculture itself, which at the secondary level includes vocational education classrooms. Skills that are key elements to mathematics education in vocational agriculture curricula, include units of measurement, unit conversions, whole numbers, and applied, problem-solving methods (Miller & Vogelzang, 1983). Several resources can help fill this need; they include detailed examples and problem sets encompassing use of whole numbers (Cosler 1974c), trigonometry (Cosler, 1974b), applied mathematics (Cosler, 1974a), and problem solving (Flowers & Osborne, 1988; Osborne & Hamzah, 1989), as well as general mathematics applications (O'Connor, 1991) in agricultural settings. Other avenues include teaching economic principles (McGuire, 1966) and energy systems (Albract & French, 1980) in agricultural contexts. Further, the U.S. Census of Agriculture can be used as a raw dataset for mathematical and statistical analysis exercises (Bureau of the Census, 1987).

In addition to mathematics, scientific principles, biological and physical, have become increasingly emphasized in vocational agriculture curricula (Osborne, 1996; Sutphin, 1992). Infusing these programs with scientific knowledge and skills has been shown to improve students' understanding and scientific literacy, owing to the synergistic connections between the disciplines (Thompson, 2001; Thompson & Balschweid, 2000). Barriers to integrating science into agriculture programs center around teacher preparation time, funding limitations, and equipment constraints (Balschweid & Thompson, 2002; Balschweid et al., 2000).

Some teachers have combined mathematics and science in vocational agriculture programs. Using aquaculture as the context for integration has worked well (Conroy & Walker, 2000). Production agriculture, which has been the traditional approach to the field, has also worked well (Briers, 1986). Moreover, college-level teacher training programs are beginning to recognize the benefits of these curriculum development efforts and have even begun integrating mathematics, science, and agriculture education (Conroy & Sipple, 2001).

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Appendix

Table 24.1 Online Resources for General Descriptions of Agriculture

Sponsoring Organization	Website URL
BC Ag in the Classroom	http://www.aitc.ca/bc/pages/lessonplans/IntrotoAgriculture.html
Univ. of Saskatchewan	http://www.ag.usask.ca/exhibits/walkway/what/agric.html
Auburn University	http://www.ag.auburn.edu/agbro/whatis.htm
Eco-Motion	http://www.edisonthebus.org/ag.html
Graves Co. High School	http://gravesffa.tripod.com/gravescountyffahomepage/id10.html

Table 24.2 Online Resources for Career Options in Agriculture

Sponsoring Organization	Website URL
Auburn University	http://www.ag.auburn.edu/agbro/success.htm
BC Ag in the Classroom	http://www.aitc.ca/bc/pages/careers/careers.html
Career Clusters	http://www.careerclusters.org/ClusterDocuments/agdocuments/AGBrochure.pdf
Career Clusters	http://www.careerclusters.org/ClusterDocuments/agdocuments/1AGModel.pdf
FFA	http://www.ffa.org/careers/index.html
Graves Co. High School	http://gravesffa.tripod.com/gravescountyffahomepage/id10.html
NC State University	http://www.ag.ncat.edu/extension/programs/dte/careers.html
Top USA Jobs	http://www.topusajobs.com/jobs-by-cat/biotech/?f=google&t=biotech
Univ. of Saskatchewan	http://www.usask.ca/students/programs/fact_sheets/agriculture/ag_econ.shtml

Table 24.3 Online Resources for Agricultural History.

Sponsoring Organization	Website URL
AAHF	http://www.agri-history.org/
About, Inc.	http://inventors.about.com/library/inventors/blpotatochip.htm
About, Inc.	http://southernfood.about.com/cs/foodhistory/
About, Inc.	http://homecooking.about.com/cs/foodhistory/
Agropolis Museum	http://museum.agropolis.fr/english/default.htm
American Food Century	http://www.geocities.com/foodedge/timeline.htm
BC Ag in the Classroom	http://www.aitc.ca/bc/pages/lessonplans/TimeLine.pdf
CA Foundation Ag in Classroom	http://www.cfaitc.org/About_the_Foundation/pdf/AgAwarenessArticle.pdf
Clifford Wright	http://www.cliffordawright.com/history.html
College of Staten Island	http://www.library.csi.cuny.edu/westweb/pages/harvest.html
Cornell University	http://rmc.library.cornell.edu/food/
Food History News	http://foodhistorynews.com/
Food Museum	http://www.foodmuseum.com/
History Link	http://www.historylink101.com/history_of_farm.htm
In Depth Info	http://www.indepthinfo.com/potato/
Iowa State University	http://www.anslab.iastate.edu/Class/Ans114L/Homework/ L1%20animal%20heritage%20S03%20.ppt
IRRI	http://www.riceweb.org/
Leite's Culinaria	http://www.leitesculinaria.com/features/dining.html
Morris County Library	http://www.gti.net/mocolib1/kid/food.html
PBS	http://www.pbs.org/ktca/farmhouses/
Portable Bistro	http://portablebistro.tripod.com/foodhistory.htm
Recipe Link	http://www.allbaking.net/history.html
U.K. National Trust	http://www.nationaltrust.org.uk/environment/
University of CA, Santa Barbara	http://titicaca.ucsb.edu/cotahuasi/courses/Anth162/162d5.htm
University of Hawaii	http://www.botany.hawaii.edu/faculty/ticktin/Agriculture-class.pdf
Univ. of Houston	http://vi.uh.edu/pages/lprtomat/fdhmpg~1.htm
USDA	http://www.usda.gov/history2/back.htm

Table 24.4 Online Resources for Agricultural Production

Sponsoring Organization	Website URL
About, Inc.	http://agriculture.about.com/cs/corn1/
Arizona State University	http://nfapp.east.asu.edu/Outlook03/Value.html
Arizona State University	http://www.eas.asu.edu/~nfapp/commodities/table/usfruit1.htm
Corn Refiners Association	http://www.corn.org/
Cornell University	http://jan.mannlib.cornell.edu/reports/nassr/dairy/pmp-bb/
FAO	http://www.fao.org/
Food First	http://www.foodfirst.org
Food Production Daily	http://www.foodproductiondaily.com/
Glanbia	http://insider.glanbiausa.com/USMilkProduction.htm
ITDA	http://www.itdg.org/html/food_production/food_production.htm
N.C. State University	http://www.ces.ncsu.edu/depts/hort/greenhouse_veg/
Ohio State University	http://ohioline.osu.edu/b472/corn.html
Purdue University	http://www.hort.purdue.edu/rhodcv/hort410/genint/ge00007.htm
Sustainable Agri-Food Forum	http://www.agrifood-forum.net/home.asp
University of Idaho	http://extension.ag.uidaho.edu/blaine/ag.htm
USDA	http://www.fas.usda.gov/currwmt.html
USDA	http://www.nal.usda.gov/afsic/ofp/
USDA	http://www.usda.gov
USDA NASS	http://www.usda.gov/nass/
Washington State University	http://organic.tfrec.wsu.edu/OrganicIFP/OrganicFruitProduction/current_trends.PDF
World Hunger Year	http://www.worldhungeryear.org/

Table 24.5 Online Resources for Agricultural Processing

Sponsoring Organization	Website URL
Bio Link	http://www.bio-link.org/docs/corn.doc
FAO	http://www.fao.org/ag/aga/agap/lps/dairy/mpr/mpr.htm
FAO	http://www.fao.org/docrep/V5030E/V5030E00.htm
Food Irradiation	http://www.food-irradiation.com/basics.htm
Food Production Daily	http://www.foodproductiondaily.com/
Iowa Corn Growers	http://www.iowacorn.org/default.htm
Joint Research Center	http://www.jrc.es/projects/euromed/TEAM/FoodTecnology/ foodtechnologybackground.pdf
Meat News	http://www.meatnews.com/
Ohio State University	http://www.ingham.org/ce/HE/basicsforcanningfruit.htm
PNPPRC	http://www.pprc.org/pprc/sbap/food.html
Texas A&M University	http://aggie-horticulture.tamu.edu/syllabi/422/ppt/Cisneros1.ppt
Univ. California Davis	http://www.fruitandvegetable.ucdavis.edu/
University of Guelph	http://www.foodsci.uoguelph.ca/dairyedu/fluid.html
University of Minnesota	http://www.ddgs.umn.edu/davis-processing.pdf
University of Wisconsin	http://www.uwex.edu/ces/dairyyouth/

Table 24.6 Online Resources for Flowcharting

Sponsoring Organization	Website URL
All Clear Online	http://www.allclearonline.com/articles/effective.pdf
City Univ. of New York	http://cis.bmcc.cuny.edu/multimedia/mrc/main/tutorials/management/flowchart/home.asp
Clemson University	http://deming.eng.clemson.edu/pub/tutorials/qctools/flowm.htm
Dexter Hanson	http://home.att.net/~dexter.a.hansen/flowchart/flowchart.htm
Six Sigma	http://www.isixsigma.com/offsite.asp?A=Fr&Url=http://quality.disa.mil/pdf/flowchrt.pdf
Six Sigma	http://www.isixsigma.com/offsite.asp?A=Fr&Url=http://www.sytsma.com/tqmtools/flow.html
Smart Draw	http://www.smartdraw.com/specials/flowchart.asp
Studio 1151	http://www.mcli.dist.maricopa.edu/authoring/studio/guidebook/flow.html

Table 24.7 Online Resources for Modeling and Simulation

Sponsoring Organization	Website URL
U.S. Army	http://www.amso.army.mil/harmon/
Concordia University	http://www.cuaa.edu/computing/softrain/excel/excel08.shtml
Duke University	http://faculty.fuqua.duke.edu/~pecklund/ExcelReview/2001_Documents/2001SvelteStepByStep.pdf
Ohio Supercomputer Center	http://www.osc.edu/education/webed/Projects/model_and_statist ics/

Table 24.8 Online Resources for Biotechnology

Sponsoring Organization	Website URL
Ag Biotech Net	http://www.agbiotechnet.com/Directory/az_detail.asp?lett=A
BioFirst	http://www.biofirst.nsw.gov.au/applications/agriculture.asp
Biotech Industry Organization	http://www.bio.org/
Biotech Industry Organization	http://www.bio.org/foodag/
Biotech Market	http://www.biotec-market.com/
Cato Research	http://www.cato.com/biotech/index.html
CBI	http://www.whybiotech.com/
CGIAR	http://www.cgiar.org/biotech/rep0100/contents.htm
Dept. of Ag, Australia	http://www.affa.gov.au/content/output.cfm?&CONTTYPE=outputs&OBJECTID=5A53B336-FC4E-411E-8C06A9D82C6AE0C9
FDA	http://vm.cfsan.fda.gov/~lrd/biotechm.html
MI State Univ.	http://www.iia.msu.edu/absp/
Monsanto Co.	http://www.monsanto.com/monsanto/layout/default.asp
Monsanto Co., UK	http://www.monsanto.co.uk/
Rutgers State University	http://www.nalusda.gov/bic/Pubpercep/
Strategis	http://strategis.ic.gc.ca/SSG/bo01376e.html
Strategis	http://strategis.ic.gc.ca/SSG/bo01410e.html
Texas A&M Univ.	http://agbiotech.tamu.edu/ag_bio_teks.html
Univ. Nebraska	http://agbiosafety.unl.edu/education.shtml
USDA	http://www.usda.gov/agencies/biotech/
USDA	http://www.nal.usda.gov/bic/
Yahoo	http://dir.yahoo.com/Science/Agriculture/Biotechnology/

Table 24.9 Online Resources for Geographic Information Systems.

Sponsoring Organization	Website URL
California State Univ.	http://www.precisionag.org/
Cranfield Univ.	http://www.silsoe.cranfield.ac.uk/cpf/
Farm Scan	http://www.farmscan.net/home.aspx
Iowa State Univ.	http://www.abe.iastat e.edu/GISLAB/gis_lab.html
Iowa State Univ.	http://www.abe.iastate.edu/GISLAB/html/project5.htm
Kansas State Univ.	http://www.oznet.ksu.edu/precisionag/
NASA	http://www.ghcc.msfc.nasa.gov/precisionag/precisionag.html
NC State University	http://www.bae.ncsu.edu/programs/extension/agmachine/precision/
Precision Ag	http://www.precisionag.com/
Texas A&M Univ.	http://txprecag.tamu.edu/
Texas S&M Univ.	http://precisionagriculture.tamu.edu/
Trimble	http://www.trimble.com/agriculture.html
Univ. of Minnesota	http://precision.agri.umn.edu/
Univ. of MO-Columbia	http://www.fse.missouri.edu/mpac/
Univ. of Sydney	http://www.usyd.edu.au/su/agric/acpa/
ESRI	http://www.esri.com/gisforeveryone/basics/
GIS Lounge	http://www.gislounge.com/
State Univ. New York	http://www.geog.buffalo.edu/ncgia/gishist/
Univ. of California	http://gis.ucsc.edu/
Univ. of Edinburgh	http://www.geo.ed.ac.uk/agidict/welcome.html
USGS	http://info.er.usgs.gov/research/gis/title.html
Utah State Univ.	http://www.gis.usu.edu/

Table 24.10 Online Resources for Incorporating Agriculture into Classrooms

Sponsoring Organization	Website URL
Ag in the Classroom	http://www.agclassroom.org/
Ag in the Classroom	http://www.agclassroom.org/teacher/lessons.htm
BC Ag in Classroom	http://www.aitc.ca/
BC Ag in Classroom	http://www.aitc.ca/bc/pages/lessonplans/IntrotoAgriculture.html
Career Clusters	http://www.careerclusters.org/ClusterDocuments/agdocuments/AGFinal.pdf
FFA	http://www.ffa.org/programs/lps/html/practicesindex.html
IL Farm Bureau	http://www.agintheclassroom.org/resources/resources.htm
Illinois Area III	http://www.lth3.k12.il.us/K-2/farm/farmunit.pdf
Industry Canada	http://collections.ic.gc.ca/agriculture/top.htm
MI Farm Bureau	http://www.michiganfarmbureau.com/education/aitc.php
NC State University	http://www.cals.ncsu.edu:8050/agexed/sae/toolbox/
OR State University	http://aitc.orst.edu/
SCFA	http://www.scforestry.org/teachers.html
Space Ag in the Classroom	http://www.spaceag.org
WA Ag in Classroom	http://www.waic.net/
Walnut Grove H.S.	http://www.mda.state.mo.us/pdf/AgLitContest20024th.pdf
WI Dairy Council	http://www.dcwnet.org/index_flash.html

25. A Strategy for Integrating GIS

Richard P. Greene

Introduction

The teaching modules enabled middle and high school teachers in the Rockford public schools to explore the local community with geographic information systems (GIS) and global positioning systems (GPS). The modules, which were introduced to the teachers in workshops conducted between 2000 and 2003, required the purchase of GIS software and GPS hardware for five separate school buildings throughout Rockford. By the end of the project, more than 60 teachers from disciplines ranging from English to mathematics were trained in the use of GIS. The goal of the program was to illustrate a powerful tool for integrating spatial concepts and geographic principles across disciplines. This pedagogical goal is consistent with other approaches taken to train teachers on the use of GIS (Meyer, Butterick, Olkin & Zack, 1999).

What Are GIS and GPS?

A GIS is usually defined as a computer system for capturing, storing, and displaying geographically referenced information; however, many definitions have been proposed (see Clarke, 2003, p. 2). A GIS system is almost always described in terms of map layering, where the software allows the analysis of many maps of information about a place (Figure 1). The types of map layers vary as much as the many disciplines that employ GIS. For instance, health specialists might include a map of hospitals for a given region as a layer combined with a census block map that includes population counts. Such maps within a GIS could be used in an analysis of the number of hospital beds available to potential patients in a region and could even lead to the identification of underserved areas. In such a definition, a GIS is composed of features (like hospitals and census blocks) combined with attributes about those features (number of beds and people) and stored in a database table that is indexed to the features. Finally, the most critical component to the definition of a GIS is geographical referencing, which ties features to a common geographic coordinate system (latitude and longitude).

A GPS, on the other hand, is a satellite navigation system that allows a user who has a GPS receiver to pinpoint a precise geographic location from a constellation of satellites devoted to this purpose. The constellation of satellites is owned and operated by the U.S. Department of Defense (DOD). Nevertheless, the use of GPS for civilian uses has increased in recent years.

The relationship between GIS and GPS is strong in that they are both systems that rely on geographic coordinates. In most cases, GPS systems serve as an efficient method of acquiring data for a GIS; for instance, if one were interested in developing a map layer of trees for a neighborhood, one could derive their location (latitude and longitude) with a GPS receiver and transfer the coordinates into a GIS and generate the map layer. Alternatively, a GIS sometimes serves as input into a GPS; for instance, consider the case where a conservation organization wishes to send naturalists into the field to verify raccoon habitats it already has in its GIS. The task is simple: feed the GIS coordinate locations into the GPS receiver and navigate to the locations with the GPS unit.

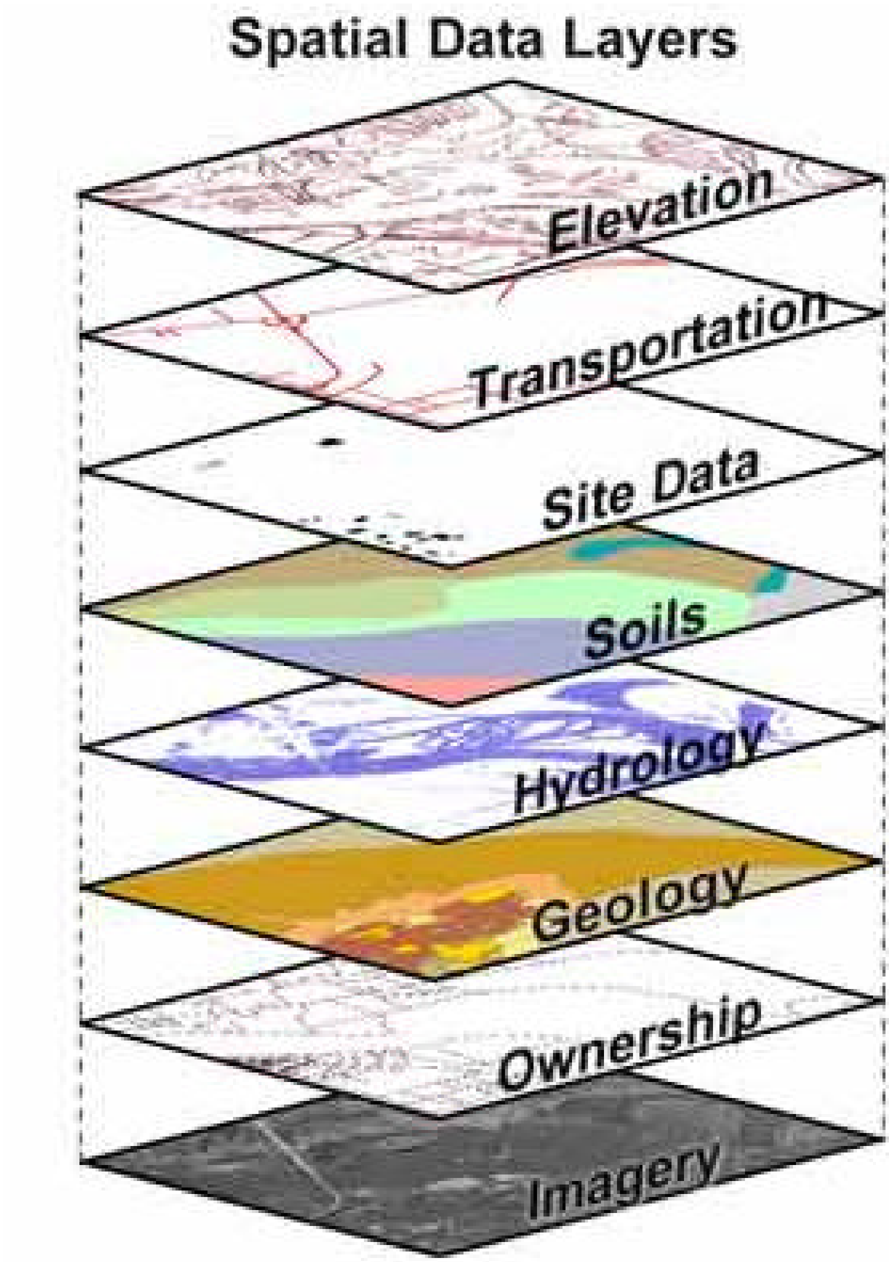

Figure 25.1 Concept of Map layering

Acquiring Hardware and Software for the Teachers

A number of studies have shown that access to hardware and software is a critical factor in the success of GIS teaching-preparation programs (Bednarz & Ludwig, 1997). Meyer, Butterick, Olkin, and Zack (1999) also note this problem by initiating two studies, one concentrated on teachers and the other concentrated on students. They specifically address the availability and cost of hardware and software and find that the larger problem was with hardware, since many GIS software vendors offered discounts.

The Rockford project on GIS/GPS had funding to purchase laptop computers for each teacher. It also paid for the purchase of Environmental Systems Research Institute's (ESRI) ArcView 3.X site licenses for five schools (ESRI, 2003). ArcView is a GIS software package that has been adopted by many schools throughout the United States (Figure 2).

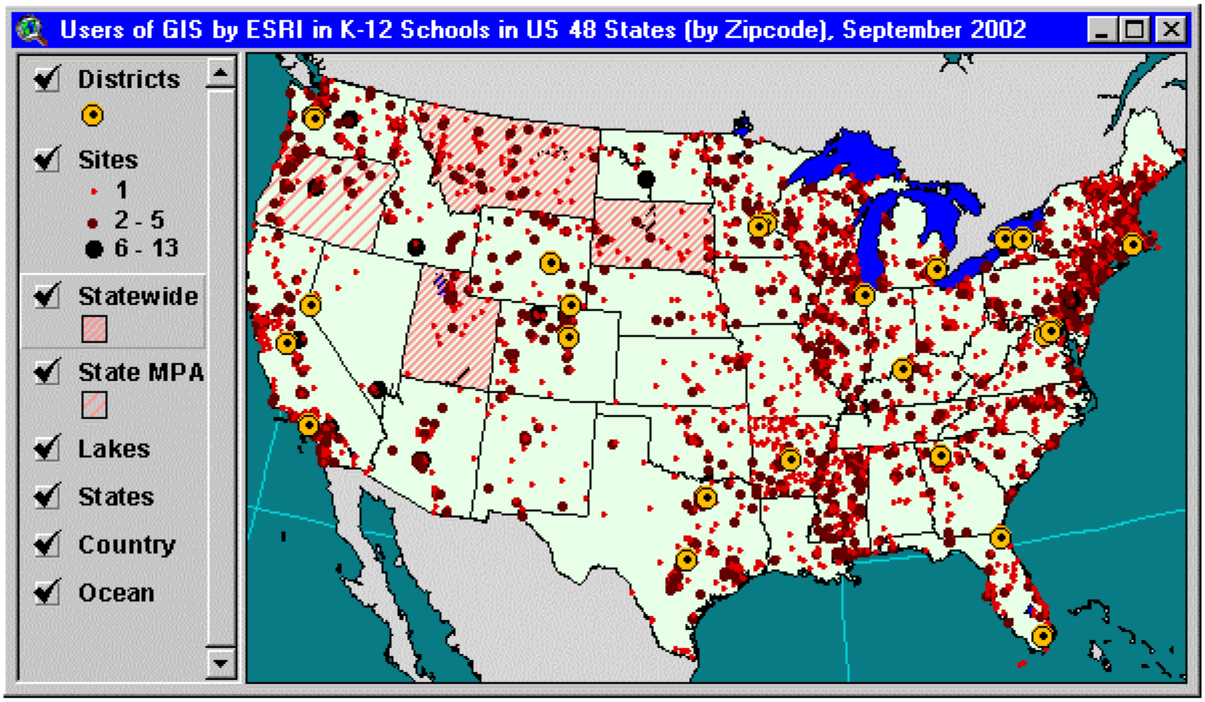

Figure 25.2 Schools Using ArcView GIS (ESRI, 2003)

In addition, the project bought Navman GPS units bundled with Rand McNally's Street Finder software for each teacher who participated in the GIS/GPS workshops.

Workshops

The project offered a two-day workshop for GIS and a one-day workshop for GPS, structured around modules developed for studying the Rockford community. The GIS module consisted of 12 lesson plans, with discussions on how teachers could use or modify them for their own subject areas. The GPS module consisted of 11 sequential and cumulative lesson plans. Unlike the GIS lesson plans, which could be taught in any sequence, the GPS lesson plans were part of one large project.

The principal educational goal of the GIS/GPS modules was to help students understand their local community and how geography has helped shape the society in which they live. A secondary goal was to introduce students to mapping and the associated concepts of map projections, map scale, and cartographic generalization. A tertiary technology goal was to develop proficient use of GIS and GPS and to understand the database structure underlying these technologies.

These goals were consistent with those developed by *Geography for Life: The National Geography Standards 1994* (Geography Education Standards Project, 1994). The GIS module was most consistent with Illinois and district learning standards, where a clear link could be made to: (1) social studies, grades 6-8, goal 17, geography, standards A-D; and (2) social studies and environmental sciences, grades 9-12, geography.

It was important to tie the GIS module to these standards, but it was emphasized that the content could be incorporated into geography, history, sociology, economics, environmental science, and technology.

In addition to drawing links to the state learning standards, industrial partnership activities were proposed. For instance, the module handout mentioned the use of GIS by the Rockford Police Department for crime analysis and suggested that a fieldtrip to the police department could be organized to demonstrate the use of GIS in the operation of city functions.

Description of the GIS Instructional Module

The first lesson in the module was the definition of GIS. Teachers were asked to go to the site www.gis.com and evaluate it in terms of how their students would respond. The lesson activity then instructed them to visit the following portions of the page and answer these questions:

1) Click on *What is GIS?*
    - What is the definition of GIS?
2) Click on *GIS for your Specialty.*
    - How many specialties use GIS?
    - Click on one specialty and summarize how GIS is used.
    - Can you think of a specialty that could use GIS but is not listed?
3) Click on *Try GIS for Yourself.*
    - Which mapping applications did you like best and why?
4) Click on *GIS-Software.*
    - What is GIS software?
    - List the variety of software options available.
5) Click on *Data for your GIS.*
    - What makes GIS data unique?
    - List some sources of GIS data.
6) Click on *Education and Training.*
    - What types of educational programs are available for GIS?
7) Click on *News/Events/Trends*
    - List some examples of GIS in the News.

The teachers especially liked the active learning aspect of this lesson.

Lesson 2 introduced the principal elements of GIS through an activity that started the teachers with the ArcView GIS software. They practiced turning map layers on and off and learned how to access attribute tables associated with each layer. Initially, they found some of the functions difficult, for instance the difference between a polygon layer (state boundaries) and a line layer (rivers) and how the drawing order was important for their display (lines on top of polygons). Most teachers felt that the students would have very little difficulty with the lesson.

Lesson 3 introduced the teachers to downloading a community map layer of roads from a website that makes U.S. Census Bureau GIS files available. A slight deviation from GIS was necessary because most map layers on the Internet are archived and require software to unzip the archives. An additional activity of the lesson was to perform a geo-coding service, sometimes referred to as address matching as it compares two addresses to determine whether they are the same. To match addresses, ArcView looks at the components of addresses in both the tabular data file and the feature data source. Then ArcView looks for certain standards and makes a decision about whether addresses match. The Census Bureau's street maps have four street address numbers, ranging from low to high, for each side of a street segment. The range indicates the possible numbers that could fall within a particular block, and the numbers are divided into even on one side of the street and odd on the other. The address components for this type of street are typically represented as:

Left_from	Left_to	Right_from	Right_to	Street_name	Type
201	299	200	298	SUNSET	ST

The teachers were instructed to assume that the Rockford Public Library had asked them to make a quick map of the locations of three patrons who visited the library that morning. They were given the following addresses:

ID	Address
1	100 Rockton Rd.
2	152 Auburn St.
3	27 Blossom Rd.

On completion of the lesson, teachers displayed the location of each library patron on a map superimposed on the street map layer. The teachers then discussed the possible scenarios they could create for students to learn the technique of address matching within a GIS.

Lesson 4 introduced the concept of map projection. Participants were asked to change the map projection of one of their map layers. Map projections involve a mathematical transformation of the coordinates (the map being a two-dimensional representation of a three-dimensional Earth). The lesson demonstrated the concept by transforming the Census Bureau road-map layer from geographic coordinates (latitude and longitude) to the UTM coordinates that were shown on a topographic map downloaded from the United States Geological Survey (USGS) Web page.

An equally important concept is map scale, a concept that the teachers could more easily appreciate. Lesson 5 demonstrated the concept of large-scale maps (more geographic detail) versus small-scale maps (less detail) through GIS by using the zoom in and zoom out function. Scale was also demonstrated by overlaying map layers collected at different scales in order to illustrate the concept of map generalization. The teachers understood the importance of scale and thought that the concept would be easier to communicate than map projections.

Lesson 6 taught the teachers how to integrate points collected from a GPS unit into the GIS. Prior to the workshop, some GPS points were collected within Rockford, and the teachers later added the points into a database table and translated them into the GIS. Not all participants would be taking the subsequent workshop on GPS, so it was important to illustrate to all of them how the two technologies were integrated. The teachers thought the students would like the fieldwork component of this activity.

Lesson 7 illustrated how an aerial photograph is used as a layer in a GIS and often as the base for referencing all other layers (see Figure 1). Teachers downloaded a USGS digital aerial photograph of the site of the high school and zoomed into the various parts (such as the parking lot). They thought the students would especially like this activity. Lesson 8 involved downloading a census block map and overlaying it on the aerial photograph to show differences in spatial precision.

Lessons 9, 10, and 11 emphasized the attribute-table side of GIS. The activities involved creating tables, adding fields to tables, updating data cells, and examining the resulting changes to the map features. Lesson 12 introduced the principles of thematic mapping with two specific types: choropleth (shaded area) mapping and dot density mapping. The activity in this exercise involved mapping several demographic variables for the Rockford area. The teachers were asked to map the 2000 African American population, first using a choropleth technique with five equal intervals. Next they were asked to use a dot map for the same population and to overlay the two and discuss differences in spatial patterns. Many of the teachers saw this as a powerful tool for mathematics applications and for visualizing patterns.

Conclusion

The project was an effective model for disseminating GIS into middle and high schools. Many of the teachers have adopted some of the module lesson plans and others expect to modify them for their own specific areas. We can expect more teachers to adopt GIS and GPS into middle and high school curricula as teachers come into the system with backgrounds in this growing area. Bednarz and Audet (1999, p. 61) note the following:

> Throughout this decade efforts to implement GIS have been directed at in-service teachers. Thus, most teachers who use GIS in their classrooms have learned the technology while on the job. However, experts in GIS and education recommend pre-service as well as in-service education (EDGIS 1995, 1996). In-service teachers have a limited amount of time to acquire the skills needed to use GIS to teach geography and, as Brownell (1997) notes, the quality, methodology, and effectiveness of such training is in question. In contrast, pre-service teachers have both the time to become technologically proficient and access to training at university facilities by GIS-literate professors.

Nevertheless, in-service training programs such ours will be of great benefit as schools make the transition to hiring teachers trained in GIS.

Echoing findings by Meyer, Butterick, Olkin, and Zack (1999), most of our teachers felt that they needed additional hands-on practice beyond the initial workshops. One of the mathematics teachers invited me to his classroom following his first GIS workshop, and I gave a presentation to the students and had them complete one of the lesson plan activities. After that visit, the teacher attended my GPS workshop, where I learned he was integrating GIS, GPS, and CAD into a project for the students. Follow-up communications showed that he was working through many of the difficulties that one encounters when developing an activity from scratch. In addition, I offered a follow-up review session at the beginning of the upcoming school year after the workshop to provide review and support for those who were going implement GPS/GIS in their modules.

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26. Computer-Aided Design Technology

Radha Balamuralikrishna

Introduction

My part of the Rockford project focused on applying school mathematics in the study and using computer-aided-design (CAD) technology. We also conceived the idea that CAD could be used as a showcase tool to advertise and promote potential careers in engineering and technology. The implementation phase of our effort required integrating CAD into middle and high school mathematics through teacher training, which would lead to learning opportunities for students. The broad objectives were to (1) provide hands-on training in CAD with the aim of inspiring teachers to blend technical thinking and problems into mathematics education and (2) provide a basic orientation in CAD and its downstream applications, thereby encouraging teachers and if possible career counselors to encourage student exploration of engineering technology as a career choice. A teaching and learning module that integrated CAD into selected school mathematics topics was also developed.

This paper summarizes the activities that were conducted in a two-day workshop and the development of an instructional module. CAD was also used in a career workshop. (For details see Balamuralikrishna & Mirman, 2002.)

Lines of Communication Between Schools and Colleges – The Need

A significant proportion of the population switches career plans during and after the postsecondary experience, but most young people map out their initial career path by the time they enter their final year in high school (Occena, Chen & Lammers, 1996). Professional bodies such as the American Society for Engineering Education (ASEE) and the Society of Manufacturing Engineers (SME) have recently embarked on initiatives geared to promote engineering and technology in K-12 education (Cohen, 2001; Hogan, 2001). The rationale is to "catch them young" and induce the best talent to pursue a career in engineering or technology. ASEE's President Jakubowski (2002) has warned that "if the United States does not start closing the gap in student achievement in science and mathematics, the country runs the risk of becoming disadvantaged in the worldwide economy" (p. 41). His faith in this proclamation was demonstrated by the introduction of an initiative called the ASEE Center for Best Practices in K-12 Science and Math Education. The College of Engineering and Engineering Technology at Northern Illinois University has joined ASEE in this effort.

Attracting good first-year students requires a sustained, multifaceted effort. The purpose of a recruitment program is to increase the visibility of the institution's offerings throughout the community and to establish ties with regional middle schools, high schools, and community colleges (Balamuralikrishna & Mirman, 2002).

Why Use CAD to Promote Careers?

CAD software facilitating the creation of both 2-D drawings and 3-D solid models is generally available in postsecondary institutions that offer degrees in technical disciplines. In fact, such software is available in many high schools, although the number of licenses (seats) may be limited. The technology offers a safe, inexpensive way to open minds to the world of creativity that is embraced by both engineering and technology. Students of technical graphics (faculty members included) will readily admit their excitement upon creating their first 3-D solid model on the computer and watching it spin on the computer monitor. (A solid model is a three-dimensional, realistic representation of an object part or an assembly of parts.) Solid-modeling technology has been popular in industry for the past 10-12 years.

Before the era of 3-D CAD, engineers relied extensively on two-dimensional images that were created on paper or its equivalent. When writing on a flat surface, one is restricted to working on a plane that has two dimensions, width and height (x and y in a mathematical sense). A CAD system is physically unrestricted because the input data is based on coordinate geometry, and a computer can deal with a three-coordinate system (x, y, z) almost as easily as the (x, y) system.

The applications of CAD offer an impressive array of potential showcase material. Technologies such as rapid prototyping, computer-aided engineering analysis, and computer-aided manufacturing generally depend on the availability of a solid model as a starting point. Computer-aided engineering analysis can be complex material for an audience that includes teachers from a wide range of disciplines, and computer-aided manufacturing can involve additional time, safety, and cost issues. On the other hand, rapid prototyping is an exciting, relatively new technology that is quite easy to learn and comes with minimal safety issues. This process makes use of the data file that is part of a solid model and proceeds to build a part, layer by layer, with the required human intervention being limited to a few clicks of a computer mouse and strokes of the keyboard. The result is a tangible, realistic looking prototype that can convey a sense of touch and instill a sense of fulfillment as users see their design ideas moving toward reality (Cooper, 2001). Rapid prototyping machines are becoming common in every college CAD laboratory. Although solid modeling is exciting, it is essential for the CAD user to learn the basics of engineering design, engineering graphics, and CAD in two dimensions. This was the driving force behind the concept of conducting a CAD skills workshop for teachers.

Table 26.1 Timetable for Day 1 of CAD Skills Workshop

Time-Period	Activity
8 - 9 a.m.	*One who dares to teach should never cease to learn – John Cotton Dana* Introductions What is it? - An exercise in communication ***OR*** an exercise in frustration?
9 - 10 a.m.	*All that I've learnt in life* Background information exercise, selected State of Illinois learning standards & the potential for blending CAD into school mathematics
10 - 11 a.m.	*A journey of a thousand miles starts with a single step – Unknown* Introduction to CAD software, the SilverScreen design package
11 a.m.-12 p.m.	*Begin with the end in mind – Steven Covey (In his "Seven Habits of Highly Effective People")* The importance of setting up your drawing screen - Drawing setup commands The story of "My first CAD drawing"
12 - 1 p.m.	*A hungry man is an angry man – Mr. Shetty (Author's former colleague in a shipyard in India)* Lunch – Yes!!! (Working lunch, CAD lab continued)
1 - 2 p.m.	*A picture is worth a thousand words…provided it's the right picture! – adapted from an old Chinese saying* Who was Gaspard Monge and how did he open new doors in technical communication/CAD? Spatial visualization exercise
2 - 3 p.m.	*An ounce of practice is worth tons of theory - Unknown* Problems to be solved using CAD techniques
3 - 4 p.m.	*The fun has just begun!* More problems to be solved using CAD

Workshop

The two-day workshop aimed at encouraging Rockford area middle and high school teachers to integrate CAD into their subject areas to enhance the learning of mathematics and science. This was the first exposure to CAD for nearly all teachers. The teachers represented a wide array of disciplines, including English, science, and mathematics. The workshop's goal was to help teachers communicate ideas embedded in engineering and technology to their students. It was necessary to buy software, the SilverScreen™ package, but almost any CAD software package available today would have worked.

One of the first concepts presented to the teachers was the problem of communicating the shapes of real-world, three-dimensional objects on a two-dimensional writing instrument (Schoonmaker, 2003). Participants were asked to match isometric pictorials of objects with their corresponding multi-view drawing. Jensen and Hines (1994) have created useful worksheets for this activity. The concept of coordinate geometry in two-dimensions was next addressed. Participants were asked to pencil sketch a two-dimensional shape defined by a series of points whose (x, y) coordinates were provided in table format. They then transferred the sketch to the computer. Teachers were pleased to see that coordinate geometry, which is a staple in their mathematics curriculum, provided the basis for CAD data input. Further application of CAD skills was introduced using a problem-solving approach. Then the teachers learned how to integrate CAD into middle and high school subjects.

As a capstone experience, participants worked in teams to create a two-dimensional drawing that could be used to produce paper carts, as described by Carruth, Peterson, and Chaney (1997). The raw materials needed were paper (manila-folder quality), two pencils, four paper clips, and a piece of string. The tools required for the project, besides CAD software, were a pair of shears and a straightedge. The teachers created the drawings with minimal help from the instructor. The teachers were excited to learn that with a little imagination they could adapt the paper-cart activity to explore various facets of manufacturing, including statistical distributions (Carruth, Peterson & Chaney, 1997). The schedule of activities for the workshop is provided in Tables 1 and 2.

Table 26.2 Timetable for Day 2 of CAD Skills Workshop

Time-Period	Activity
8 - 9 a.m.	CAD Laboratory More draw, edit and display options
9 - 10 a.m.	CAD Laboratory continued True shape description of objects
10 - 11 a.m.	Solving heights and distances problems from traditional trigonometry employing CAD methods
11a.m.-12 p.m.	CAD Laboratory Solid modeling
12 - 1 p.m.	Lunch Break – Yes!!! *In the United States anybody can grow up to become a teacher; it's just one of the risks one takes in life - adapted from Adlai Stevenson* CAD Q & A session (friendly quiz)
1 - 2 p.m.	*Those who can, do; those who can do more, teach - Unknown* Solid modeling continued
2 - 3 p.m.	Designing and constructing paper carts – potential student activity
3 - 4 p.m.	*The great aim of education is not knowledge but action - Herbert Spencer* Testing paper carts – potential student activity Evaluations, wrap-up

Instructional Module

In Illinois, K-12 education is largely standards-based. The availability of state standards for learning simplified the task of writing the module (www.isbe.net/ils/Default.htm).

The instructional module consisted of Lesson 1, "Plane Geometry − Creating Familiar Two-Dimensional Shapes and Estimating Areas," and Lesson 2, "Employing Computer Aided Design (CAD) to Solve Problems Involving Heights and Distances." Lesson 1 could be used in either middle or high schools with minor adaptation. Lesson 2 was strictly for use at the high school level. CAD was integrated into these lessons as appropriate. The basic purpose was to introduce students to the technology of computer-aided design while making use of mathematical concepts that were typically covered at that particular level of study. Students would need a prior knowledge of applying mathematical formula to compute areas created by enclosed 2-D shapes to complete Lesson 1. Also, they should have prior knowledge of solving problems related to heights and distances, using trigonometry, to complete Lesson 2. The module would allow students to experience how computer-aided design enables calculating areas of 2-D shapes and solves typical trigonometry-based problems involving heights and distances through the application of full-scale vector graphics.

Lesson 1 highlights

The Illinois state educational standards driving the content of Lesson 1 are (www.isbe.net/ils/math/mag6.html, www.isbe.net/ils/math/mag7.html):

IL-6.C	Compute and estimate using mental mathematics, paper and pencil methods, calculators and computers.
IL-7.A	Measure and compare quantities using appropriate units, instruments, and methods.
IL-7.A.4b	Apply formulas in a wide variety of theoretical and practical real world measurement applications involving perimeter, area, volume, angle, time, temperature, mass speed, distance, density and monetary values.

The students learned the basics of CAD through use of the SilverScreen™ software. They could model a two-dimensional situation using either the U.S. Customary or the SI units. The lesson focused on creating regular 2-D shapes, such as a triangle, rectangle, and circle, precisely to specifications and used problems to demonstrate the use of CAD in engineering applications through problems. Finally, the module included a set of activities (assignments) to be completed by the students with minimal guidance from their teachers. The learning premise was that if students followed the lecture material and completed the sample problems, they should have no undue difficulty in completing the assignment problems. A sample assignment problem follows:

> The surface of an aluminum metal sheet has the shape of an equilateral triangle. The base measures 525 mm. What is its area? Solve the problem using CAD and state your answer specifying correct units. Also, determine the altitude (height) of the metal sheet in mm. (Schaaf, 1963)

Schaaf also provided several other appropriate examples of problems that could be adapted for CAD usage and are strongly recommended for further investigation. The reader will recognize that problems of this nature are not limited to the cited sources; similar problems can be found in numerous textbooks dedicated to school mathematics.

Lesson 2 highlights

The state educational standards driving the content of Lesson 2 are (www.isbe.net/ils/math/mag7.html):

IL-7.C.4a Make indirect measurements, including heights and distances, using proportions (e.g., finding the height of a tower by its shadow).

IL-7.A Measure and compare quantities using appropriate units, instruments, and methods.

IL-7.A.4b Apply formulas in a wide variety of theoretical and practical real world measurement applications involving perimeter, area, volume, angle, time, temperature, mass, speed, distance, density and monetary values.

Students should have completed Lesson 1 before starting Lesson 2. Complete step-by-step tutorials to solve the following problems were included as part of teacher presentation material:

1. What is the angle of elevation of a tower 20m high from a point 80m away?
2. Using a pair of binoculars, an ornithologist is observing birds that are resting on a cliff. She is standing 100m away from the cliff. Ignoring the height of the ornithologist, find by CAD drawing the heights of the birds being observed when her line of sight makes angles of 15^o, 30^o, 45^o, and 60^o with the horizontal.
3. A surveyor standing 50m from a cooling tower measures the angle of elevation of the top as 31^o. What is the height of the tower if the measuring instrument itself is 1.5m above the ground?

The following assignment problems were included with the expectation that students would solve these with minimal guidance from their instructor:

1. A boy of height 1.75m is measuring the heights of trees in the school grounds. He stands 24m from a tree and measures the angle of elevation as 42^o. Calculate the height of the tree (from ground level to treetop) as accurately as possible.
2. At a certain time during the day, the shadow (on the ground) of a vertical 75 foot pole is 100 feet long. What is the angle of elevation of the sun?
3. A tree located at a distance of 20m from a house is being chopped down. The angle of elevation of the top of the tree as measured from a first floor window is 44^o. Is it safe for the tree to fall in the direction of the house?

The problems included in the module encompass various levels of mental stimulation as defined in Bloom's Taxonomy, which includes knowledge, application, analysis, and synthesis. For example, the preceding assignment problems address the knowledge and application of trigonometry. In addition, problem 3 requires analysis.

Results and Conclusion

Participants of the CAD workshops provided very favorable feedback. In particular, the teachers with a science, mathematics, or technical background were able to acquire the skills rather quickly. The teachers appreciated the hands-on approach used to deliver instruction. Many of them indicated that they would like to integrate CAD into their lesson plans based on what they learned during the workshop. Nearly all of them also noted that the activities were clearly tied to the Illinois State Board of Education teaching standards. Teachers are beginning to experience positive results in the classroom, in the form of increased levels of student enthusiasm, curiosity, and problem-solving ability. It appears that career counselors also have a better understanding of CAD and its critical role in engineering and technology. Both teachers and counselors strongly emphasized that this workshop enabled them to acquire confidence on this subject.

Engineering and technology programs have historically enjoyed considerable popularity among high school students. By actively including engineering applications in high school subjects, we may exploit the abundant, innate technical aptitude of students and encourage them to pursue science and mathematics more seriously. The experiences described here should encourage engineering and technology faculty to employ CAD as a marketing tool for increasing the visibility of engineering and technology programs. As CAD programs become more user-friendly and versatile, more teachers are likely to pursue workshops and basic orientation in this discipline. Middle and high school educators are close to the students colleges and universities wish to attract, and there would be mutual advantage in teachers and engineering and technology faculties finding new lines communication with one another.

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27. Language Arts Online: Technological Literacy in the Secondary Language Arts Classroom

Michael Day

> Good oral and written communications are considered by ABET to be a necessary achievement of a college graduate. Technically trained individuals should not be considered educated regardless of the depth of their technical capability if they cannot communicate, both orally and in writing, their technical findings, thoughts, and philosophy to others around them…. Course work in English composition, including both written and oral presentation, literature, and especially technical writing, is appropriate for meeting the quantitative requirement.
> (Criteria for Accrediting Engineering Technology Programs, I.C.5.a)

Background: Technology and the Language Arts

With the advent of the personal computer in the 1970s, writers were among the first to realize the potential of the computer as something more than a glorified electronic calculator. Using early word processing programs, writers recognized that the computer, with its ability to outline, format, and display revisions immediately, would revolutionize the process of bringing thoughts into print form. By the 1980s, teachers of writing also began to recognize that the computer would become the standard writing tool of the future. And by 1993, many teachers were aware of the educational research of such scholars as Papert, whose *The Children's Machine: Rethinking School in the Age of the Computer* showed the potential for computers in the schools to change educational dynamics by empowering young students to take more control of their own learning. Teachers and scholars were already publishing articles and books that demonstrated that while computers do not necessarily improve writing, they help students write more, revise more, develop community, and publish their writing for real audiences more often. At this juncture, 1993, the Web jumped into the popular consciousness, and teachers of writing, many of whom had already found success in having students share writing with others over the pre-Web Internet, were quick to see the potential for students to share not just writing but also multimedia compositions including graphics and sound over the Web.

Sadly, although many colleges, universities, and resource-rich schools have been able to invest in hardware, software, and faculty development to help teachers learn how to integrate technology in their classes, the resource-poor schools in general have not been given reliable access to computer technologies. Foundations and corporations have given generously to schools, but without software, training, and funds for repair and replacement, the computers have just as often as not ended up as fancy doorstops.

Our Project

The PI of the NSF-funded project in Rockford recognized the importance of communication skills for middle and secondary students who might go on to become technicians, technologists, or scientists. The grant proposal included funding for the training of middle and high school language arts teachers and for its potential to provide evidence of learning through written and spoken communication. I was among a group of English professors asked to join an ongoing initiative establishing connections between university and community college faculty and school teachers. We were supposedly experts with much to offer the teachers, but in fact much of our job, especially in the first year, involved listening to their stories and gathering enough information to make what we offered them count.

Identifying and Prioritizing Needs

In January 2000, we attended the first meeting. Representing more than half a dozen disciplines, we were scattered about the room, one at each roundtable, prepped with handouts of questions about what makes strong and weak teaching and learning environments. We shared our answers with those at our tables and began to recognize that though we had many common values about teaching, the secondary school teachers had to confront at least two problems that we did not. First, they had to face daily disciplinary problems, and second, their access to computers was much more limited than ours, and the machines were often unusable because of broken hardware, the wrong software, and limited training for teachers. Thus we decided to focus the workshops on training.

During the first year, we met as a large group for articulation. Neither the professors nor the district teachers had a very concrete idea of what was meant by articulation or what could be gained from it. We spent a lot of time defining it and attempting to answer a series of questions to identify common concerns about teaching and learning language arts. We made little progress, at first, because the answers were so wide-ranging and diffuse, but soon we realized that just having these conversations and identifying common concerns was the point of the entire process.

Among other things, the professors learned a great deal about the day-to-day strictures that the district school teachers face. When they described their standards for each grade, we were surprised both at how detailed these standards were and at how much had to be covered in a single year. We were also disappointed to hear about how much time the teachers spent drilling the students to prepare them for standardized tests. In turn, the district teachers expressed some envy when they heard about our teaching loads and our relative freedom to teach language, literature, and composition.

The first articulation session modeled a communication approach by creating Web pages for the project's sessions and workshops. The articulation page can be found at www.engl.niu.edu/mday/web/artic.html. For all three articulation sessions over the past three years, we were able to secure a computer lab to display and explain the links. The professors had to learn about the 6-12 standards and course designs through discussions with the teachers and references to paper handouts, while the secondary teachers were able to learn about our courses and expectations through a combination of discussion and resources on the Web.

Educational Pathways to Careers Workshops

For the career workshop day, we prepared information about the required core competency composition sequence in the English Department, as well as information about minimum high school English requirements for admission. We decided that since so much career research now happens on the Web, we should have them do something on the Web to learn about careers for English majors. Then we gave them a very quick lesson on creating a website with Netscape Composer, and they made rudimentary but functional career sites for their students in a few minutes. This process went very well. Many of these teachers had not previously looked at the wide range of career resources on the Web, so they were making discoveries and excitedly reporting them to one another.

Reading and Writing across the Curriculum Workshop

This workshop is described in the CAC chapter (Chapter 15); therefore, I will discuss aspects related to working with resources that facilitate reading and writing. We showed the teachers how to use an online discussion tool, the bulletin board or webbed discussion board, to begin to understand how written online discussions on almost any subject can help students engage with one another and the subject matter. Those who study online discussion groups often use social construction theory to demonstrate how, when students are involved in written conversations, they are learning by collaboratively constructing a world of discourse that demonstrates and embodies their learning process. Many of the teachers successfully used WebBoard software to post messages and respond to each other.

The second half of the session focused on information literacy. Before the Internet and Web, the process of bringing a work to print had the effect of filtering out many unreliable sources (the review process) and making others extremely easy to identify (tabloids and poorly mimeographed documents). However, on the Web, anyone can be a publisher, which has led to a sticky problem of unreliable pages that can trap the unwary visitor. Teachers need to help students become critical users of the information they find. We viewed a site created for my college writing classes, "Evaluating Web Sources for Research" (www.engl.niu.edu/mday/web/wmc.html), with the intention that the teachers could replicate it with their classes. The teachers gained a better sense of how misleading Web pages can be, and that the URL itself, the design, or technical sounding language can fool many viewers into believing that the site is credible. Another key problem discussed was "appropriate and credible for whom, and for what purpose?" We used the example of "Your Gross and Cool Body" to show how pages, like this one, that are appropriate for younger audiences are not appropriate for high school or college research. Our comments turned into a list of criteria for credible research sources.

Technical Writing Workshop

The challenge for a full-day workshop was to find activities that would be interesting and relevant to the secondary teachers, while introducing them to elements of technical writing that might help them think of activities for their students. We planned a series of five modules.

The first module was to brainstorm answers to questions about what technical writing is and how it fits into the academic and work worlds. We split them into groups of three or four people that collaborated on answering the questions. They emailed their answers for posting on the workshop website. Once we had focused them on general technical writing categories, in the second module we asked them to try a simple exercise to get a sense of the difficulties of writing detailed instructions. We used a webbed exercise for an NIU technical writing course that asked them to write instructions for baiting a mousetrap or for snapping their fingers. The third module had the teachers brainstorm the most common technologies used in technical writing, which led them to exchange ideas about what kinds of software and machines their students might eventually need to use in the workplace. In the fourth module, we asked them to critique examples of technical documents on the Web.

To give a more practical application to the ideas and activities we had introduced in the last module, we asked the teachers individually to write a short description of a lesson plan using some aspect of technical writing. The most innovative and appropriate of the lessons plans were:

1. An art teacher asks students to describe artwork up for auction to potential bidders.
2. A mathematics teacher invites students to write instructions to other students for completing a problem.
3. An interdisciplinary team asks students to write detailed instructions on how to investigate a crime scene without destroying crucial evidence.
4. A science teacher asks students to write instructions for using a GPS unit to map the school.
5. Two business teachers have students write a car-buying guide of the sort one might find in *Consumer Reports.*
6. Several teachers want students to create brochures about fictitious countries, planets, or businesses.

Discipline Updates

During the first year of discipline updates (2002), we planned a series of workshops for three groups: level-one high school and middle school teachers, level-two middle school teachers, and level-two high school teachers. The middle and high school teachers in level one only had one discipline update together, while the level-two high school and middle school groups had two days each, in separate sessions for more in-depth work.

We tried to bring the teachers relatively new and important areas in language arts instruction. In earlier workshops, we incorporated writing across the curriculum and portfolio learning, but the technological areas were more popular with the teachers and perhaps more in keeping with the theme of the original NSF grant, so we modified the focus to include mostly computer and Internet-based activities.

We usually began with computer-based activities for invention; that is, for brainstorming and generating ideas. For level-one teachers, especially middle school teachers, we showed how to download free software, such as Rosemary West's Poetry Generator and Electric Mind. We showed how they might let the computer help them generate new ways of thinking through the process sometimes called synectics, ("bringing different things into unified connection"). We then demonstrated how to download a free demonstration copy of the Inspiration software, a handy tool for making graphical organization charts that are helpful for moving from notes to more formal structures in planning their work. We also discussed research techniques, especially for the Web, since part of the problem with students using poor Web sources for research projects is that they are not able to use search engines and other search techniques effectively.

The teachers were impressed when we showed them how to make productive use of standard features of Microsoft Word, which has become the default word-processing program in many schools and workplaces. Since secondary school is often where students first use word-processing for school assignments, the teachers agreed with us that they should know more about built-in functions such as the grammar checker, track changes/compare documents, and comment. We also introduced the topic of multi-draft essays, which are common in both college writing classes and the workplace, and showed how students and teachers alike could use the compare documents feature to illustrate revision between successive drafts. Throughout these sessions, we were careful to frame the activities in two ways. First, we introduced each activity by explaining which part of the writing process it would support, and second, we had them actually perform the activity on their own computers.

To give the Rockford teachers ideas for how they might enrich and extend their own class discourse, we had each group log into WebBoard, set up an account, and experiment with the program by answering prompt questions and then responding to each other. After they tried out the program, we led them on a tour of some of my students' thesis workshops and peer-response postings on the course WebBoard. Once the teachers saw the level of engagement, collaborative idea generation, helpful response, and community building in the posts, many of them were enthusiastic about trying out WebBoard, or a similar discussion program, with their classes.

Professional development needs to be part of any workshop on using the Internet. Usually near the end of each discipline update, we included a session on Internet resources for language arts with links on the workshop Web page. This shows online help in a variety of forms, including idea repositories such as the ReadWriteThink project, a joint effort of the National Council of Teachers of English (NCTE) and the International Reading Association that archives hundreds of lessons available to language arts teachers. Online resources are not limited to static Web pages. We introduced participants to email discussion groups sponsored by NCTE, where they found teachers with similar interests.

We were initially worried that the eight-hour workshops looked imposingly long. Yet we soon realized that these teachers, though overworked and underpaid, craved the attention that we could give them in the workshops. The Rockford teachers, in their evaluations, indicated that they appreciated the individualized, hands-on approach.

Classroom Visits

During the first year, each of us was paired with a district teacher who had expressed interest in our special subfield or skills. The coordinators assumed that the university faculty would first visit the class of the participating teacher and then plan a module to teach in that class. Two teachers were interested in partnering with me, so I volunteered to work with both. I had seldom been inside a secondary classroom since graduating from high school in 1974. Of course I was startled, but I learned a great deal about the realities of instruction and student behavior.

When I arrived at the school on a March morning, there had just been a fight, so the police were hauling bleeding and screaming students into the office, where I waited for one of my teachers to meet me. As we walked to her classroom, she explained that she had two classes of sixth graders in her room that day to watch and respond to Spike Lee's *The Four Girls*, a documentary on the 1963 murder of four young black girls in the racist bombing of a church. She wanted the students to write about their feelings as they watched the film, so she wrote appropriate questions on the board and stopped the video at appropriate times to allow them to jot down their feelings or draw pictures. Since the subject of the film was so emotionally charged, the students were obviously affected. At the end of class, she gave them more time to write and draw and encouraged them. Most of them were writing, but even the ones who were talking were talking about the film. On the way out, she proudly showed me a bank of computers lining the walls of the hallway, and we made plans for a module to create Web pages for her class.

My next visit that morning found me sitting in an old-style chair with desk attached – the kind that still has an inkwell – near the back of the senior English class. The topic was Shaw's *Pygmalion*. The teacher was showing scenes from two movie versions, an older black and white version of *Pygmalion* and *My Fair Lady*. He discussed the endings and tried to get the students to talk about why they are different, but he had to keep hushing them to allow the few interested students to hear the film. The two nearest me were talking about their jobs, not watching or listening at all. As if the noise were not enough, other faculty and staff kept interrupting too: once to drop off a box of career handouts and once to give the teacher a notice that he later told me was his pink slip ? he had been fired while in the middle of teaching! Even with the interruptions, he was persistent and got the class to watch a scene from *Trading Places* that made a good connection to the story of the "person created for a bet" in *Pygmalion*. I admired his tenacity.

His next class was similar; the students would not be quiet and would not even sit down in their seats for quite a while. During the film, the girl in front of me slept. After the movie, he generated interesting discussion with some of the class members before they bolted out the door for lunch. But there was a surprise: one of his star students wanted to share a paper with me and get a college professor's response. His writing was pretty good, and he seemed genuinely interested in making it better. The teacher and I had discussed a Web page creation module, but we decided to work on an electronic exchange of writing between his students and tutors at a college writing center. This would eventually become the successful exchange between his students and my teacher certification students described below. We were both committed to finding ways to use appropriate technologies to help secondary students become more engaged, excited, and involved in their own educational experiences. Since computer networks can connect student writers to each other and to the outside world, we reasoned that the modules would need to involve the Internet or Web in some way.

Online College-High School Connection

Our project had originally involved an exchange between senior English students and tutors in the university's writing center, but then we realized that this would be an appropriate learning experience for the English 300C Advanced Composition for Teacher Certification class. We thought that the university students would benefit from an assignment that would ask them to respond to writing from the sort of students they might eventually encounter in their teaching assignments. Crucial to this module, in the eyes of the project coordinators, was my attention to district standards, so I was careful to explain how the exchange would help students meet a standard requiring them to "apply acquired information, concepts, and ideas to communicate in a variety of formats." I was also mindful of a now generally accepted principle that computer networks allow students to contact and communicate with outside audiences whose very presence may change their commitment and attention to their writing because that writing is now truly public. This exchange offered the potential to influence the attitudes of students toward writing by giving them a readership other than their teacher.

However, the school district would not allow students, even seniors, to have email accounts that they could use at school. So, that first semester, the teacher collected copies of his students' essays on *Beowulf* and emailed them to me along with questions from the students about how to improve their essays. The university students, upon seeing the level of work from the senior English students, expressed shock because they had expected lengthier papers with more coherence and mechanical correctness. We coached the university students on how to respond with a few model comments and some suggestions for the kinds of phrases that might be the most encouraging to their high school counterparts. For the most part, they replied to their high school counterparts with candor, specific advice, and a great deal of encouragement.

Since I was giving my students credit for responding to the high school students, they copied their messages to me. I was impressed by the detail of their advice and the comradeship they displayed toward their counterparts. They faithfully answered the sometimes vague questions that the students sent along with their essays, always included encouraging words, and often ended their messages with a friendly closing such as "Your NIU buddy."

The second semester of the exchange, we managed to streamline the process by having the teacher send the drafts directly to my teacher certification students. My students then sent their comments to him, and he distributed them to his students. Of course, everything was also copied to me so that I could help them with problem cases and give my students credit for their work. This time, we were able to get the paper assignment to show my students beforehand, so they knew approximately what to expect and how to coach the students to meet expectations. Because we had learned from our mistakes, the entire process ran a bit more smoothly, with better results from all involved. Unfortunately, late in the semester the teacher failed about half of the papers because of plagiarism.

We would have continued this exchange in following semesters, but other commitments interfered; therefore, it became part of NIU's Teaching of Writing classes in the upcoming academic year. At this point, we discovered a much more efficient method of having students from both groups share their work and comments online. As mentioned above, the NIU English Department uses commercial software called WebBoard to give all English classes online discussion spaces. Luckily, even with Bess protective software filtering connections, students at the participating secondary school could access our WebBoards, so it was easy to create a new WebBoard solely for the exchange.

This plan required the NIU students to ask the teacher questions and him to provide a rubric for evaluating his students' work along with the assignment itself. Because the class was for more advanced teacher certification students and focused on the teaching of writing (not just advanced writing itself), we expected that the responses to the students would be both helpful and detailed. However, for several reasons, including the fact that the students did not have time to evaluate such long drafts of research papers and the fact that the high school and college semester schedules did not mesh very well, the results were mixed.

The secondary school students appreciated the feedback, but the less accomplished writers had difficulty following the advice because they did not always understand the concepts and terminology used by my students. Still, many students did revise according to the comments sent to them, thus improving their papers. But most importantly, they received *attention* to their writing from helpers far removed from the immediate context of their educational setting.

We would like to expand these exchanges to other high schools and other teacher certification programs, and we have had at least a dozen inquiries from high school teachers who would like to have outside readers for their students' work. The problem is in finding certification faculty who can find time for such activities. We plan to regroup and explore this possibility with the director of the University Writing Center.

Who Learned What?

The past few years have filled me with memories of moments when learning was palpable: teachers were going to be able to *use* what they learned in our workshops and maybe even apply it in their own teaching. But even if they never use some of the software and hardware solutions we introduced them to, they are informed and more critical users of the various computer and Internet technologies for writing and communication. They will be able to help their students think about best practices for using computers, and they will reach out on the Internet to other teachers of language arts. In the end, changing attitudes about the possibilities of connecting with others through technology is the best we can expect from workshops like these.

The experience of working with the teachers has changed me in important ways. The workshops enabled my colleagues and me to put aside the assumptions about *who secondary school teachers were* and *what would concern them*. Instead, we could *listen* to their actual concerns and aspirations. The initiative provided for extended time and space for dialogue to take place among the teachers and professors, so that if we listened to each other well enough, we could develop activities that would be of value to our students and address difficult problems (often related to discipline and motivation among the secondary students) in a creative, collaborative manner.

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28. Technological Advances in English / Communication

Kerri Shaw

I was asked to present a workshop about recent technological advances in the English and communications field. With the head of Rock Valley College's (RVC) drama program, we developed "Literary Technologies: From Invention to Publication." We wanted to provide a very basic introduction to the wide variety of Internet and database resources available to English and communication teachers today.

The workshop presented in one of RVC's computer labs used a hands-on approach to introduce Rockford teachers to resources available in the fields of composition, literature, and drama. We began by discussing the technological resources available to composition teachers, starting with online writing labs (OWLs). These websites are created and maintained by university writing programs as aids to their own students, but also offer valuable resources to students and composition and literature teachers in general. The Purdue University OWL, in particular, offers a wide variety of resources for teachers, from a database of printer-friendly handouts and writing assignments to downloadable PowerPoint presentations on a wide range of grammatical and mechanical issues. Workshop participants were pleased to discover these resources, and a number of them planned to make use of them in the classroom.

We went on to examine sites useful for researching literary texts, with a special emphasis on drama. We followed with a discussion of plagiarism issues, a tour of plagiarism-detection sites, and finally copyright law. Participants were shown a number of the sites at which students can purchase plagiarized papers and then were introduced to online resources, such as Turnitin.com, that are designed to help instructors identify plagiarized work and locate the original sources. We ended with a discussion of the plagiarism and copyright issues facing drama teachers and a demonstration of Web resources. Many participants commented that they had not been aware of the resources demonstrated in the workshop; several were enthusiastic about the OWL sites we demonstrated.

I presented a similar workshop (without the drama emphasis) the following year. Because we had more time, participants could explore individual resources. They were able to access research materials on some of the authors and texts they were currently teaching and identify specific resources for use with future classroom projects. Several brought disks and downloaded entire PowerPoint presentations on grammar and mechanics issues from the OWL sites. Second-year participants were even more enthusiastic about the plagiarism detection resources and used our expanded session time to formulate specific plans for using them in the classroom.

Articulation

My second project experience came as part of the articulation roundtable in Fall 2002. After presentations by industry representatives about the qualities and skills they look for in new employees, we broke into discipline-specific groups to discuss the ways in which our various curricula met those needs. Our group included middle school, high school, and community college instructors.

We began our discussion by identifying institutional overlaps, gaps, and areas of difficulty. Although we discovered a great deal of overlap, particularly in the basic skills to be mastered, we also discovered fairly large gaps between curriculum expectations and student performance. Lack of time, resources, and student and parent commitment were all cited as problems leading to poor student performance and articulation difficulties. We discussed assessment techniques and strategies and the differences in our expectations for student performance at the middle school, high school, and community college levels.

This was a jointly led program. We at RVC and a university English professor shared not just program and course descriptions but also sample syllabi, course assignments, and student papers. Finally, we discussed the availability and use of technology in our various programs. Our main finding was that Rockford teachers lacked the resources to provide students with the technological experience and training they need in community college and university courses.

Overlaps

At all three levels (middle school, high school, and community college), instructors felt they spent an inordinate amount of time covering material with which students should already have been familiar. Almost all of the instructors expressed frustration at students' failure to learn and retain basic skills and with the amount of classroom time they were forced to devote to them. We identified potentially problematic results of these instructional overlaps, including the following:

- Because they spend so much time re-teaching basic skills, teachers cannot adequately cover more advanced materials.
- Because students do not receive adequate exposure to advanced or course-specific materials, they are unprepared in later courses.
- Because courses contain so much repetitive information, students may become frustrated and bored. Even students whose grasp of the material is less secure quickly lose sight of the larger purpose of lessons.

Gaps

Participants identified a gap between curriculum expectations and student performance. Written curriculum descriptions project a smooth transition from one level of English and communications study to another, but in our classrooms we see something very different. Students experience difficulties (sometimes severe) moving from one curriculum level to the next, and the vast majority are under-prepared to meet course expectations. In addition to the time constraints created by the curriculum overlaps noted above, we found other causes for gaps, including the following:

- Teachers lack basic classroom resources, such as textbooks and photocopying supplies, and are unable to present appropriate materials and assignments. They cannot ask students to read an assignment at home, for example, if there are not enough textbooks to go around. Class time that should have been used for discussion of the assignment must be sacrificed to provide students time to read the assigned material. Teachers may find themselves spending weeks on an assignment that should take days.

- Students and parents lack commitment to the subject matter and the educational process, leaving teachers with few allies inside or outside the classroom. Students often fail to put the necessary effort into their work, and when parents fail to support the teacher and the course goals, the problem is compounded.
- A mismatch between the kinds of assessment techniques and strategies used at the various curriculum levels tends to compound these problems. At the community college and university levels, writing assignments are the primary vehicles of student assessment, and credit is seldom given for attendance, homework, or participation – all of which tend to count heavily in both high school and middle school assessment practices. Time, resource, and motivation difficulties hinder high school and middle school teachers from providing adequate or appropriate writing opportunities for students, who may be unprepared to enter community college and university courses.

Areas of Difficulty

One area of particular concern to all participants was the integration of technology into the classroom. Students are expected to have mastered basic computer skills *before* most university and community college courses even begin, but most middle and high school teachers are unable to teach these skills. Participants cited various reasons for this inability:

- Limited or restricted on-campus access to computers was the most basic difficulty. Some schools in Rockford have computer labs, but access is limited, and there is little or no provision for administering English instruction in them.
- Limited or severely restricted Internet access was another basic difficulty. Administrative concerns that students might use the Internet inappropriately have led many schools to limit student access; others simply forbid its use.
- Inadequate technical support was another limiting factor. Technical problems frequently prevent the effective use of equipment, and repairs or upgrades are rare.
- Limited off-campus access to computers and the Internet was also cited as a major instructional impediment. Many students do not have computers at home, and assignments that require off-campus computer use are particularly burdensome.
- Teachers lack the time in class to help students become technologically proficient.

Conclusion

My experiences with the Rockford teachers were interesting and informative, but also a bit daunting. The teachers face severe problems, difficult to resolve, yet all of those with whom I spoke were committed to solving them and giving students good teaching and learning experiences. I learned to understand the sources of many problems I face with my own students – their weak grammatical and mechanical skills, poor work and study habits, and lack of motivation.

29. Green Chemistry

Dennis N. Kevill

What is "Green Chemistry"? Simply put, it is an eye-catching name for environmental chemistry. The concept of using environmentally friendly materials has become a major consideration in both consumer and industrial production. However, to fit into this category not only the end product but the process used to produce it must be "green." Much research is being carried out with the aim of developing environmentally friendly processes that minimize the use of energy and the production of toxic side products (wastes). Especially beneficial is when a process can be developed that minimizes waste because the side products also have uses.

Needless to say, the concept of green chemistry has been abused. We can probably all point to commercials that would be laughable, except that since they are repeated on a regular basis, it appears they must be commercially successful. A common approach to salesmanship based on the green phenomenon is to describe something as "all natural – contains no chemicals." Strictly speaking, of course, this statement is only true in reference to a vacuum.

Most aspects of green are positive, such as the establishment of the federal Environmental Protection Agency (EPA), which sets maximum limits for exposure to or release of a wide range of common pollutants, and the Superfund, for cleaning and restoring previously unsupervised (and often undocumented) toxic waste sites. Also notable are the removal of asbestos from schools and other buildings and the proliferating emission controls for automobiles and other modes of transportation.

A full consideration of any situation where green chemistry applies involves not only the chemistry itself but also a biological assessment of the extent of risk involved for various levels of pollutants to humans (where medical considerations are also involved) and to all other forms of life. This, in turn, involves the use of mathematical models and a statistical assessment of risk factors. Further, a critical evaluation of reports from the EPA or local authorities regarding environmental protection requires the ability to read technical documents and, if input is desired, to write to legislators and officials. Also, the ability to dissect questionable claims based on green considerations is a requirement for being an informed consumer. A workshop on green chemistry would therefore benefit from input by representatives from biology, mathematics, and English composition.

In late 2001, the American Chemical Society (ACS) publication, *Journal of Chemical Education*, began an ongoing series entitled "Topics from Green Chemistry." This series is edited by the assistant director of the Green Chemistry Institute of the ACS. The initial article defined green chemistry as "pollution prevention at the most fundamental level of atoms and molecules" (Kirchhoff, 2001, p. 1577). In practical terms, the institute promotes the practicing of chemistry in an environmentally responsible manner and has developed "The Twelve Principles of Green Chemistry" (Anastas & Warner, 1998; Hjeresen, Schutt & Boese, 2000; Ritter, 2001).

The idea of incorporating a green chemistry component into the NSF–Rockford Schools program arose after listening to organizational presentations in September and October 2000. It was not a major component of my teaching or research activities, but I had recently read a couple of environmental chemistry books (Baird, 1999; Spiro & Stigliani, 2003) intended as texts for upper-level undergraduate special-topics courses and had attended two green chemistry symposia at National Meetings of the ACS.

Initially the workshop was planned only for one day, with contributions from chemistry, biochemistry, and biology. After further discussions, we decided to develop a two-day workshop, and subsequently we added contributions from English and mathematics. On each day, the teachers received an overview of aspects of environmental problems, the biological implications of those problems, ways in which mathematical modeling can be applied, the interpretation of technical reports, and techniques for persuading local, state, and federal authorities to take action to alleviate pollution and punish polluters. It is important to note that when working with the university during class time, one may run into difficulty scheduling laboratories and classrooms; however, it is important to note that Northern Illinois University's Department of Chemistry and Biochemistry were willing to make accommodations.

Organization of the Agenda

After the broad outline for the workshop had been established (two days with participants from biology, mathematics, and English, as well as chemistry and biochemistry), the university faculty met to establish an agenda for the first day with suggestions for the second day. We deliberately did not finalize the program for the second day to allow input from the teachers after the end of the first day. I developed an agenda that was then circulated to the others for comments. The idea for the first day was to place an emphasis on waste management and water pollution, with air and soil pollution to be emphasized on the second day.

Handouts for Participants

At the beginning of the presentation, each participant received two handouts. One consisted of copies of the projections used during the talk, and the other was a collection of items from recent issues of the *Journal of Chemical Education*. The first sheet appeared under the heading "Green Chemistry – Innovations for a Cleaner World" (Kirchhoff, 2001). The next article described a high school project incorporating fieldwork and showing an approach integrating high school chemistry with environmental studies. The linking study involved the analysis of water removed from a brook joining two lakes near a high school in northern Michigan (Randall, 1997). This was followed by a report from the secondary school section of the journal outlining a joint U.S.–Mexico program concerning water pollution in the two countries. The article described high school activities for the analysis of lead, atrazine (a water-soluble herbicide), and nitrate content (Kelter, Grundman, Hage, Carr & Castro-Acuña, 1997).

A fairly brief article (Judd, 2001) discussed online sources for information about mercury in the environment, ending with a listing of Web addresses. These were useful in the context of the contribution from English, which involved the use of websites to gain information for developing political and social arguments for environmental protection. The theme was primarily how mercury enters aquatic ecosystems, especially lakes, and then the food chain.

In looking for experiments suitable for middle and high school students that the teachers could perform during the workshop, I surveyed the "JCE Classroom Activity" sections that appear in the *Journal of Chemical Education* several times per year. Three were chosen for this activity on the first day. Since laboratory work was not possible on the second day (no laboratory being available) and since two of the three additional experiments selected would require a series of days to complete, instructions for these three experiments were included in the handouts. One concerned acid rain and the environment's acidity and buffering capacity (Halstead, 1997). A companion experiment dealt with acid snow and would have required experimentation over two to three days (Halstead, 1998). A third experiment, requiring a day or more for the recycled paper fibers to dry, involved modeling of the process involved in recycling newspapers (Gettys & Jacobsen, 2001), a good project related to waste management. The classroom activities section of the *Journal of Chemical Education* always contains the statement "This Classroom Activity may be reproduced for use in the subscriber's classroom," and photocopies of the published activities constituted additional handouts.

Activities

The English representative briefly introduced the program and stressed the importance of political and social issues connected with combating pollution and the need for an informed public. This presentation was followed by my own, outlining the relationship between pollution and population growth, the 12 principles of green chemistry (Anastas & Warner, 1998; Hjeresen et al., 2000; Ritter, 2001), the major types of pollution, the chemistry of the formation and precipitation of acid rain, and a review of the principles behind the experiments to be carried out in the afternoon. Then the biology professor discussed water pollution from a biological standpoint, and two mathematics professors showed how patterns of water pollution relate mathematically to the sources of the pollution. One presented to middle school teachers and the other to high school teachers.

The participants spent time in the laboratory, working through three experiments. The initial "Cartesian Diver" experiment (Pinkerton, 2001) showed that increased pressure (squeezing) increases the volume of water in a barely floating dropper in a capped bottle filled to the top with water. This increases the average density of the dropper above that of the water and it sinks to the bottom of the bottle. When the pressure is removed, the situation reverses itself and the dropper rises to the top. This experiment is inexpensive, uses harmless materials, and is suitable for students at any class or ability level.

The second experiment involved using zeolites as environmentally friendly water softening agents ("Cleaning Up with Chemistry," 1999). This experiment had been well checked beforehand. It was the one I chose to incorporate into the module that I prepared and presented to five streams of a gifted eighth-grade class at West Middle School in Rockford. The students seemed to enjoy it and learn from it, and the teacher has continued to use it. Only a few of the teachers present had previously carried out the experiment. The major problem with this experiment was to convince the experimenters that one *very* small drop of liquid dishwashing soap really meant *very* small. If one used more, only a portion was neutralized by the hardness of the water and the excess gave a false positive with regards to the action of the soap in the blank (no zeolite) sample.

The third experiment was very appropriate for a program emphasizing water pollution. The morning presentations had outlined the formation and precipitation of acid rain and its biological consequences. The experiment simulated acid rain falling into lakes by adding vinegar to bowls of water, one of which also contained chalk (calcium carbonate) (Gettys & Jacobsen, 2003). Lakes where the water is in contact with chalk (limestone) are capable of neutralizing the acid. In the published procedure, the acid was monitored by an acid-base indicator prepared from red cabbage. Due to time restraints, we substituted a commercial indicator.

After leaving the laboratory, the program moved to the undergraduate computer laboratory. The session focused on the importance of political action to protect the environment, coupled with the need to provide information validating the points one wants to make. The program ended with a required exit evaluation by the teachers.

Participants learned about using websites to obtain a balanced view of a current issue. A handout outlined the uses and sources of energy, with a chart showing per-capita energy consumption for various countries; the United States ranked second, marginally behind Canada. It was then shown how the principal sources of energy had dramatically changed in the United States, with 91 percent from wood burning in 1850, 71 percent from coal burning in 1900, and about 40 percent from oil and 24 percent each from natural gas and coal in 1990. The presentation cited the relevance of these figures to the severity of pollution, outlined the extent to which the energy content of different fuels was usefully employed, including losses in transmission, the energy consumption of appliances, and the processes used to refine crude petroleum. We also mentioned alternative fuels for automobiles − in response to a request from a teacher. Participants discussed global warning, the greenhouse effect, and ozone-layer depletion, followed by the effects of smog and the constituent oxides of carbon, sulfur, and nitrogen on animals and plants.

The mathematics contribution was originally planned as involving a half-hour presentation, by an undergraduate mathematics major, about an internship he had held the previous summer at a federal government laboratory. This was to be followed by separate presentations to middle school and high school teachers, as on the first day of the workshop. However, when he was developing his presentation, it became clear that a meaningful and understandable presentation would benefit from a longer time period. We agreed to give him the full time assigned to mathematics.

His theme was how mathematics can be applied to atmospheric sciences (meteorology) and concentrated on aspects of vertical air motion, a topic that he had studied in his internship. Air motion is influenced by many factors, but primarily by gravity, friction, pressure differences, types of terrain, changes in elevation, and land use. Mountains can have a profound influence on the weather around them. Studies of the vertical motion of air are important in weather forecasting, especially for consideration of thunderstorms and other types of severe weather. Another factor involving the vertical motion of air is the formation of smog, which occurs when an inversion of temperature hinders the vertical motion of the smog constituents. Smogs are especially severe in mountain valleys (Los Angeles, Mexico City, etc.), where lateral motion is also hindered. The presentation led to a lively discussion.

The final topics in the workshop highlighted soil pollution, which had not received appreciable attention earlier. The origin and extent of hazardous waste sites were discussed, including the economics of cleanup and details of the federal Superfund program. The common contaminants and types of hazardous wastes were discussed, followed by domestic garbage and landfills. Finally, we presented the four “R’s” of waste management: Reduce (amount of material used), Reuse (materials once formulated), Recycle (materials by re-fabricating components), and Recover (energy content if materials cannot be reused or recycled).

Relevance to Illinois Learning Standards

The Illinois State Board of Education adopted learning standards in 1997, which had been formulated by its Standards and Assessment Division. Our workshops were relevant to at least four of the seven recognized learning areas. Concentrating only on those areas where there was a clear and important relationship to the standards, I will consider first the science goals, listed as 11–13 within the standards. The overall goal 12 is to “understand the fundamental concepts, principles and interconnections of the life, physical, and earth/space sciences.” The second workshop was especially well-connected to part B, “Know and apply concepts that describe how living things interact with each other and with their environment.” In each case (such as 12B), there are then lists of what the students should be able to do after early elementary, late elementary, middle/junior high school, early high school, and late high school levels. The workshop concentrated on middle and high school, and items covered during the workshop would be relevant at all three of those levels. Also relevant is goal 12C, “Know and apply concepts that describe properties of matter and energy and the interactions between them.” Energy considerations, such as generation of energy in environmentally friendly ways and minimizing energy usage, were an important component of the workshop.

The workshop was especially relevant to two of the six learning standards (subgoals) listed under 12. The learning standard 12E is “Know and apply concepts that describe the features and processes of the Earth and its resources.” Relating to this learning standard at the different levels, everything mentioned under middle school is directly relevant to topics discussed in the workshop. Benchmark 12.E.3a analyzes and explains the large-scale dynamic forces influencing land, water, and atmospheric systems; benchmark 12.E.3b involves description of interactions between organisms and earth, oceans, and atmosphere that cause changes such as erosion and El Niño/La Niña; benchmark 12.E.3c evaluates the biodegradability of renewable and nonrenewable natural resources (directly related to the consideration of landfills). In benchmark 12.E.4a (early high school), the consideration of how external and internal energy sources drive weather patterns is closely related to the discussion of weather forecasting. For late high school (benchmark 12.E.5), the analysis of the processes involved in short-term and long-term events was the basis for the mathematics presentation to high school teachers on the first day of the workshop.

It might at first seem strange that a representative from the English Department would participate in a green chemistry workshop. The descriptions given in the discussion of activities for the English representative’s introduction to Web-based activities and the consideration of how to evaluate commercial claims made for products and services show that his presentations related not only to the English standards but also to important sections of the science goal 13: “Understand the relationship among science, technology, and society in historical and contemporary contexts.” This goal was divided into two learning standards, the second of which is described as “Know and apply concepts that describe the interaction between science, technology and society.” Among the benchmarks for middle school and high school are: 13.B.3e, “Identify advantages and disadvantages of natural resource conservation and management programs”; 13.B.3f, “Apply classroom-developed criteria to determine the effects of policies on local science and technology issues” (e.g., energy consumption, landfills, water quality); 13.B.4d, “Analyze local examples of resource use, technology use, or conservation programs; document findings; and make recommendations for improvements”; 13.B.4e, “Evaluate claims derived from purported scientific studies used in advertising and marketing strategies”; and 13.B.5e, “Assess how scientific and technological progress has affected other fields of study, careers and job markets and aspects of everyday life.” A teacher seeking to present these topics would benefit from having attended our presentation.

The mathematics presentations were relevant to aspects of the learning standards for mathematics (Goals 6–10). The discussion of graphs as an aid in predicting weather patterns was consistent with benchmark 8.D.3a, “Solve problems using numeric, graphic, or symbolic representations of variables, expressions, equations, and inequalities.” Similarly, the general learning standards B and C, under goal 10 were involved in most of the mathematics presentations. Standard 10B states, “Formulate questions, design data collection methods, gather and analyze data and communicate findings,” and standard 10C states, “Determine, describe and apply the probabilities of events” – exactly what was involved in the treatments of the mathematics of predicting future weather patterns and population growth, the latter being very relevant to pollution issues and destruction of natural resources.

There was also a tie-in with aspects of the English/language arts goals (1–5). The aim of Goal 5 is to “Use the language arts to acquire, assess and communicate information.” The three learning standards (subgroups) are:

A. Locate, organize, and use information from various sources to answer questions, solve problems, and communicate ideas.
B. Analyze and evaluate information acquired from various sources.
C. Apply acquired information, concepts, and ideas to communicate in a variety of formats.

Our presentations and the participants’ work at the computers directly involved A and B, with environmental issues as a specific example. Also, the teachers were given advice as to how the treatment of the information obtained could be presented in the context of learning standard 5C.

Aspects of the workshop were relevant to some of the social science goals (14–18). Goal 15 states, “Understand economic systems, with an emphasis on the United States.” Environmental issues have economic consequences, and this was a theme throughout the workshop. The early high school benchmark 15.E.4b is “Describe social and environmental benefits and consequences of production and consumption.” Standard 16E also involves environmental history: “Understand Illinois, United States, and world environmental history.” For example, the workshop’s consideration of the history of energy sources and their dramatic changes over the last 150 years would be highly relevant. Standard 17B was also addressed: “Analyze and explain characteristics and interactions of the Earth’s physical systems.” Especially relevant was benchmark 17.B.3a, “Explain how physical processes including climate, plate tectonics, erosion, soil formation, water cycle and circulation patterns in the ocean shape patterns in the environment and influence availability and quality of natural resources."

Exit Evaluations

At the end of each of the two days, the teachers completed exit evaluations. The evaluation sheet asked five questions to be marked on a Likert scale ranging from "strongly agree" (5) to "strongly disagree" (1). There were also three questions allowing for written comments. The five scaled questions were:

1) This activity increased my knowledge and skills in my areas of certification, endorsement, or teaching assignment.
2) The relevance of this activity to ISBE teaching standards was clear.
3) It was clear that the activity was presented by persons with education and experience in the subject matter.
4) The material was presented in an organized, easily understood manner.
5) This activity included discussion, critique, or application of what was presented, observed, learned, or demonstrated.

For both days, all participants marked "strongly agree" for each of the five questions. Clearly, they were happy with the content, organization, and presentation. Every evaluation form had something written in the section asking about the best features of the activity, but considerably fewer participants offered suggestions for improvement or other comments and reactions. The teachers very much appreciated being able to go to the laboratory and work through the experiments that they would take back to the classroom. Written comments strongly indicated that the workshops should have an appreciable hands-on component so as to maintain interest.

Conclusion

While the workshops were a resounding success, they can be improved. I would like to extend them to three days and complement lectures with hands-on opportunities for the teachers to do experiments suitable for middle and high school students. The second-day presentation by the undergraduate student, about his internship, was a great success and suggests we should try other less traditional presentations. We might also devote some time to safety in the laboratory (Webber, 2002). Perhaps the university's safety officer could present. Many of the safety features to be observed in university laboratories would apply equally in secondary school laboratories.

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30. Navigation

Paul R. Stoddard, Augden Windelborn, Richard Blecksmith & David Rusin

Rationale and Motivation

Physics and geology faculty at Northern Illinois University (NIU) began to explore possible ways to run joint interdisciplinary workshops in the second year of our participation because (1) Rockford has only four high schools, and also only four physics teachers; (2) earth science is offered only at the middle school level; (3) one of the initiative goals was interdisciplinary curricular, and (4) we viewed the initiative as an excellent opportunity to bridge the gap between middle and high school and the university. The first joint workshop covered basic astronomy and planetary geology. The multidisciplinary approach worked well, and so it was decided to include mathematics and change the emphasis from astronomy to navigation, a field that could incorporate all three disciplines. Involvement in teacher certification and undergraduate general education had made us aware of the weaknesses of incoming freshman in mathematics, English, and science. Our work with the Rockford teachers helped us identify potential sources of those weaknesses. One of us, for example, was quite surprised during a classroom visit to find the level of material being presented to eighth graders regarding plate tectonics. Perusal of a ninth-grade astronomy exam revealed a much greater level of desired achievement than the teachers were aware of. Many of the questions and concepts were similar to those covered in undergraduate general education courses. The problem, therefore, was not in the K-12 curriculum itself but in a “use it or lose it” sense. That is, even though students have been exposed to the appropriate material, they lose their mastery through lack of using it. The eighth grader who was well versed in tectonics will have forgotten much of the information five years later in college. The problem is even more serious in mathematics and English.

Workshop

The multidisciplinary approach that we employed for the workshop is good for addressing the problem of lost mastery. If we could exercise a student’s knowledge in different areas, we could strengthen it and even expand it. The daylong workshop included lecture, question-and-answer, and activity sessions. We covered the history of navigation techniques, mathematical principles of navigation, astronomical navigation, historical development of the zodiac, and planetary spatial relationships.

We devoted the morning session to mathematical principles of navigation and cartography, complementing a lecture with group exercises using mathematics to solve problems. The three forms of geometry were discussed, with emphasis on spherical geometry. The afternoon session started with a question-and-answer period, followed by a demonstration of the origin of the zodiacal constellations. We used cards with the constellations, a globe, and an overhead projector as a light source to demonstrate the position of Earth and sun during various times of the year, relative to the 12 zodiac signs. We also took this opportunity to demonstrate how precession of the Earth's spin axis has changed the timing of the zodiac in recent millennia. We then divided participants for the final two activities – the mobile planetarium (SkyLab) and the Web-based Animated Virtual Planetarium (AVP) simulations. The SkyLab is an inflatable dome, approximately 10 feet in diameter, with a star projector inside. Modules allow for different demonstrations of star positions throughout the year and over long periods of time. It is inflatable, mobile, and can be loaned to individual schools.

The AVP is a series of Web-based, interactive planetary and astronomical simulations developed by one of us for use in a general education course. These can be found at jove.geol.niu.edu/faculty/stoddard/planetarium.html. Among the simulations, "The World's Horizon" can display the sky at any point in time from any point on the Earth's surface. By changing time and viewing location, the user can see how the star patterns change and how they can be used as a navigational aid. Teachers were instructed in its use and were invited to explore other simulations (cometary orbits, a comparison of the Ptolemaic, Copernican, and Tychoan models). In addition, we introduced participants to a Web page mounted for this workshop that includes many resources for middle and high school teachers.

Assessment

We asked each participant to complete a generic workshop evaluation. The results are summarized in Table 1.

Table 30.1 Evaluation Results Summary

	Strongly Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Strongly Disagree
Increased Knowledge & Skills	10	1 (a.m.) 2 (p.m.)	0	2	1 (a.m.) 0 (p.m.)
Relevant to Standards	8	3 (a.m.) 4 (p.m.)	1	1	1 (a.m.) 0 (p.m.)
Experienced Presenters	13	1 (a.m.) 0 (p.m.)	0	0	1 (am) 0 (p.m.)
Material Organized	9	3 (a.m.) 5 (p.m.)	0	0	2 (a.m.) 0 (p.m.)
Ample Discussion, Activities	8	2 (a.m.) 3 (p.m.)	0	0	1 (a.m.) 0 (p.m.)

The strongest points of the workshop, based on teacher comments, were the mobile planetarium, with the website a respectable second. One of the few improvement suggestions was to deliver the mathematics portion of the workshop at a lower level more appropriate to middle and high school students. Most participants felt the workshop increased their knowledge, one of our primary goals, and that it related to the state and NCATE standards.

Conclusions and Recommendations

The school teachers gained in concepts, activities, and materials that could be directly used in the classroom, while the university faculty gained an understanding of the problems and concerns of the teachers, and both felt that they developed relationships that may continue beyond the initiative. Further, teachers and faculty together agreed that their respective teaching approaches would become more interdisciplinary and integrated in nature. A secondary benefit is that by improving the level of understanding among the teachers, we may see improved freshman classes in the future. Upon reflection, we also found that more time for informal discussions between the different faculty and teachers would have been of great benefit.

31. Role of School Counselors in Emphasizing Science, Mathematics, and Technology across the Curriculum

Toni R. Tollerud

When did you decide what you were going to be when you grew up? Take a minute and ponder your own growth and development. Think about the path you took to where you are today. How did you come to be who you are professionally? Where did your dream start – elementary, middle school, high school, or college?

Take this one step further and consider *who* most influenced or assisted you at the start of your journey. The most influential people in children's career choices are parents, but who else assisted you in that decision? A teacher? A friend? A mentor? A school counselor? What factors during your school years may have helped in learning about careers and provided important information in the many decisions leading to where you are today? Did your classroom teacher link what was being taught to careers related to the field? Did guest speakers from the workforce come into classes and help you see the relevancy of what you were being taught? Were you encouraged to go to worksites as a student and observe others engaged in your career of choice? Did your school counselor actively discuss potential career options with you as you selected courses or picked a college? Did your school counselor offer other options in addition to a four-year college degree that might lead you to a prosperous and innovative career?

Sadly, most will probably not identify their school counselor in this picture. Research suggests that school counselors traditionally have not been the helpers in career education that many once thought they would be. In a study of high school graduates conducted by the American Association of University Women (1999), participants affirmed that school counselors often miss prime opportunities to assist students in career development and college transition issues. In part, this lack of help or direction might be accounted for by high counselor/student ratios that inhibit counselors from meeting with students while planning career choices (American School Counselor Association, 2004). However, participants in the AAUW study reported not feeling positively supported, even during one-on-one sessions with their school counselors: "Significantly more students with 'below average grades' feel that guidance counselors did not give them enough time or attention. This response is especially prevalent among men with below average grades, who may not conform to a counselor's image of 'college material'" (p. 54). Additionally, high school graduates in the study reported being more likely to hear what they could not do from their counselors because of poor grades or lack of proven academic strength. In contrast, these same students reported having been more interested in learning ways that might enable them to achieve educational goals, whether or not those goals happened immediately after graduation. Clearly, school counselors must address their rigid and academically based opinions to facilitate student growth and provide additional options, even when students have not performed to standards of the educational system.

Herring (1998) has supported a role for school counselors as agents of change, suggesting that they influence students at both individual and institutional levels. Counselors work with individual students to broaden career choice and address internal barriers like gender, ethnicity, and age that could potentially limit vocational options. At an institutional level, school counselors work with parents, teachers, and business leaders to provide optimal choices without the limitations of stereotyping.

The opportunity for all students in a school system to develop to their fullest potential and use education to engage in meaningful work is vitally important. However, if this is to be successful, school counselors must play a critical role in student academic and career success, especially in science, mathematics, and technology. A discussion of how the counselor's role can be enhanced to achieve this goal is presented below.

Historical Background

School counselors have long been affiliated with career development and helping students enter careers. Examples of students receiving guidance to make meaningful vocational choices have been noted since the 1800s. In 1908, Frank Parsons established "vocational guidance" as a way to address the social, economic, and educational problems of helping young people find work (Gysbers, 2001; Herring, 1998). Simultaneously, the U.S. Bureau of Education was concerned with bolstering schools to help students find purpose for their education and meaningful employment. Industrialization and the movement of migrant workers to the city also meant people needed to be better prepared for the workplace. Gysbers (2001) has remarked, "Social concerns emphasized the need for changing school methods and organization as well as exerting more control over conditions of labor in child-employing industries" (p. 97).

In response to government concern as well as social and economic factors, Parsons (1909) published *Choosing a Vocation* and presented a *trait-factor theory* he believed would lead to career success. This model consists of (a) studying the individual, (b) studying the occupations available, and then (c) matching the individual to the occupation. Herr and Cramer (2003) note that these factors still provide a foundation for career counseling. During the past hundred years, extensive research and analysis have continued to explore developmental aspects of individual differences, occupational information and resources, and career decision-making based on Parsons' original work.

Early in the 20th century, counseling shifted to an emphasis on the academic aspects of guidance, such as learning and intellectual development, that overshadowed vocational education. This was followed in the 1920s by increased attention to personal and educational development (Gysbers, 2001). Referring to this era, Johnson (1972) describes careers as shifting from a systemic perspective to one in which "vocational socialization problems were reinterpreted as educational and psychological problems of personal adjustment" (p. 221). Vocational education became narrowly defined within the boundaries of selecting an occupation and was limited to preparing, entering, and progressing through that career until retirement.

During the years following Parsons' introduction of the trait-factor model, vocational guidance became limited to career choice based upon test scores and training. However, in 1946, the federal Vocational Education Act provided funding for state supervision of guidance and vocational counselors in schools to meet massive workforce changes resulting from the end of

World War II (Gysbers, 2001). Shortly thereafter, Super (1949, 1957) blended psychotherapeutic techniques with vocational choice, renaming vocational education as "developmental career guidance." The developmental approach encouraged the notion that a person's "self-understanding" was equivalent to occupational understanding and the mastering of tasks (Herring, 1998). This revitalized the vocational movement by advancing the emphasis on engaging students in career decision-making as the primary function of school counselors.

Additionally, the Soviet Union's success with Sputnik in 1957 had a tremendous impact on school counseling. In 1958, the National Defense Education Act (NDEA) called upon school counselors to respond to emerging national concerns. Congress asked school counselors to identify the best and brightest students in high school and direct them toward college majors that would lead to careers in mathematics and science. The surging need for college preparation and meaningful career direction gave emphasis to the term "career guidance," which has replaced vocational guidance in professional literature (Herr & Cramer, 2003).

In the 1980s and 1990s, career guidance was assimilated into counseling models with a more comprehensive focus (Campbell & Dahir, 1997; Gysbers, 2001; Herring, 1998). School counselors struggled to claim a clear and concise definition of their role and function (Gysbers, 2001; Paisley & McMahon, 2001). Today's counselors, like those of a century ago, find themselves challenged by a mix of social problems, including substance abuse, gangs, and changing families. Their professional identity and roles involve dealing with societal economic issues, such as a changing labor force and the effects of globalization, as well as educational problems like school failure, increasing dropout rates, and lack of connection between courses and workplace skills.

Counselors also have been challenged legislatively by the federal Perkins Vocational Education Act of 1984, which has affected their role in helping students with career choices but seems riddled with changing and confusing definitions. For example, Gysbers (2001) notes that in the Perkins Act of 1990, "career guidance and counseling" was defined as a body of subject matter that included developmental components such as awareness, planning, decision-making, workplace skills, and trends. The Perkins Act of 1998, however, replaced these components with a single view of providing individuals with information, and more narrowly restricted the purpose of counseling. This view has not coincided with the developmental guidance models (American School Counselor Association, 2003; Gysbers & Henderson, 1997, 2000; Gysbers, Heppner & Johnston, 1998) or the National Standards (Campbell & Dahir, 1997) in terms of integrating guidance and counseling into the total educational system of a school.

A Present View

Since the 1980s, more school counselors have been using a comprehensive developmental model that focuses on three primary domains of growth and achievement: career, personal, and academic counseling. Professionals in most states have adopted comprehensive developmental models to address the needs of all students. From these models and in conjunction with the Educational Trust Foundation, the American School Counselor Association (ASCA) recently developed a *National Model for School Counseling Programs* (American School Counselor Association, 2003), compiled from the best practices of the various state models. The *National Model* also emerged from the *National Standards for School Counseling Programs* (Campbell &

Dahir, 1997). There are three standards for career development, reflecting recommendations made by the Secretary's Commission on Achieving Necessary Skills (U.S. Department of Labor, SCANS, 1991) and the National Career Development Guidelines (NOICC, 1989, as cited in Campbell & Dahir, 1997, p.24):

- *Standard A*: Students will acquire the skills to investigate the world of work in relation to knowledge of self and to make informed career decisions.
- *Standard B*: Students will employ strategies to achieve future career goals with success and satisfaction.
- *Standard C*: Students will understand the relationship between personal qualities, education, training, and the world of work.

The profession is moving toward a comprehensive developmental approach to working with all students in a school. The *National Standards* and subsequent *National Model for School Counseling Programs* call for these standards to be delivered by school counselors through individual and small-group counseling as well as classroom guidance. In individual counseling, school counselors work one-on-one with students to develop individual career plans (ICP) based on interests, aptitudes, and abilities, as well as the predicted job market for a given career. The ICP also guides the selection of classes that students take in preparing for the next level of training. In small-group counseling, counselors work on decision-making skills and strategies, focusing on matching career to interest to ability, again working within the framework of Parsons' trait-factor theory. In classroom or large-group guidance, counselors may work collaboratively with teachers to present developmental units related to the subject area being taught. In mathematics and science, for example, students may do a class research paper on a career related to the field. The classroom teacher may grade the paper on content and relevancy to class goals or content learning standards, while the school counselor and students discuss career possibilities. Follow-up may include job shadowing or internship opportunities through the school.

A growing body of research demonstrates the effectiveness of school counselors working on career development with students. For example, in a meta-analysis of 47 outcome-based studies conducted between 1983 and 1997, Whiston, Sexton, and Lasoff (1998) find that counselors are effective in assisting middle school children with career development, individual counseling being the most successful, followed by group counseling and classroom delivery. Similarly, Peterson, Long, and Billups (1999) note counselor-led career interventions improve the educational choices of eighth-grade students as they prepare for high school. Numerous other studies (e.g., Bearden, Spencer & Moracco, 1989; Morey, Miller, Fulton & Rosen, 1993; Schlossberg, Morris & Lieberman, 2001; Wirth-Bond, Coyne & Adams, 1991) present strong evidence that developmental units presented in classrooms have improved behavior and general attitudes toward school, while addressing developmental needs. These findings are consistent across levels of student achievement and prior attitudes about school. An approach that invites input from teachers, students, counselors, and administrators through needs assessments may maximize resources and services for both traditional and nontraditional students. Additional research (Lapan, Gysbers & Petroski, 2001; Lapan, Gysbers & Sun, 1997) suggests that such programming may help to overcome the generally chaotic and impersonal way school counseling services have often been delivered.

Keyword Collaboration: A Model for Career Development

Counselors must work collaboratively across the curriculum with other professionals to promote student development. Their role must become an integral part of the total educational system and not seem ancillary or extra. This is especially true in the area of career development. If career exploration, awareness, and decision-making are left *only* to counselors, the task is certain to fail. Therefore, it is critical that within the type of comprehensive developmental model discussed above classroom teachers and school counselors work together to address student career needs. In Illinois, for example, a four-phase model for career development has been recommended, consisting of awareness, exploration, orientation, and preparation. Table 1 links each phase to its appropriate grade level for implementation.

Table 31.1 Four-Phase Model for Career Development in Illinois Schools

PHASE	*GRADE LEVELS*
Awareness	K-5
Exploration	6-8
Orientation	9-10
Preparation	11-16

This model illustrates the comprehensive nature of career education and development by indicating its necessity and importance through all grade levels, as opposed to the more traditional implementation in high school alone.

The four-phase model used in Illinois schools can be made operational in two dimensions, breadth and depth, where the educational program works uniformly to promote career development. Table 2 identifies factors at each level that contribute to a successful career development program.

A model that has both depth and breadth enables the school system to build for career development. Classroom teachers and school counselors have complementary roles, achieving depth and breadth by considering career education and career counseling equitably. Career education activities are developed and accomplished through classroom teachers. Without career education, students would not have access to accurate and honest information about the world of work. If their only resources for making career decisions were observations of friends, relatives, and media-portrayed careers, students likely would not make good choices.

School professionals must be responsible for communicating with one another, across grade and discipline, about what they are doing in career education. Otherwise, unnecessary repetition could lead to student disinterest in the career program.

Table 31.2 Depth and Breadth of Comprehensive Career Education Programs

Breadth	• The school career program occurs by meeting a goal or objective at all grade levels, where learning builds upon itself. This makes the program comprehensive, systematic, and sequential. • Classroom teachers teach relevancy, so that students can see how their learning may address workplace skills and career interests. • Career development is intentional for *all* students at *every* grade level. • Everyone in the school system is working collaboratively toward the same goals for students.
Depth	• Every grade level has identified student objectives addressed within that grade. • Every grade level has developed and implemented activities that address student objectives in creative and meaningful ways. • Every grade level creates a way to evaluate what the student has learned and its helpfulness in the student's educational progress.

Career Education + Career Counseling = Career Development

Most career education occurs in classrooms and should be integrated across the curriculum. School counselors, classroom teachers, career specialists, parents, and community leaders all may play a role. After-school or enrichment programs also may enhance career education activities. In contrast, career guidance and counseling encompass activities led by professional counselors who are trained to work with students and parents in planning and decision making. This type of career counseling, however, is meaningless without student opportunities for awareness, exploration, and hands-on experience through classroom activities. Education and counseling must be combined for effective career development with students. Table 3 provides a few of the many examples of career education and counseling activities.

Table 31.3 Career Education and Career Counseling Examples

CAREER EDUCATION	*CAREER COUNSELING*
Classroom activities led by a teacher that are connected to learning standards	Individual or small-group sessions to discuss possible careers
Guest speakers from traditional and nontraditional careers	Postsecondary planning, including college, trade schools, apprenticeships
Research assignments and reports on careers of interest to students and related to the curriculum	Integrating career information into a meaningful packet, such as a career portfolio, to assist in planning
Career portfolio development	Working with student and parents
Computerized software programs used within classroom work	Crisis counseling about the future
In-school programs such as junior achievement and school store	Career and college decision making Advocating for lifelong learning
Community service activities done in a career area of interest	Visiting community workforce leaders and linking education with business

Application of a Model for Career Development

Promoting careers in science, mathematics, and technology easily fits into this model, but counselors must be willing to adopt the national standards and create a comprehensive developmental model that addresses the needs of all their students. Once career development is recognized as an educational domain and a model has been integrated across the curriculum, teachers and counselors have limitless opportunities to work with students. The following discussion suggests how to promote science, mathematics, and technology within the four-phase model of career development.

Phase one: Awareness

In phase one, school counselors and teachers establish goals or objectives that promote awareness in grades K-5 by assuring that science, mathematics, and technology careers are presented to students as a part of the educational curriculum. Note that promoting career awareness involves more than simply asking a few parents to come in and talk. Instead, educators seek out guest speakers from those fields who explain to students how learning science, mathematics, and computer skills can prepare them for a career. It is important that some of the classroom speakers are nontraditional workers to provide role models for girls because most workers in fields related to mathematics, science, engineering, and technology are men (Wiberg & Harris, 2001).

Blackhurst, Auger, and Wahl (2003) investigate elementary student perceptions about vocational preparation requirements. They find that by fifth grade, students understand the conceptual framework well enough to comprehend job requirements but poorly understand the need for college and training to attain these careers. This implies that fifth graders are at a critical point in their development and need to look at careers realistically. Career fairs, fieldtrips, nontraditional guest speakers, and other related activities are very important in the upper elementary grades. Mathematics and science teachers should take classes on trips to laboratories, engineering facilities, technology centers, and other science-related sites.

Phase two: Exploration

Middle school grades build upon career awareness from elementary school to promote exploration of careers in grades 6-8. Exploration may include student research about careers within assigned science units and guest speakers from less-known careers in science, mathematics, and technology, as well as trips to see workers performing daily tasks. For example, reading about marine biology and seeing related videos are great for introductory information, but students are much more excited by going to an aquarium and spending two hours with a working biologist.

It is especially important at the exploration level to introduce students to software such as Discover, Bridges, and Career Cruising, which offer valuable resources to explore career clusters while providing a wealth of explicit information on each career, ranging from salary possibilities to educational requirements. Students should also begin to explore information about themselves that will better inform them about career choices. Computerized career programs generally come with a variety of self-awareness components, including interest inventories, aptitude surveys, and labor information regarding availability of jobs.

One middle school teacher divided the curriculum into units, including weather, machines, health, and space. Students selected a career related to each unit, researched that career, and put the information into a poster. They presented and hung their posters in the classroom. In another middle school, seventh-grade mathematics classes competed to identify the most careers related to sports. Classes submitted their lists to a panel of judges, and the class that identified the most occupations won a pizza party. The teachers invited a school counselor to listen to the students' information as well as offer additional resources and guidance.

Career development is also important to emphasize because students at this age begin to select their high school courses. Counselors have a unique responsibility to assist them in choosing challenging courses, including advanced mathematics and science. State graduation requirements now emphasize three to four years of mathematics and science. School counselors are much better able to recommend advanced mathematics, science, and technology courses to prepare students who have already begun to explore their career interests and want to prepare for college and career possibilities. Nevertheless, counselors working with middle school students during their transitional planning session to prepare for high school must be aware of potential pitfalls:

Pitfall 1. Students need to know the importance of advanced mathematics and science courses. Many think that if they take the minimum course requirements they have optimal choices in careers. Four years of advanced coursework in mathematics and science are essential to enter some technical careers. A handout adapted from *Career Select*, by the Women's Bureau of the Ontario Ministry of Labour (1982), suggests that students who stop taking mathematics after grade 11 may be eliminating more than 80 professional jobs from their options. Twelfthgrade mathematics is required for careers like X-ray technician, drafter, horticulturalist, pharmacy assistant, and general accountant. Mathematics is required in grade 13 for careers as computer scientist, geologist, astronomer, architect, meteorologist, and physician or dentist.

Pitfall 2. Students need to know more about a career than salary. School counselors and teachers must assist students in exploring a career beyond how much it pays. The goal is to help students understand educational requirements, job possibilities, and workplace skills. Two experiences that assist with this goal are helping students explore relevant and accurate information through career software and giving students hands-on job-shadowing experiences.

Pitfall 3. Avoid telling students what they cannot do. Students need to know that they have many options. Counselors must encourage students to aspire to career goals rather than discouraging them, limiting them, or setting barriers. A good way to enrich the options is to offer alternative career possibilities. For example, if a student wants to become a dentist but has not done well in mathematics or science, the counselor should help the student find ways to strengthen the deficient skills. Tutoring, after-school enrichment, or additional work with teachers can sometimes raise the achievement level. A recent study by Campbell and Sheehan-Holt (in press) finds school counselors integral to raising achievement scores in core content areas. School counselors should also help explore career options beyond a single choice. Gray (2000) encourages school counselors to help parents also become informed about career options. Some of these may include careers where a four-year college degree is not necessary. High-skill, high-wage jobs include careers for which four years of college are not necessary, while still offering employment options. Counselors must discuss the options with students and parents at the eighth-grade level.

Pitfall 4. Students need to know about nontraditional career choices. At this critical age, students, especially girls, begin to restrict career choices because of gender expectations. Sadker and Sadker (1994) advise, “the transition from elementary to middle school may be the most damaging period of a girl’s young life” (p.78). Unfortunately, parents and teachers often reinforce these messages. By the end of middle school, career aspirations for girls diminish, and they rate themselves lower in academic self-concept and job competence than boys. Boys focus on mastery and power, while girls emphasize achievement in social arenas. Traditionally, this phenomenon pushes girls toward nurturing and people-oriented occupations such as nursing and teaching. Counselors must challenge students to consider nontraditional careers. For boys, this means discussing nursing, child care, or elementary education; for girls, it means encouraging jobs in technology, mathematics, health care professions, and science. Counselors should also provide girls with critical resources that include nontraditional mentors in the sciences, names of support groups, and opportunities for scholarships and financial assistance.

Phase three: Orientation

The counselors' role in career development increases greatly when students enter high school. An important distinction must be made at this level. In fact, preparing students for college often seems a high school counselor's most important task. However, although helping students go to college is a meritorious act, there is more. Rather than focusing only on college, the goal of school counselors should be encouraging students to plan for future careers. How is this different? For one thing, it is much more inclusive because many students do not choose a four-year university after high school. If the counselor focuses only on college, students who elect not to go on or who do not have college-graduated parents as role models will be neglected. Yet they are the most in need of counseling and career planning assistance. Some students postpone college to gain work experience. Others select military options, community college, or trade schools. Regardless of a student's direction, school counselors must take an avid role in assisting with career planning and guidance.

Counselors using a developmental model work across grade levels to provide all students with career information and assist with academic selections. Developmental school counselors work collaboratively with curriculum teachers to make students aware of how academic courses relate to the world of work. Emphasis in classrooms highlights workplace skills that enable students to graduate with both general knowledge and workplace skills and competencies. Mathematics and science teachers might intentionally use these skills to promote employment skills such as teamwork, hypotheses testing, technology use, ability to work with diverse people, schedule keeping, deadline adherence, and attendance. The goal in this phase is to begin orienting students to more specific career options of interest and the associated skills. Counselors should highlight opportunities for job shadowing, interviewing, internships, work-study opportunities, and career fairs.

Finally, a key activity must include the development of an individual career plan (ICP), mentioned earlier as a key aspect of the developmental model. *Get a Life* (1995) is a commercially developed ICP packet that helps students make career choices and plan their education accordingly. Each student receives an ICP packet in ninth grade that contains columns across every grade level regarding aspects like self-knowledge, career information, and academic planning. Each year, students reassess their career plan and decide whether to move in a different direction or delve deeper into the selected area. School programs can also develop ICPs locally or broaden them to include a portfolio component. Portfolios enable students to showcase examples of their best work from a class or include information pertaining to job exploration or employment. Electronic career portfolios are now available. Career Cruising (www.careercruising.org) is one such program, retrievable on the Internet. With it, students can develop portfolios where they can place material at any time. An administrator's component enables school counselors to access the portfolios to see what has been recorded. Career Cruising schools also receive an option that allows students to do their own course planning and interest inventories as well as career and college searches. Using a career portfolio or an ICP requires an intentional commitment by school counselors and administrators and cannot be done alone. Classroom teachers must provide time to introduce, update, and assist students in keeping their ICPs current.

Science and mathematics teachers may want to have students record class events that involve the study of careers in specific areas on their portfolios. They may encourage students to explore nontraditional careers and list them on the ICP. Students may want to place their reports or fieldtrips into the portfolio component for later use in a career counseling session.

Phase four: Preparation

School counselors may begin to see increased interest regarding postsecondary planning and career exploration by students in the latter part of high school. Suddenly students begin to realize they have less than two years left before graduating, and they may not have very realistic or concrete plans. The increased attention can create an awkward position for the school counselor who feels obligated to get the student placed. Of course, the first choice for academically capable students is getting them into college and hoping someone there will provide career-decision-making assistance. Unfortunately, research does not support this outcome. The U.S. Department of Education reported in 1997 that almost half of students who start at a four-year college do not finish. By six years after high school, only 52% of students who entered a four-year college had graduated. Gray (2000) suggests that the reasons for this might include poor grades, lack of money, feeling unaccepted and alienated in college, and lack of a clear and reasonable career goal.

On the other hand, high school students who have been exposed to career development across all grade levels (including career awareness, opportunities for exploration and exposure, and ICPs to record and process their interests, thoughts, and experiences) and who know how to access resources on the Internet are far more likely to enter college and succeed. For them, school counselors can implement the fourth phase in which students begin to prepare for a career. This includes helping students select electives that fit their career goals. Opportunities for articulation courses at community colleges, after-school work placement, internships, and summer employment can all enhance career preparation in a student's career of choice. School counselors should not discontinue good career development and career counseling just because the student has selected a career area.

Students in science, mathematics, and technology can choose from various activities and opportunities. Those interested in pursuing nontraditional arenas can develop support groups. Counselors can help them identify and connect with mentors in the field. Students in high-technology fields can learn about scholarships and financial aid through the Internet. School counselors help them find summer employment related to career goals.

The Rockford Project

In 2001, as a part of the NSF-funded Rockford project, an effort was launched to include school counselors in the overall goal and training. The leaders of the project saw the importance of including school counselors in this venture. They convened workshops for all counselors in the district and started two year-long projects aimed at making counselors more aware of best practices. All the school counselors received the following:

- Workplace skills chart
- State and national career development competencies
- *Developmental Counseling Model for Illinois Schools*
- *National Model for School Counseling Programs*
- *Getting Real: Helping Teens Find Their Future,* by Kenneth Gray
- Access to monthly district-wide counselor meetings
- Access to district-wide training on development curriculum provided by the Rock Island/Moline Regional Office of Education
- Information on brain development
- State standards for school counselors

Year one project

Counselors from middle and high school participated in a series of workshops. One of the goals was to help school counselors increase their awareness about careers, especially in mathematics, science, and technology, and to assist in the development of an ICP to be used across the school system. The participants were released from school and received graduate credit or a stipend to attend the workshops, which began in September and ended in May. Topics included the development and implementation of the ICP and information about educational pathways to careers. They spent two days visiting Rock Valley College's (RVC's) career services area and gained a better understanding of the 2+2 articulation agreements between the College and Northern Illinois University (NIU).

Participants appreciated the opportunity to review a wide variety of ICPs from other school districts across Illinois. These served as templates for the creation of the Rockford district ICP. Participants would have liked more time, and some looked forward to having more regular meetings with colleagues over the year.

At the end of the workshops, participants presented an ICP, "Pathways to Success." It included:

- Checklist for graduation requirements
- Grade-level place to record coursework to be taken during each semester
- List of personal qualities sought by employers
- List of the skills sought by employers
- Place to record when the ICP would be updated

Inside the ICP, an additional page included personal information from students. Topics included:

- Checklist for a plan to help me learn about occupations
- Occupations I have explored
- Occupations I am most interested in
- Work experience
- Career assessment taken
- Other activities I was involved in
- Student responses to "My Work Skills"
- Student responses to "My Personal Skills"

All school counselors also had the opportunity to participate with teachers in other professional development workshops. For example, there were panel presentations consisting of representatives from across the business and industry sectors, including manufacturing, medical fields, agriculture, aviation, science research laboratories, engineering firms, and more. The forums highlighted expectations for workers in these fields, educational requirements, and entry level jobs, as well as how they could lead to career advancement. The representatives came from some of the more than 300 businesses and industries that partnered with the schools in the Rockford project.

Teachers and counselors attended two workshops on articulation, one led by RVC faculty and the other by NIU faculty. Attendees learned how students could go to the community college and then transfer into many programs at NIU through the articulation agreement that culminates in technical degrees. They saw how important it is for students to understand that the associate's degree is an excellent credential for technical careers or for completing a bachelor's degree from NIU. In the second year of the project, the articulation workshop occurred jointly with RVC and NIU faculty, which helped make the collaboration and connection between the programs even more evident.

Finally, counselors participated in Educational Path to Careers workshops cohosted by RVC and NIU. These workshops began with a focus on admissions requirements by each institution and also covered what students could do if they did not meet these requirements. This information stressed that students still had opportunities for higher education, even if they did not take all the appropriate courses at the high school level. This was especially important to the career-counseling, college-advising, and decision-making strategies the school counselors engaged in with their students.

After going over the admissions information, workshop attendees participated in three mini-sessions that focused on mathematics, science, and technology. Each session presented a variety of career options in a discipline. Additionally, participants learned how some careers transcend a single discipline. This highlighted the relevance and the importance of integrating mathematics, science, and technology across disciplines in the school curriculum. In summary, school counselors who participated in this workshop gained first-hand experience about careers and their educational requirements and learned which careers students could enter by completing an associate's degree or a bachelor's degree. The new arena of certificates was mentioned regarding how students can go to the community college for a certificate to gain entrance into a job and the possibilities for more education beyond the entry level.

Overall, the accomplishments made in tier one provided valuable information and were good foundations for school counselors. Working with teachers in this project helped to establish links with the classroom and to introduce the concept that career development is everyone's responsibility. To this end, efforts got underway to adopt the use of the ICP across the district and to create a plan to implement this in grades 6-12. In addition, counselors began to request more involvement *with* classroom teachers through team teaching in order to promote technical careers as a natural part of the curriculum. They wanted to work directly with teachers in planning, integrating career development into the curriculum, and delivering the lessons jointly with teachers. This was a very important result. Teachers were receptive. Ultimately, this could result in career information and planning becoming a natural and ongoing part of the curriculum, with counselors having a collaborative role in the classroom with teachers rather than separate and ancillary to student development. It also supports the new comprehensive model that school counseling programs need to address: a model that puts counselors in the classroom and emphasizes their work in career development with all students.

When career content and learning activities become a natural part of the ongoing educational process in mathematics, science, and technical education, students begin to see more possibilities and relevance to learning mathematics and science. This relevance helps students expand their potential because of the understanding that mathematics, science, and technical education open career choices and options.

Year two project

During the second year of funding, a slightly different format was taken. Instead of workshops, a graduate-credit course was offered to school counselors in the district. The goal of this course was to emphasize best practices for counselors as related to the comprehensive developmental counseling model discussed earlier in this chapter, with an emphasis on careers and academic, personal, and social growth. It also could become a resource for counselors to develop strategies for working collaboratively with teachers in the classroom, especially in addressing student developmental needs. This class took on a broader scope than the ICP focus. However, efforts to incorporate the ICP and continue its implementation into the school district were included.

The school counselors who participated in this project met across the spring term. The goals that were established by the instructor of the course were to:

- Understand the role and importance of career, academic, and personal/social development for every student across all grade levels.
- Learn the principles of a comprehensive career development program, understand how these are linked pre-K-16, and strategize on how to implement them across the curriculum.
- Review and critique current trends and issues in school counseling.
- Discuss the latest in ethical and legal issues for school counselors.
- Consider the impact of multiculturalism and diversity issues in counseling.
- Learn a variety of classroom activities, career programs, and exercises that can be integrated into the classroom and that relate to Illinois learning standards.
- Understand the role of school counselors regarding the connection between career development and the No Child Left Behind Act of 2001.
- Differentiate between traditional and nontraditional career and academic planning and counseling.
- Review and revise the individual career plan and portfolio.
- Design and implement a career assessment strategy for their school district.

This course covered many important aspects for school counselors. Of primary importance was the opportunity to network and discuss issues that occurred across the district in different buildings. This also seemed important as middle school counselors were able to share transitioning issues with high school counselors. Participants explored resources and materials on career development, spent an evening visiting RVC's counseling center, and attended a presentation on articulation agreements and career training programs. Current issues in school counseling were also made available, including the role of the counselor in No Child Left Behind, nontraditional career counseling, and developmental models that work across the state. Finally, as class assignments, each member was asked to do a brief assessment of their current school counseling program. The final assignment asked participants to focus on one area needing improvement and create an action plan that would improve counseling programs. Excellent ideas were shared, including collaborating with classroom teachers on career and personal/social issues, infusing the ICP into all schools, working with parents on career issues, and adding a nontraditional component to the career fair. Participant feedback on the class was excellent, and comments were very similar to those received in the first year.

Summary of the Rockford Project

The inclusion of school counselors as an integral component in promoting careers in science, mathematics, and technology is paramount if the goal is to help more students enter these fields. Bolstering career education involves a unified effort from classroom teachers, administrators, parents, and staff. School counselors hold up the other half of this picture in the individual and group counseling work they do that assists students in career decision making, postsecondary training, and career pathway planning. In Rockford, some of these links were established through intentional inclusion of the counselor. More needs to be done to redefine the role of school counselors. Increased numbers of counselors are needed to have time and resources to deal with students individually or in small groups. Team planning with all counselors from a school and links to counselors across buildings and grade levels are critical to systematic career programming. Students graduating from high school must be aware of their career options (including mathematics, science, and technology) and have (a) explored these careers through hands-on experiences; (b) arrived at personalized careers in light of their own interests, skills, and aspirations; (c) explored nontraditional careers, especially for girls in the areas of science, mathematics, and technology; and (d) realized the relevancy of their academic program to their future preparation.

Conclusion

The inclusion of school counselors in career development is critical if we are really going to increase the number of students interested in technical careers requiring associate's or bachelor's degrees. Career education must not be artificially separated from the academic curriculum, but rather the norm should include teachers and counselors as collaborators who work together in the classroom and with business, industry, and community partnerships to make the academic curriculum come alive with relevance and possibilities. All educators must understand the foundational aspects of mathematics, science, and technology education requirements so they can effectively guide students.

Additionally, granting agencies must begin to include counselors as required partners with teachers in professional development regarding mathematics, science, and technology education and careers. These partnerships need to emphasize the design and implementation of programming that affects students more intentionally and systematically so that the numbers of students pursuing technical careers increases. However, these numbers will not change if educational systems keep operating in the same old way. The traditional roles of the school counselor must change. The new roles must:

- Include counselors within classrooms across all grade levels in career development

- Foster effective ICP planning for students as the responsibility of all educators in the school
- Promote hands-on learning opportunities, such as job shadowing and internships
- Build bridges with business and industry in the community
- Intentionally integrate mathematics, science, and technology careers into the curriculum
- Devise awareness, recruitment, and retention strategies for students entering nontraditional careers
- Educate students and their parents about the value of technical education that is broader than only a four-year educational degree

School counselors have always played a significant part in vocational development and career planning, but in the 21st century they will need to use a developmental approach. This approach, aligned with *National Standards* and the *National Model for School Counseling*, suggests counselors be active, collaborative, and accountable for the work they do in promoting academic, career, and personal and social growth.

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Contents

PART III. Research Data & Evaluations

32. Background

Jule Dee Scarborough

This chapter provides historical perspective of the results reported for the "Strategic Alliance" project, which ended in June 2003. It also discusses results of a concurrent regional project.

PHYS-MA-TECH, 1989-1991

The research reported here is a continuation of work begun in 1989. The National Science Foundation funded a project, Frontiers of Physics. Officially renamed PHYS-MA-TECH by the participating teachers, this project resulted in a yearlong integrated physics, mathematics, and technology education course developed to extend participation in physics to a greater audience by enhancing its relevance and relationship to the other two disciplines. The external evaluator found that the result did represent a significant and valid step forward in demonstrating the viability of an integrated approach to teaching physics, mathematics, and technology education at the secondary level.

Participant Description

Five secondary schools in northern Illinois were selected to participate in the study, representing appropriate diversity: Chicago, urban; Grayslake, bedroom community; Moline, rural; Shepard, suburban; and West Aurora, suburban. School size, student diversity, socioeconomic range, geographic location, and financial status were diverse as well.

Students participating in the pilots were selected in the following manner: in each of the five high schools, the experimental groups were students who were identified as those who would not normally enroll in regular high school physics; however, these students were then randomly selected to participate in the PHYS-MA-TECH classes. Also, in each school, one or more regular physics classes were selected to participate as control groups.

One hundred and thirty-nine students participated in the experimental groups, and 314 students participated in the control groups, for a total sample of 453 students. Several differences in demographic and ability indicators existed between the students in the experimental and control groups. The regular physics classes, the control group, consisted of a larger proportion of females as compared to the experimental groups. There were larger proportions of African American, Hispanic, and Asian students in the control groups, while a larger proportion of Caucasian students were found in the experimental group. This unusual distribution was due to the selection of schools; most schools participating had very diverse or non-majority student populations.

Although students in both groups had previously taken similar types of mathematics, science, and technology courses, students enrolled in the control group had completed more mathematics courses as compared to the experimental group. The grade point averages (GPA) of mathematics, science, and technology classes completed by students in the control group were higher than those in the experimental group. The overall school GPA and the mean IQ percentile scores for students in the regular physics classes, the control group, were higher than for the students in the PHYS-MA-TECH classes, the experimental group. Several major differences in student ability were also found between the five schools. Among those were student IQ percentile scores and overall GPA. As a result, a decision was made to treat school, student IQ percentile score, and overall GPA as extraneous variables in the analyses.

Student attitudes

Student attitudes toward science, mathematics, and technology were also a focus of the research. An instrument was designed to assess the attitudes of participants toward science, mathematics, and technology coursework. The instrument was administered at the beginning and end of the pilot period or beginning and end of the courses. Students enrolled in the regular physics classes had a greater preference for mathematics as compared with those in the PHYS-MA-TECH classes, while those in the PHYS-MA-TECH classes exhibited a greater preference for technology classes than their counterparts in the regular physics classes. However, there were no apparent differences in preferences toward science classes. The students in the regular physics classes exhibited a significant decline in the preference for science over the school year. The group of students in the experimental class showed no change in the preference toward science classes during the school year. There were no significant changes in student preferences toward mathematics or technology classes over the span of the project. At the beginning of the school year, 55% of the students enrolled in the regular physics classes indicated they were enrolled to help them prepare for college, as compared to 22% of the students in the experimental PHYS-MA-TECH classes. At the end of the school year, the proportions indicating preparation for college had shifted to 39% and 29%, respectively.

Students perceived that success in physics related to their potential for attending college. At the pre-assessment stage, students in the control group indicated that their reason for enrolling in physics was college preparation. Students in the experimental group indicated that they were recruited for the study. At the post-assessment stage of the attitude assessment, students in the control group showed a preference for biology and chemistry, while those in the experimental group showed a preference for physics and physical science. However, both groups perceived the difficulty of science classes similarly. Also, the results of the post-assessment show that fewer students from the control group indicated that their reason for enrolling in physics was college preparation, while significantly higher numbers of the experimental group indicated their reason for taking physics was college preparation. There seemed to be an attitude shift about going to college by a significant number in the experimental group

Although no data were collected on mathematics, it was found that taking higher-level mathematics as a prerequisite for physics was not necessary. The teachers in this study taught the necessary upper-level mathematics skills simultaneously when needed. Upon formal evaluation, the mathematics teachers themselves determined that the mathematics-teacher partner was not needed as often as originally established and became the “swing” teacher in the model.

Technological literacy

In assessing participant technological literacy, it was hypothesized that students participating in a technologically based physics curriculum might become more technologically literate as a result of the course than those enrolled in a traditional physics program. Thus, a technological literacy test was administered at the beginning and end of the project year. In order to control for the effects of teacher and other community-related factors, school attended was included as an additional independent variable. Participant GPA and IQ percentile scores were used as covariates to control for the effects of ability and previous school achievement. The administration of the technological literacy test at the beginning of the year revealed no significant difference in technological literacy between experimental and control groups nor between schools, indicating that the groups were evenly matched. The analysis of gain scores between the initial and final administration of the technological literacy test revealed no significant difference between the groups. Thus, both the traditional and the PHYS-MA-TECH courses made equal impacts on technological literacy.

Participant achievement

An instrument was developed to measure the achievement of physics concepts in five units of instruction across the year-long PHYS-MA-TECH course. This instrument was adopted in part from an achievement test developed by the American Association of Physics Teachers and the National Science Teachers Association. Additional test items were developed by the participating science, mathematics, and technology teachers and the project research leader. The corresponding physics unit test was administered at the beginning and end of each of the five-unit instructional periods. The gain between the pretest and the posttest administration was used to identify differences in achievement among the experimental and control groups. As before, school was included as an additional independent variable, and participant GPA and IQ percentile scores were used to control for the effects of ability and past achievement. Pretest scores for each of the five units revealed no significant differences in achievement between the experimental and control groups. Differences in achievement among the five schools were, however, shown to exist in each unit test except modern physics.

Gain in achievement between the pretest and posttest administrations of each of the five unit tests revealed no significant differences between groups or among schools. This indicates that students enrolled in the PHYS-MA-TECH program learned the concepts of physics at the same rate as those enrolled in traditional physics courses. This was a significant finding, considering the differences in demographics and ability between the experimental and control groups, the fact that the experimental group consisted of students who would not have enrolled in physics, and the fact that the pretest-posttest was adopted from a rigorous national test. High school students enrolled in a technologically based physics course like PHYS-MA-TECH accepted physics content at the same rate as those enrolled in a traditional physics course. The data suggested, however, that the ability and motivational levels of the students participating in the PHYS-MA-TECH course were not equal to those enrolled in the traditional physics course. The major conclusion of this project was that the technologically based PHYS-MA-TECH program was especially well suited for the high school student who might not be motivated toward the advanced sciences demanded for college entry. The achievement levels demonstrated by the participants in the study indicated that these students were accomplishing the same content objectives at the end of the program as their counterparts who were pursuing a more traditional route. The equal gain in learning had even more significance because this was the first time teachers taught a new curriculum that was (1) integrated and technological in context, (2) taught as an interdisciplinary and blocked team, (3) used new teaching methods, and (4) used new laboratory settings, equipment, and working relationships.

PHYS-MA-TECH included many other major aspects; for example, there were strong industrial partnerships, and the report describes many other lessons learned. Detailed information on this project, the full curriculum, the research report, the external evaluator's report, and two articles summarizing the results are available at the Strategic Alliance website (www.strategicalliance.niu.edu). Once in the website, click on PHYS-MA-TECH. Full curriculum and abstract reports are available through ERIC at ED 355 366.

Sources:

ED 355 366 PHYS-MA-TECH. An integrated partnership, results and models. Includes 45 complete integrated physics, mathematics, and technology education modules.

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NSF Strategic Alliance Project PILOT, 1997-1999

Beginning in 1996, the Illinois State Board of Education, through the Scientific Literacy Program and the Illinois Board of Higher Education Eisenhower Program, funded a pilot project to integrate mathematics, science, technology, and English contents to enhance relevance and to increase learning. The focus also included PHYS-MA-TECH's formal interdisciplinary teacher teaming and the blocking of teachers and students for several class periods using a variety of scheduling models. It extended beyond that project in several ways. As national standards were introduced, the curriculum modules were standards-based, reversing the curriculum development protocol. Also, authentic and performance-based assessment was of priority, along with pretests and posttests to measure student achievement. English was included as a discipline and English teachers as team members because written and oral communication provides evidence of learning. Reading and writing are critical to learning about and expressing or manipulating knowledge from all disciplines. Therefore, reading and writing across the curriculum was encouraged in the new modules and approaches. Bloom's Taxonomy became a more formal metric for teachers to achieve higher levels of learning, and incorporating new teaching models was of great importance to increase repertoires of teaching models from which to draw. A formal curriculum module format that was initiated in an earlier project in Chicago was presented for adaptation. Teachers modified this model and then used it as their template for developmental consistency so that sharing, networking, and transferring across schools would be more easily accomplished. The project and research results to be presented in this section begin with a report of the pilot funded by the State of Illinois agencies.

It is important to mention several compounding factors about the pilot research report. Nine interdisciplinary teams participated. Each team consisted of teachers from mathematics, science, technology, and English (MSTE), and occasionally another discipline. The pilot studied the effect of an integrated curriculum and included a variety of listed teaching models; it required that the interdisciplinary team and students be blocked for delivery. There were both experimental and control groups.

The research model employed a quasi-experimental, nonequivalent control group design. Treatment groups were constituted in one of two ways. In two high schools, the treatment group consisted of students common to each of the disciplinary areas of the team. During the school day, each student in this group came into contact with each teacher in the team. In two high schools, the treatment group was not composed of common students; however, the teachers had common planning periods and were able to employ team teaching strategies in each other's classes. Control groups were selected from classes in the same disciplines as the treatment groups but had no teachers in common, nor did they employ team teaching strategies. Pretest and posttest data were collected at the beginning and end of each module, respectively. These tests were designed to measure the same instructional objectives taken from the Illinois learning standards as those incorporated into the instructional module. These tests were designed by the teachers, with leadership provided by the project research associate.

Posttest results revealed that the treatment group for four of the nine teams demonstrated significantly higher achievement when compared with the control groups, 14-22% higher. Students in the control groups scored significantly higher mean scores on the pretest as compared with the treatment groups in two teams, a third scored slightly higher, while the treatment group scored slightly higher in the fourth team. Two of the "successful" teams had all students in common across each discipline. One team had approximately one-half of the students in common, while one team had only a few students in common. The fact that these teams were "allowed" to follow through with the pilots as planned, meaning that the administrators followed through with the committed scheduling requirements, resulted in a continuation of the positive effects resulting from the PHYS-MA-TECH project.

However, the other five teams were not adequately supported as planned. The follow-up of commitment for block scheduling teachers with students did not occur. This greatly affected the research aspect of the project for those five teams. Although the control groups in three of the five remaining teams had adjusted scores that were slightly higher than the treatment groups, the differences were not significantly higher, ranging from 2% to 4%. Control group students for one team exhibited pretest scores that were 19% lower than the treatment group, which was significant. The adjusted mean posttest scores between the groups were not significant, which might suggest that the control group made a better gain than the treatment group. The students in the control group for another team scored 11% higher on the pretest, which was also significant. The non-significant results of the adjusted mean scores might indicate in this case that the students in the treatment group "caught up" with those in the control group. This was the only team having students in common. Since the pilots were planned as block-scheduled teacher teams and student classes, the "common student" factor appears to explain an aspect of the program success and also failure. The program could not be delivered appropriately for testing with four of the pilot groups. However, the results do provide some empirical evidence that an integrated curriculum, incorporating other teaching factors, could increase student achievement when teachers are supported to follow through with the modules, strategies, models, and procedures as planned.

The pilot was used as the basis to continue development and piloting of integrated modules, through the NSF-funded "Strategic Alliance." It was not possible to continue the control groups, but quasi-experimental pilots of modules used pretests and posttests to establish the amount of student learning gain. In almost every case for the 50 teams, collected data indicated that a significant gain in achievement took place during the integrated modules. See the following analysis for more detailed information about gender and ethnic differences in achievement. Also see the website, www.strategicalliance.niu.edu, and click on the link to the Rockford School District to gain more information about the integrated modules.

33. Methodology, Findings, and Conclusions

Conard White

A total of 59 teacher teams were organized from participating school districts beginning in the 1996/1997 school year through the 2003/2004 school year. The number of teachers in each team ranged from two to as many as four, and in each case represented more than one subject matter area. Teachers volunteered to participate in the program, to work together across curricular areas to develop interdisciplinary instructional modules, and to pilot test the modules within their regularly schedules classes. Data was collected on nearly 2800 students across 67 classes. In most cases, the data from a team represented a single "class," as the same instrument was administered to all participating students. The data from seven teams, however, were separated by subject matter because different test instruments were used.

Teachers received special instruction in team dynamics, integrated curriculum models, authentic assessment strategies, teaching models, and use of state standards in developing learning modules. Instructional modules developed by each team met specific criteria:

- Have a duration of three to six weeks
- Be based in specific standards taken from the Illinois Learning Standards
- Use at least two of the integrated curriculum models presented
- Encompass content across MSTE disciplines
- Include two or more authentic assessment strategies as well as pretests and posttests

Each module focused on concepts common across disciplines. These included common curricular content, common cognitive content, and common skills. Modules encompassed such concepts as problem solving, oral, written, and graphic communication, computer skills, critical thinking, computation, and measuring.

During the first project year, the research model employed a quasi-experimental, nonequivalent control group design. Treatment groups were constituted in one of two ways. In two high schools, the treatment group consisted of students common to each of the disciplinary areas of the team. During the school day, each student in this group came in contact with each teacher in the team. In two high schools, the treatment group was not composed of common students; however, the teachers had common planning periods and were able to employ team-teaching strategies in each other's classes. Control groups were selected from classes in the same disciplines as the treatment groups but had no teachers in common nor did they employ team-teaching strategies. Posttest data were collected from both groups at the conclusion of each module. An analysis of covariance using a generalized linear model was used to test for differences in mean posttest scores between the treatment and control groups. Pretest scores were employed as a covariate to control for the effects of student ability and prior knowledge. The research hypothesis tested using this model was:

H_1: There is no significant difference in adjusted mean achievement scores between the treatment and control groups.

As a result of research done in the previous year, it was found that the use of control groups to adequately assess achievement gain attributed to the instructional module was not practical in the school setting. It was very difficult to locate groups of students that were comparable to those participating in the study, to gain cooperation of additional teachers not associated with the program, and to coordinate the testing of possible control groups within the timeframes of each of the modules. It was decided to eliminate the use of student control groups, although this reduced the effectiveness of the research model.

In order to test for student gain in achievement, each team, as a part of its design of instructional modules, developed a traditional test instrument. This instrument had to be designed to measure the same instructional objectives taken from the Illinois Learning Standards as those incorporated into the instructional module. These tests were designed by the team instructors, approved by the project research associate, and administered at the beginning of module instruction to assess students' prior knowledge of the subject matter. At the end of the module, the test was again used to measure student accomplishment.

A paired-difference t-test was employed to test for significant differences between the pretest and posttest mean scores. A significance level of 0.05 was selected to distinguish a significance. The hypothesis being tested here is:

H_2: There is no significant difference between mean pretest and mean posttest scores.

To analyze the effects of gender and race/ethnicity on posttest scores, a generalized linear covariance model was employed. Pretest scores were used as a covariate to control for the effects of prior knowledge on the part of the students. A significance level of 0.05 was used in these tests also. The hypotheses being tested here are:

H_3: There is no significant difference in adjusted mean posttest scores between male and female students.

H_4: There is no significant difference in adjusted mean posttest scores among students in differing racial/ethnic categories.

Limitations

Team members designed the instruments used to assess the effectiveness of the instructional modules. They were given instruction in developing test items to measure specific objectives. The completed instrument met these requirements:

- Measure instructional objectives contained within the module.
- Include items that measure content in each subject matter area.
- Include a variety of item types.

The instruments developed by the teams were monitored by project staff, and a variance in quality was noted. No attempt at assessing the validity was made, other than ensuring that the test items were directed toward state standards. Reliability checks on the test instruments were not required. Each instrument is assumed to have been reliable, since the same test was used before and after the instructional module.

The initial study, conducted by the project staff in academic year 1997/1998, used a more sophisticated research model employing equivalent control groups. As a result of consultation with participating teachers and school administers, it was determined that the use of control groups was not practical in a public school setting. It was difficult to locate groups of students that were equivalent to those participating in the study. If equivalent sections of classes were taught by project teachers, it was thought that "cross-over" might occur between the control and experimental groups. It was difficult to find teachers not associated with the project who would cooperate by allowing testing of their students. Project staff determined there was no alternative to eliminating use of control groups, although it greatly reduced the power of the research model.

Performing research in schools is a complex endeavor, ranging from the level of administrative support to the logistics of collecting data from teachers in the prescribed format. There are limitations in large and complex districts. For example, this initiative began using control groups the first two years, but the following years we were unable to schedule control groups. The burden was too great for the district to coordinate. It took considerable effort to get teachers to report the pretest and posttest scores on the forms provided, which entailed much follow-up. In spite of the research limitations and the "messy" business of social research, the research model and results reported here have positive implications.

Findings

The project's website contains all data and statistical procedures employed to evaluate student achievement, from 1997 through 2003: www.strategicalliance.niu.edu.

Summary and Conclusions

During the seven years of the project, 59 teacher teams were trained; they developed more than 102 instructional modules and piloted them in the classroom. These teams consisted of teachers from five Rockford high schools, six Rockford middle schools, and four high schools in northern Illinois. Data were collected from 2794 students.

In order to test for student gain in achievement, each team, as a part of the design of instructional modules, developed a traditional test instrument. This instrument was designed to measure the same instructional objectives taken from the Illinois learning standards as those incorporated into the instructional module. These tests were designed by the team instructors and administered at the beginning of module instruction to assess students' prior knowledge of subject matter. At the end of the module, the test was used to measure student accomplishment.

Figure 1 displays the results of the posttest administered at the close of the instructional module. The chart indicates the frequency of mean class scores in categories roughly associated with ABCDF grade ranges. That is, 3 of the participating classes had a class average in the "A" range, and another 16 classes had an average in the "B" range. The fact that 28% of the classes participating (16 out of 67[1]) had averages of "A" or "B" is outstanding. The largest number of classes (23 or 34%) had an average in the "C" range. Sixty-two percent of the classes represented in the study had "final exam" class averages in the "C" or above range. The data clearly indicate that high levels of learning were taking place within the participating classrooms.

Gain in achievement of each of the participating classes can be shown by comparing the posttest with the corresponding pretest class averages. A significant gain in achievement was demonstrated in 67 of the 68 classes represented in the study. One class showed a slight but insignificant gain. Those data are displayed in Figure 2.

As can be seen from the data, six classes experienced a gain in achievement of over 200% during the course of the instruction. In addition, 25% of the classes at least doubled their achievement, while over half experienced a gain that exceeded 50%.

In order to summarize the findings of the project, one must examine the 1997/1998 year separately from the others. A fundamental change in research design took place after that year. The major thrust of year one was to determine if the use of teacher teams in conjunction with integrated curriculum could demonstrate an increase in student achievement when compared with a traditional separate curriculum approach. Treatment groups, composed of students enrolled in classes incorporating an integrated curriculum, etc., were compared with control groups of students enrolled in regular separate subject areas. The success of this year would form the basis for further study in subsequent years.

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[1] There were 68 classes. A percent correct could not be determined for one class that did not report the number of points possible.

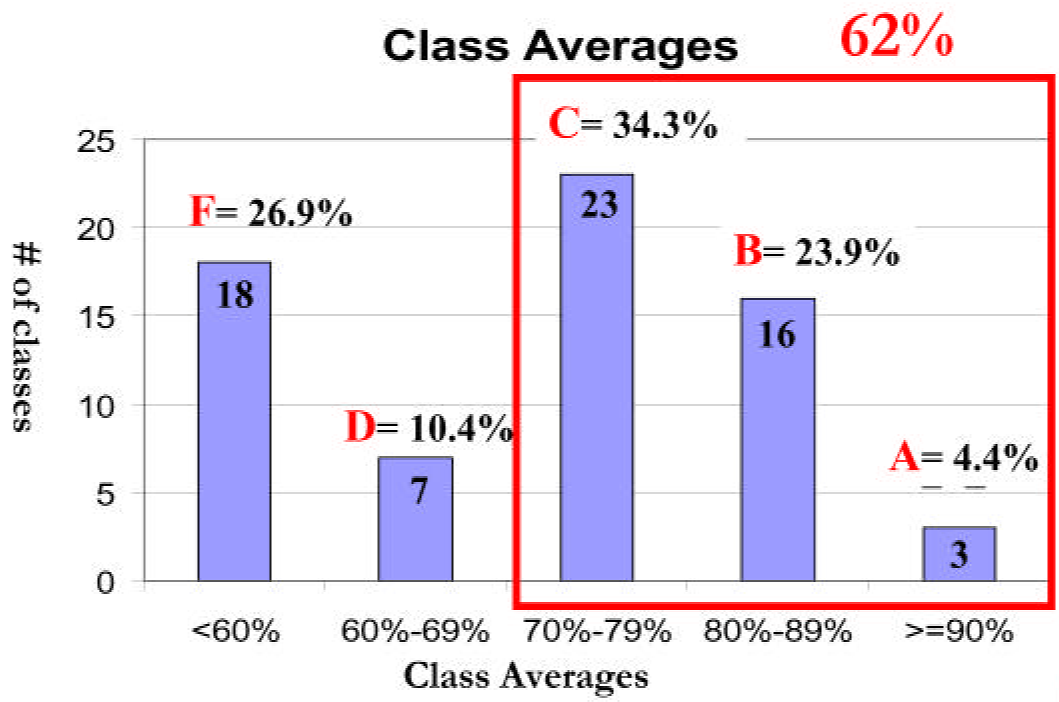

Figure 33.1 Class Averages

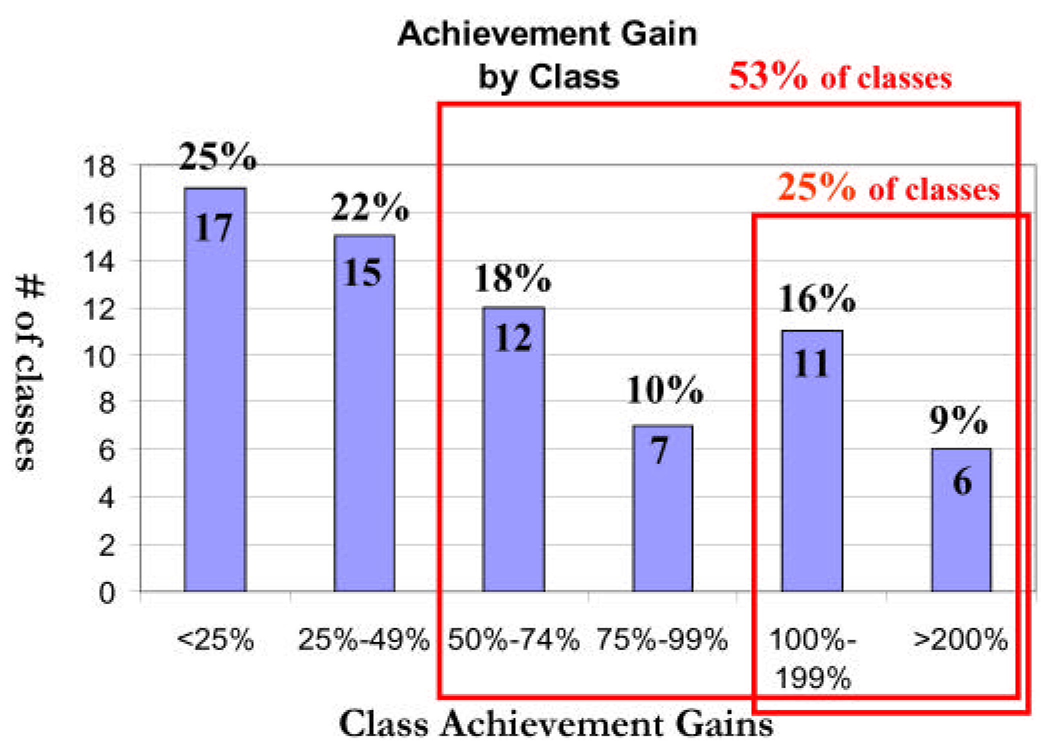

Figure 33.2 Achievement Gain by Class

Data collected during the first project year indicated that the integrated curricular/teacher-team method was viable. Data from four of the nine first-year teams exhibited a significantly higher gain in achievement in the classes using the integrated curricular approach when compared to the classes using the traditional separate approach. The data from the remaining five teams showed no significant differences between the treatment and control groups. None of the teams experienced outcomes where the integrated curricular approach was less effective than the separate approach. The conclusion is that the use of teacher teams in conjunction with integrated curriculum, etc. can improve student achievement over a traditional, separate-curriculum approach.

Subsequent project years focused not only on student achievement gain over the course of instruction but also on the effectiveness of the integrated curricular/teacher-team approach with regard to gender and race/ethnicity. In almost every case, data collected during those years indicated that a significant gain in achievement took place over the course of instruction.

Of the 59 teams reporting during these years, only seven showed a significant difference in achievement scores between male and female students. Of those seven teams, five showed that females scored higher than males, while the reverse was true in the remaining two teams. No interviews were conducted with teams to determine reasons for these differences. However, it is interesting to note that the only module subject areas where males outscored females were architecture and physical education. All of the modules where females topped males in achievement featured the subject matter area of English.

Ten teams reported data that displayed a significant difference in achievement among the categories of race/ethnicity. In six of those teams, Caucasian students displayed higher achievement scores than students in other categories. In three teams, Asian students outscored students in the other categories. No additional information was available that might explain the differences.

Recommendation

The models, products, and results reported here have been evaluated and provide evidence of improved student achievement in mathematics, science, technology, and English at the secondary level. Integrated MSTE curricula, new teaching models and strategies, improved traditional tests, and new performance assessments may improve student success. However, the studies should be replicated with tighter controls to enrich and strengthen the empirical evidence. See the website: www.strategicalliance.niu.edu, for supplementary information.

34. External Evaluation

Joseph Kolar

Evaluation Philosophy

There are two principal ways to approach program evaluation: the traditional model and the participatory model. The *traditional* module involves an evaluator, employed as a third-party objective observer, who collects and interprets quantitative and qualitative findings and presents the information. A scientific paradigm focuses on the quality of the data collected, and an evaluation is considered valid to the extent that it meets specific standards of methodological rigor. In the *participatory* model, all the stakeholders in the program are engaged in a process to increase their evaluation skills and knowledge and the likelihood that the evaluation findings will be used. Because this approach to evaluation involves the people who are involved in the program, these investigations may be less objective by the standards of the scientific paradigm; however, they are valued because they improve the analytical capacity of the program participants and increase the likelihood that evaluation results will be used to refine and improve programs.

My methodology blends the participatory and traditional models, using both quantitative and qualitative data and a variety of methods and procedures to solicit as much information as possible, with an overall focus toward ongoing program improvement. Both formative and summative evaluations are employed, using established criteria with an emphasis on continuous feedback from everyone involved. It is important to quickly identify concerns, issues, or problems and find means to eliminate or minimize them (*Selecting an External Evaluator*, n.d.). My primary role is to observe all the aspects of the grant, its progress and process; review all products and results; help identify what is going well and what may need to be improved or changed; and then work with the key project personnel, program leaders, and participants to generate solutions. It has been noted that "the task of evaluators is to walk the line between solid preparation and flexible responsiveness to whatever situations may arise" (*Sample Evaluator Questions*, n.d., p.1). I listen to all parties and make it a practice not to include my opinions in the interview process.

Evaluator Process

Site visits occurred during workshops, industry tours, panel discussions, planning meetings, classroom module delivery to students, module writing sessions, feedback sessions, articulation roundtables, and other venues. Upon beginning, I introduced myself, stated that I was the external evaluator (EE) for the project, and tried to blend into the activities. During this interview, if anyone attending the activity felt that there was a problem, I expected them to discuss it with me. Within a week of a visitation, the pattern was to write to the principal investigator (PI), inform her of my observations, and end my correspondence with "Evaluator Comments." However, whenever need arose, we discussed issues or met. Participants seemed to be comfortable with my presence, freely discussing the events, their feelings, and the perceptions of outcomes at each event.

Design

The project employed a rigorous system of assessment, feedback, and evaluation activities. Sometimes a fine line separates these activities. Assessment was used to determine or confirm how the program was progressing for participants: performance assessment to determine if participants were gaining the planned knowledge and skills, and feedback to help participants understand where they were in the development or achievement of their goals throughout the entire program. Products were then evaluated. Assessment was more formative in that it enabled project leaders to identify needed changes along the way by event or specific process; evaluation was more summative in nature. Formative and summative evaluation were used to determine the level and merit of accomplishment at particular points. Both teacher assessment and program assessment helped to assure a positive evaluation outcome. Program content was determined by pre-assessing the teachers' self-perceived and self-analyzed level of knowledge and skills. By assessing each program activity or event and its outcomes, and participants' products and performances, program success was determined. If it was successful, teachers increased the knowledge and skills they wanted to learn. So, there was interaction between two types of ongoing assessment, teacher and program, as well as both formative and summative evaluation. Each type of assessment led to critical feedback from which judgments were made about changes.

Formative evaluation occurred each year at the program's end. Culminating teacher performances and products were evaluated, and the program was evaluated as well. The ongoing assessment was formative, while the end-of-year evaluation also served as formative and to determine if any changes should be made from year to year. Finally, a summative evaluation, an NSF requirement, occurred to consider the questions of value added for "intellectual merit and broader impacts."

Data Collection Methods and Procedures

Questionnaires

Administrator: Administrators were initially surveyed to determine priorities and support levels. Programmatic adjustments were made as necessary. Some minor adjustments were required. For example, teachers were not allowed to be absent from school for institute days; therefore, a weekend was substituted for the intended weekdays.

Teacher: Teachers were surveyed regularly at each workshop, event, or activity, after their pilots, at the end of most years, and at the end of the project.

Student: Students were surveyed at the end of the module pilots. This data was not used because not all teachers followed through; therefore, it was not possible to draw reliable conclusions. However, most of what was collected indicated positive feelings on the part of the students about the modules.

Observations

Classrooms: External observers visited classrooms, unannounced, to gather information and initial perspectives about teaching skills, knowledge, use of technology, classroom management, teaching and learning practices, and more. This information was used to construct an initial picture of strengths and general areas of potential improvement across teachers and classrooms. This was shared with individual teachers, and a composite report for the whole group was shared as well. Teachers then used the information in their self-analyses and the goal development of their professional growth plans. They reported that this was an insightful process exhibiting great respect for care taken with confidentiality.

Workshops, events, activities: I visited, unannounced, and observed workshops, events, and activities. Reports were filed with the PI. Since they were very positive, there was little need for problem resolution; however, the standard practice was to discuss each observation to connect more deeply what could be improved for the next round of offerings.

Module evaluation: I participated in all module evaluation, with evaluation teams, observing the process of reviewing each module and providing input.

Module pilots: Teachers and teams were observed by an external key project person during the module pilots. Observations were shared with teachers, followed by discussions about what to change. (See Table 1 for the sampling of workshops observed.)

Interviews

Administrators: The PI interviewed administrators periodically to determine if the project was progressing as planned. This did not occur as often as planned because district turmoil resulted in a lack of cooperation by some administrators.

Teachers: Each year, I interviewed teachers at two levels: informally during workshops and other events and then again at an exit interview.

Project personnel: I interviewed program leaders and key project personnel throughout the grant period.

The interview was critically important for the evaluation process. Through interviews, participants provided greater insight and depth about information gathered from the surveys. When participants had responded to the general questions, I asked more specific questions, ending with, “Do you have any suggestions to improve this activity or the overall project?”

This question opened the floodgates. Interviewees informed me about boring food, incompetent administrators, poor working conditions, union negotiations, teacher strikes, layoffs, contracts, judicial mandates, overwork, and an infinite number of other concerns that were not always related to the project. I filtered all responses and reported issues germane to the project. Allowing teachers to openly provide information built a level of trust, developed an avenue for venting, and allowed the interviewees to discuss any issues. The openness of our exchanges enhanced my acceptance as a full participant in their endeavor.

Teachers had many good ideas on what made the project better, although some suggestions were specific to the classroom not the project. The important suggestions were forwarded to the PI, who in turn shared the information with a variety of different audiences involved in delivering the program. Many ideas were implemented. I formally presented the ideas to the PI and sometimes unofficially made suggestions and provided information on possible improvements after observations.

Product Review

I reviewed and evaluated all project products, data, results, and information.

Student Achievement

There was a pattern of significant student gain during the module pilots. The first year's pilot design included control groups. When comparisons were made between the control group's and the experimental group's achievement, the pattern of growth by the experimental group was remarkable. However, only one year included a control group, so no direct conclusions could be made that the treatments were the cause of the gain with the experimental groups during the subsequent years. But it is possible that the new practices, strategies, models, techniques, assessment procedures, teaching models, and partnership activities contributed to the gain.

Administrator or District Priorities

The district's priorities for teachers could change overnight. For example, one year the district mandated that all teachers had to focus on reading in their curriculum. Program leaders quickly adjusted and incorporated reading across the curriculum as an additional standard in the culminating module. Thus, it is important to conduct an annual needs assessment from the administrative or district perspective and infuse that information into the program as much as possible. That was never a problem, but rather served to make the program even more relevant by showing teachers how they could integrate other content, process, or skill agendas with very little difficulty.

Participant Achievement Evaluation

Teacher pre-assessment

At the beginning of each project year, participants were assessed on their needs and how they felt about program priorities. Priorities had already been established and were based upon an initial needs assessment. However, major changes in personnel and district priorities often occurred over summers, especially during these years of high turnover and retirements. Each new group of teachers was asked to participate in a self-assessment and an analysis of strengths and areas to improve to identify professional learning needs and to prioritize them. As part of this process, they were asked to study the state teaching standards and state student learning standards and to identify where they needed to extend knowledge and skills. They then participated in an initial workshop with program leaders and identified discipline-specific needs, wishes, or desires for learning.

Although this was a qualitative process, it resulted in an understanding and focus by program leaders and teachers. Usually, this process simply confirmed the originally planned program, often extending it to include greater depth, breadth, or additional types of in-service education. It was possible, through a number of creative strategies, to extend the program offerings each year.

Using any type of formal quantitative or traditional knowledge testing was not usually possible with teachers for two reasons: (1) testing teachers in any way was intimidating to the point that a majority would drop out, and (2) project personnel did not want to be perceived as evaluating teachers in any way, with the exception of project products, and even that had to be sensitively and carefully completed. Therefore, the PI and program leaders involved teachers in a self-study of their knowledge and skill levels by engaging them in an analysis of standards and content requirements (i.e., benchmarking) and then joined them in a self-discovery process that led them to identify what they needed. It was important to assist them in becoming comfortable with "not knowing" and, beyond that, in becoming comfortable with openly stating what they did not know to others. The teachers' analyses usually confirmed what was planned. When teachers began to realize what could be accomplished and that it was okay to request particular knowledge, process, or skill development, they often became excited and asked the PI to extend the program. Teachers were also exposed to a variety of careers across business and industry sectors, including community opportunities and higher-education requirements (i.e., educational pathways to careers). This exposure helped teachers to explore what they needed to learn more about and what would be expected of their students in communities of practice and higher education. The culminating activity for teachers at this stage was to develop a "learning plan," which was possible to achieve within the overall professional development program. Because teachers were "pulling" the program versus project leaders "pushing," program leaders often responded to their requests by incorporating new content, adding more depth, or eliminating some aspects. Once teachers felt that project personnel were partners and that they could participate in the leadership, they became "seekers" of learning. For the pilot of this particular endeavor, the teachers agreed to unannounced external visits to their classrooms by the evaluator to gain an objective perspective about what others perceived was going on in their classrooms. This data was collected and shared only with the observed teachers and the PI. This process served to establish an objective baseline perspective about strengths and areas needing improvement to add to their own self-studies. The teachers unanimously agreed that this process was insightful and very helpful when they began their self-study. Although this strategy was used only once, for the one year as an extended pre-assessment activity, this segment of the program really worked with and for teachers.

Teacher assessment

There was no traditional assessment to measure teacher progress throughout the program, but the project and program leaders used performance assessment in a number of ways (performances, products, processes, and technologies). All workshops and activities were parts of the whole development. Each workshop, event, or activity provided teachers with new information, models, strategies, processes, techniques, procedures, tools or skills; teachers were then responsible for incorporating these into new integrated, interdisciplinary mathematics, science, technology, and English curriculum modules. These modules were built progressively while participating in program events and included both content and process (e.g., new models, teaching/learning strategies, and techniques, etc.) to pilot in the classroom with students. Teachers worked together as interdisciplinary teams or as individuals responsible for integrating the interdisciplinary requirements and then delivering them in a variety of ways. Performance and products were assessed at each workshop, activity, or event that had deliverables to confirm progressive growth by the teachers. Most teachers were highly committed and spent a great deal of time between events working on segments of the products. There were measurable performance, process, product, and technological outcomes. These were identifiable and could be assessed and evaluated.

Teacher feedback

Teachers received feedback about their progress at each stage, so they could then modify aspects along the way. This ongoing assessment with immediate feedback usually ensured high-quality products and performances. If having difficulty, teachers could seek further assistance. Although most used the feedback to revise their work, some either chose to ignore the feedback or waited so long to make changes that they forgot what it involved, even when written feedback was available. Generally, an average of 55-70% were highly committed and produced higher quality and useful educational products, also performing well. Another 25-45% were outstanding in the quality of their performances and product development. Finally, on an average, 0-5% participated for the wrong reasons and did not produce what was expected. We could not expel them from the program for political reasons. Thus program leaders tried very hard to motivate them.

First-year participants sometimes became involved in a staff development/curriculum project for the money. They assumed that they would be paid whether they did a good job or not. The 0-5% non-productive group did not often choose to continue beyond the initial year of participation.

Program Evaluation

Program pre-assessment

A district needs assessment related to teaching and learning was executed to prepare the project proposal. Evidence suggested that mathematics, science, and technology education needed improving and also reforming. The program was designed to engage Rockford's teachers in new teaching and learning practices, strategies, models, techniques, and procedures; to assist them in the development of partnerships with local education, business, industry, and community organizations to make learning more relevant and purposeful; to integrate curriculum across MSTE, also infusing information about careers and educational pathways to those careers; and to use performance assessment along with improved traditional assessment.

Program assessment

Program assessment occurred at every workshop, activity, and event. There were survey questionnaires that all participants completed for each event. This was the initial level of information. Participants consistently rated the activities and program leaders so highly that one could have justified not assessing at a deeper level. However, good qualitative data and research processes can provide the "why" and often the "how" to why things are going well or to why they need to improve or change.

Therefore, the process always involved external observation and interviewing. I determined which workshops, activities, or events to observe. This resulted in feedback to the project personnel and program leaders. I informally interviewed to gain deeper insight beyond that provided by the simple state-required surveys. Often the most insightful information gained was when teachers identified "what else" they would like to learn about.

Finally, program assessment also occurred based upon how well the teachers performed and delivered. A holistic picture was drawn from analyzing the level of performances and deliverables. There were three typical reasons for teacher failure: (1) they attended for the wrong reasons with the wrong attitudes, (2) they did not use the feedback to make important changes in their deliverables, or (3) they did not come to sessions prepared or with particular work completed. Overall, 95-98% of the teachers responded very positively; they worked very hard to learn as much as they could and deliver high-quality performance and product. They were usually very excited about producing something that was practical and best-practice based. They were appreciative of producing something that had rigor and could be used immediately to engage students in relevant learning.

Program feedback

The survey questionnaire data from each event was compared with the data from the observations and teacher participant and program leader interviews. This allowed me to triangulate the qualitative data for a deeper level of information. The surveys gave a very general picture; the interviews of the participants and program leaders added depth and more definition and more clearly identified what might need to be changed, enhanced, or extended.

Program evaluation

The project was organized to achieve eight major objectives:

1. Provide in-service education and training on a variety of targeted content and skills
2. Provide in-service training to district administrators and counselors on change, reform leadership, and strategic planning
3. Partner with local industry, community organizations, and the community college
4. Externally evaluate all activities through ongoing assessment, feedback, and formative and summative assessment
5. Produce a systemic reform model aimed at improving mathematics, science, technology, and English education through industrial and educational partnerships
6. Develop teacher skills in the use of computer technology for teaching and learning
7. Develop teacher skills in working with students to develop postsecondary and career goals
8. Develop long-term sustainability and continuous improvement plan

Evaluation outcomes

All but one of the objectives was accomplished. The in-service education exceeded all expectations. The PI recruited funding to extend the program beyond its initial level and number of activities. She was able to build the program into several levels of in-service programming and piloting; each year the initial or base level program was offered to new participants as planned, and then veteran participants could return for greater depth and additional staff development opportunities. With each advanced level, participants followed through with piloting. This developed knowledge and skills to a much greater breadth and depth and enhanced sustainability.

The district engaged in intense training for reform leadership and strategic planning; therefore, it would have been redundant to require administrators to participate in a similar activity. Instead, this objective was met by the district and was determined to be a match. However, the district was in such political turmoil and had experienced such great turnover at all administrative and teaching levels that it was really impossible to get much administrator cooperation beyond that required. The partnership between the district and its local community college was enhanced. The connections are expected to last beyond the grant period. Teachers responded well to the professors and were excited by their workshops and the prospect of future collaboration.

The business and industry and community (BIC) organizations provided overwhelming support, with more than 300 organizations participating over the grant period. Teachers had a minimum of three and up to five days in local companies or community organizations annually. This aspect of the program was exceptional in every way. The ability of the industrial liaison (IL) to work with organizations to help them understand what they could provide resulted in companies offering more extensive and higher quality experiences. The IL made suggestions; she also coordinated what teachers needed based upon the learning standards chosen as the basis for their modules, as well as their backgrounds, and then worked with them to schedule the experiences. Having an IL presented teachers with much greater opportunity in the broader sense, provided experiences during which they could deepen their knowledge, and also gave them real-world problems around which to build their student performances and problem-based curricula. The teachers connected with partners for the long term and felt more comfortable and confident requesting help from them. At the beginning of each project year, an industry/articulation activity was scheduled for all participants. Stakeholders from both Rock Valley College (RVC) and Northern Illinois University (NIU) met with an industry panel to better understand the needs of business and industry. Relationships blossomed into teacher visits, guest speaker invitations, module development, classroom interaction, student field trips, equipment donations, and the opportunity for the BICs to provide better services to educators and students

Teachers were especially excited about the knowledge, skills, variety of disciplines, research interests, and approachability of their community college and university partners. Teachers felt much more connected to their regional university and local community college, becoming aware of the vast resource network available to them. The professors were interested in continuing their relationships with teachers after the grant period, and the teachers felt comfortable emailing or calling to request support.

All aspects of the project were externally evaluated. A systemic reform model was designed, developed, and evaluated as successful. Teachers received computers, printers, scanners, and digital cameras. They were trained on the hardware and a variety of software packages and were then motivated to use the technology for learning and producing educational products and processes. In fact, the teachers asked for more types of technology and software training, which were also delivered.

Teachers included careers and educational paths to careers in their newly developed curriculum and, during the pilots, worked with students to plan educational paths toward targeted career clusters. The duration of the project was not long enough to achieve measures of the number of students entering the community college or choosing technical careers.

The ongoing political turmoil in the district prevented the administration from developing a definite long-term sustainability plan. However, the new superintendent was a great supporter of this initiative. The teachers themselves provided strong evidence of sustaining their own changes. They were offered more than one year of training and piloting; many were able to participate in three or four years of development, with two to three years of piloting new curriculum, strategies, models, techniques, and technology with students. This changed the potential for sustainability in the classroom, so even though the district's political turmoil could delay the long-term sustainability of the district models, most of the teachers seemed to have moved into long-term sustainability of their new products and best practices. These teachers were seeking ongoing development. That is exactly where key project personnel planned for the project to be phased out and the district to continue. The RPS Board of Education was impressed with the initiative's outcomes and after receiving final documentation was to consider sustainability action.

One aspect of the program failed to meet expectations. One year the industrial liaison tried "clustering" teams and visiting industry sectors with all teams, as a new model to simplify coordination. However, teachers were not as satisfied, largely, we think, because the preparation did not change with the experience. The model should work well with appropriate preparation.

Teachers overwhelmingly reported that they had extended their knowledge, implemented major changes in their instructional strategies, begun to use performance assessments and rubrics, built integrated MSTE career-focused curricula that had rigor and were standards based, and learned to use computer technology for teaching and student learning, to name just a few of the major outcomes.

In addition:

1. Teachers changed their attitudes about education: teaching, co-teaching, working with counselors, using technology, working with low-performing students, using new strategies and curricula, and much more.
2. We saw evidence that teachers would sustain the improvements in MSTE education. However, it was impossible to determine if the systemic staff development model would be sustained.
3. All curricula and instructional decisions (within project parameters) were now based on state teaching and learning standards, largely due to this initiative.
4. Student pretests and posttests showed significant gain in learning. Although not formally used as measures, the performance assessments suggested that students made significant gains.
5. It was not possible to measure change in parental attitudes or numbers of students moving into technical careers.

Observed changes in participants

One of the goals of MSTE was to change the way education was delivered to students. Participating teachers were exposed to a myriad of models, strategies, etc. designed to encourage the use of alternative methods of instruction. Participants exhibited increased skills in developing curriculum, planning lessons, using rubrics, creating standards-driven objectives, and using a variety of teaching models to engage students in learning. Additionally, they were inspired, motivated, and confident in their ability to alter daily instruction from traditional direct delivery. Many teachers stated that their experience in this initiative had been their most stimulating and professionally enriching career activity.

Critical Personnel Factors

Principal investigator or project director

The PI was intensely involved in every aspect of the project. The PI wrote numerous grants based upon the premise of interdisciplinary delivery of mathematics, science, and technology/career/vocational and English education. All of the grants included the use of an external evaluator.

Below is a sampling of the expertise needed by the PI and EE:

> *Knowledge:* interdisciplinary teaming models and processes; project management; leadership, theory, and application; staff development strategies; best educational practices, research and evaluation methods and procedures; technical backgrounds
> *Abilities:* to motivate others, to build self-esteem and confidence, to build knowledge and skills, to establish standards, and to hold others accountable
> *Skills:* organization, management, leadership, interpersonal, and technological skills
> *Attitude:* to encourage, praise, build self-esteem, instill confidence and ownership, and be positive, flexible, and questioning

Project co-directors

Co-directors of such a project need to understand their opportunity to lead aspects of the project and contribute as full and equal members rather than wait to be directed. This was an opportunity to be part of the design team, to be able to design opportunities for college professors and teachers that had never been attempted, as well as to adapt some that were successful in other communities. The co-directors relied on NIU’s leadership, even though NIU encouraged local leadership and educational partners.

Administrative relationships

The PI and co-directors must have a close working relationship. If the key administrators design aspects together, work closely together, and feel comfortable putting issues on the table for open resolution, there is a much greater opportunity for success.

Key Personnel

Each individual involved in the content and delivery of the program must be knowledgeable about the overall goals of the initiative. Workshop presenters were well prepared, followed an outline of activities, distributed useful information using both hard copy and websites, provided information for ongoing contact, and exhibited a command of the subject content. The effectiveness of the workshops, scheduled at appropriate times during the development process, was crucial to provide information essential to teacher development. All key project personnel were effective. Participants rated all project personnel excellent or superior.

Critical Factors about Teacher Participants

Teachers come to a project with great differences in perspectives, backgrounds, motivations, and purposes. It is important to understand:

> *Purpose:* A few teachers joined for the technology, stipends, and graduate credit of continuing professional development units (CPDUs) toward certification renewal. Most, however, joined because they genuinely wanted to improve their teaching and student learning.
>
> *Expectations:* Some teachers expected to be paid for every hour of involvement; even when they did not complete something in a workshop, they requested pay for the extra hours it would take them to finish it at home. Most, however, understood that workshops were set up on averages, with time for assistance and work built in, and that it was their professional responsibility to come to the subsequent sessions with work completed so that they would be prepared to continue their developments in the new sessions.
>
> *Attitude:* Some of the teachers felt that they were entitled to all the technology, stipends, graduate credit, and CPDUs if they just sat in on the activities. They did not want to be held accountable for performances and product completion. However, the greater majority desired to learn what they could to make themselves better teachers and to increase student achievement.
>
> *Insecurities:* When working toward complex reform in districts that have issues, there are unexpected and hidden dynamics that can be great challenges to the project leadership. Teachers who feel very insecure when learning something new or who feel that they should already know something exhibit a defensive attitude that is difficult to work through. Some districts have become punitive in nature or at least have conditioned teachers to become invisible, when what should be desired is to have them knocking on the door every day asking for support. Teachers in politically charged districts may also fear success because they may be penalized by their peers if they are recognized for succeeding with students or as professionals. Some of our participants seemed to share these concerns, and project leaders had to find ways to build their self-esteem, confidence, professionalism, and willingness to shine as leaders.

District Climate: The Rockford Project

The project was successful in spite of a politically charged environment. There was limited support from the central administrative office and principals. The PI was determined to overcome challenges by motivating and working with the teachers and administrators. The grant exceeded its goals, with the exception of getting the administration to develop a long-term sustainability plan. The responsibility of long-term sustainability lies with the district leadership. Teachers cannot be held accountable for district-wide sustainability.

Overall Project Merit and Broader Impact

The greater impact of this project will result from the potential to learn from it and replicate it. Its results have intellectual merit, as exemplified by the models, program, strategies, philosophy, results, and outcomes, clearly speaking to others who may be seeking a more holistic approach to staff development for increased student learning and achievement. In this approach teachers pull the program, seeking to build more knowledge and skills and deepen their professionalism and commitment. It is well worth replicating in part or in whole.

Recommendations

All parties interested in improving education should examine this project carefully. Key events and indicators are guides in ensuring that the change process is effective:

1. Teachers involved must be challenged, and their comfort zone must be disturbed.
2. The administration has to be willing to block-program students and teachers if initiating a team structure.
3. Funding is required to attempt the change process.
4. Participants need support and nurturing.
5. District, university, or community college administration must support and strongly encourage participation, modeling through their own participation.
6. All investigators should become familiar with the wide range of literature confirming and informing the need such an initiative seeking to improve student achievement in MSTE and motivating them toward technical careers.
7. Teachers are not held accountable at the same level when not involved in a project.
8. Excellence in teaching is primary to classroom management and vice versa.
9. Program leaders model best practices.
10. For districts in turmoil, five years are required for institutionalization or sustainability to be achieved.
11. Explore the Online Evaluation Resource Library, http://oerl.sri.com, a resource for professionals seeking to design, conduct, document, or review project evaluations. OERL's mission is to support the continuous improvement of project evaluation.
12. A PI with appropriate qualifications is critical to success.
13. External funding is very helpful.
14. The collaboration of business/industry community organizations is a must.

15. Piloting a similar endeavor before attempting full implementation is advisable.
16. Reviewing professional literature on all teaching/learning concepts as well as other topics included in the program is helpful.
17. Developing a standards-driven approach to curriculum and process development is essential.
18. School districts need to team with higher education partners.
19. Stakeholders need to thoroughly understand the goals of such a project.
20. Parties should never lose sight of the purpose of education, the development of lifelong learners who contribute to society

This initiative began in 1997, with NSF funding for the final three years. Unfortunately, OERL was not available at the time, but the evaluation process used was confirmed when the resource became available. The information presented in the OERL was used to benchmark the processes used in this project. Table 1 lists OERL procedures and methods of reporting evaluation data and a description of the methodology followed in this project.

OERL lists areas of standards for program evaluation:

Utility Standards: intended to ensure that an evaluation will serve the information needs of intended users.

Table 34.1 OERL to MSTE Methodology Comparison

	S=Similar procedure followed	
OERL		**Strategic Alliance**
Reports -2 types		**Reports -2 types**
1. Progress report-formative information and recommendations	**S**	1. Progress report-formative information and recommendations
2. Final report-summarize qualitative and quantitative data	**S**	2. Final report-summarize qualitative and quantitative data
Plans -2 types		**Plan**
1. Embedded	**S**	Embedded-Included within NSF Proposal narrative
2. Stand-alone		
Instruments		**Instruments**
1. Questionnaires	**S**	1. Questionnaires
2. Surveys	**S**	2. Surveys
3. Interviews	**S**	3. Interviews
4. Assessments	**S**	4. Assessments
		5. Event and Site visitations

Feasibility Standards: intended to ensure that an evaluation will be realistic, prudent, diplomatic, and frugal.

Propriety Standards: intended to ensure that the evaluation will be conducted legally, ethically, and with due regard for the welfare of those involved in the evaluation, as well as those affected by its results.

Accuracy Standards: intended to ensure that an evaluation will reveal and convey technically adequate information about the features that determine worth or merit of the program being evaluated.

Each of the four areas has subsets that clearly identify all aspects of the evaluation process. Using this information, the evaluator can easily be evaluated. OERL information related to evaluation standards is essential to a PI when considering the employment of an external evaluator. Additional standards are available to evaluate students and personnel; they are similar in format to the program evaluation standards.

The process used met the standards in each of these areas. The NIU project was supported by a grants compliance office and fiscal/administrative agents. The EE, as a third party, was another requirement for accomplishing the process with rigor, objectivity, and integrity. Finally, program leaders and participants shared in all assessment and evaluation activities and processes.

Closing Statement

Anyone interested in developing a proposal should explore OERL for ideas related to curriculum development, teacher education, faculty development, laboratory improvement, under-represented populations, and technology. The information is designed to be used without extensive revisions.

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35. Echoes Across the Years: What the Teachers Had to Say

Jule Dee Scarborough & Joseph Kolar

Over the years of this initiative and its pilots, teachers participated in a continuous feedback and evaluation process about the program's delivery, leaders, changes they would like to see, and much more. This chapter provides data that reflects the previous years, echoing the feedback, evaluations, and comments across the years in Rockford, the regional groups, the Chicago groups, the small and rural schools groups, and the NSF funded PHYS-MA-TECH groups. The information for the final year also applies to most of the program components offered throughout the entire time period. Most of the various kinds of workshops were offered during the final year, and for those not reported, the feedback and evaluations can be reviewed at the website. The website (www.strategicalliance.niu.edu) makes available feedback and evaluation data from each of the project and pilot years, through state event forms and end-of-year questionnaires.

For each year of the grant-funded initiative, a variety of feedback and evaluation data and information was collected. The most important and most thorough was collected in two formats. (1) Throughout each year, we used the state-required form for any events that provided teachers with recertification units. Although this form fell short of asking questions we would have liked to ask, it informed us generally about each event and did help us determine if corrective action was needed. (2) However, to augment the information provided by that form, at the end of each year, teachers completed a questionnaire about the overall experience throughout the entire year. This gave us valuable information and was also used to determine any necessary changes for the next year. The open-ended responses from both questionnaires provided deeper insight as well. We accumulated far more feedback and evaluative data and information than can be presented here, and instead we offer selections.

Each participating teacher was required to complete at least the basic program and follow through with piloting the second year. Some joined us for each year, beginning with the pre-NSF pilots funded by the state and continuing in each new round of professional development. Each year involved a new group of teachers in the basic program, while others continued to follow through for two or three years on average. Each year, the basic program continued and other workshops were added. An important aspect of this program is that teachers could continue at different levels – broadening and deepening their knowledge and skills at each level. The following reflects their perceived value of the program.

Final Year of Grant

For each workshop or event, feedback forms informed project leaders of any concerns, issues, or problems to be considered and addressed. However, with the exception of one year (described below), there was very little to address.

Lessons from the Difficult Year

During one of the years of the Rockford project, we had to address difficulties so severe that we used a formal conflict resolution process. That was the only time, in all our projects, when we needed formal conflict resolution, but we had never before worked with a district where the climate involved so many political and attitudinal factors.

For one year of the program, district leaders changed the time that had been scheduled to spend with the teachers; instead they decided to let the teachers complete the development of the modules on their own and without support. In adjusting, the district agreed to at least let us offer some help days for support. However, teachers were not required to use the support. Those who sought it did well and completed their modules. Those who did not seek our assistance, however, did not complete their modules, delivered low-quality work, and were so frustrated and afraid of being penalized by the district that they disrupted the program scheduled for the week of their return to us (the two weeks before school started). Teachers felt guilty for not completing their modules or for doing so at low quality levels and acted out against some of the project leaders.

When we tried to move forward with the scheduled program, the recalcitrant teachers refused, saying that they needed to finish their modules or they would not get their stipends due at the end of the summer. We had never mentioned withholding of stipends as a possibility in the situation, and in fact union rules required that teachers had to be paid for “seat” time, whether finishing requirements or not. Completing work had not usually been a problem. Teachers felt a normal sense of pressure from our desire to work at a fast pace, but we provided the support they needed at any given point.

It was a horrible way to end a year. We resorted to a good and reliable conflict resolution process, with observers who could vouch for its integrity, but accomplished little. We scrapped some of our program, gave additional time to finish the modules, and paid the stipends. We discussed various options among ourselves but were powerless to change anything. So when teachers did not appear for the support sessions and then showed up with incomplete modules, we were disappointed but not surprised. It was a traumatic event for all of us and the teachers as well.

The second big issue confronted during that same time period was a strike by the teachers. While we were working with them, their union was deciding whether to go on strike against the district. This added to the complexity of the situation, increased poor attitudes, and contributed to a fear by some of our teachers that they might be punished for not delivering what they had committed to. This was not my first experience with a strike or a late start to the school year. Several years before, while working with approximately 150 teachers in the Chicago district, three of five school years had traumatic beginnings. To the credit of the teachers, however, they took it all in stride, remained positive, perceived the grant initiative as an overall positive, and found ways to adapt to the situation. Therefore, when the Rockford teachers threatened to go on strike, we understood that the tense situation did not inevitably have to produce a negative climate. The difference, in our view, was that the Rockford teachers felt badly about not living up to their commitments.

We have drawn some lessons from that difficult year. (1) When the integrity of a program is in jeopardy and the outcome could be worse than refusing to do it a different way or not at all, it is better to hold true to the right and best way and refuse to do the program at that time. It is better to wait to deliver it when things can be appropriately accomplished. (2) When using a conflict resolution procedure, especially with a group that lives in perpetual conflict and turmoil, it is a good idea to have objective observers who can vouch that the process has integrity and is of the highest standard or best practice and that the individuals leading it have integrity and can lead it appropriately.

Our lessons do not imply that we would shy away from districts that have issues because they are where the greatest impact can be accomplished for students. In fact, most of our initiatives have been intentionally with districts needing support for change and reform. Generally, we feel very good about the results each year of the project, even this one, but it is important to understand that when working with districts in need or politically charged, there are times that are not easy and may require conflict resolution.

Summary

We have found that most teachers will provide useful and informative feedback and that they will evaluate professional development, support, leadership, quality, needed or desired improvements or changes fairly accurately. We have chosen to show our respect by listening and valuing their responses, thoughts, commitment, dedication, respect, quality, and productivity. The program keeps growing because they feel that it is their program and that we have their goals as our primary purpose. When trust and understanding are the foundation for working together, the feedback and evaluation are genuine and well-meant.

The following data reflect what teachers had to say about the last project year; data from all the other years are available on the website: www.strategicalliance.niu.edu.

Table 35.1 Program-Specific Questions

		Percentage	
Question 1	Superior	44%	Overall, when considering all NSF workshops that I attended this year, I feel that their value has been
	Excellent	48%	
	Good	4%	
	Fair	4%	
	Unsatisfactory	0%	
Question 2	Yes	69%	I am better prepared to use standards as a basis for curriculum, learning activities, daily lessons, student assessments, and other instructional decisions because of my involvement in the NSF project
	Most of the Time	27%	
	Somewhat	2%	
	Seldom	2%	
Question 3	Yes	79%	I am better prepared to use technology and related software in my teaching.
	Most of the Time	18%	
	Somewhat	6%	
	Seldom	0%	
Question 4	Yes	69%	Has the NSF project changed my thinking about the use of inter-disciplinary instruction in my teaching?
	Most of the Time	16%	
	Somewhat	10%	
	Not Really	4%	
Question 5	Yes	67%	I'm better prepared to develop and implement an interdisciplinary curriculum in the areas of math, science, English and/or technology.
	Most of the Time	25%	
	Somewhat	6%	
	Not Really	2%	

Table 35.2 Program Specific Questions (continued)

Question 6	Yes	86%	I am more informed about the Illinois Student Learning Standards in my own discipline
	Feel More Confident	10%	
	Somewhat	2%	
	No	2%	

Question 7	Yes	72%	I am more informed about the Illinois Student Learning Standards in other disciplines, e.g. mathematics, science, language arts, and the national technology standards.
	Feel More Confident	22%	
	Somewhat	4%	
	No	2%	

Question 8	Yes	78%	The NSF has prepared me to use a wider variety of teaching strategies and teaching models
	Feel More Confident	16%	
	Somewhat	4%	
	No	2%	
Question 9	Yes	70%	I have learned to develop more authentic performance-based assessment(s) to measure student achievement
	Feel More Confident	22%	
	Somewhat	6%	
	No	2%	

1st Question 10	Yes	73%	I have learned to develop rubrics for assessing student performance
	Feel More Confident	16%	
	Somewhat	7%	
	No	4%	

2nd Question 10	Yes	70%	The NSF project has increased my ability and potential to incorporate real world problems and applications, and/or to organize learning around real world or career themes, connection the classroom to the world of work
	Feel More Confident	26%	
	Somewhat	2%	
	No	2%	

Table 35.3 Program-Specific Questions (continued)

Question 11	Yes	80%	I have increased my ability to bring more career awareness into my curriculum
	Feel More Confident	15%	
	Somewhat	2%	
	No	2%	

Question 12	Excellent and Extremely Helpful	40%	My involvement with the Rock Valley College faculty has resulted in valuable professional growth that has been (circle one)
	Very Good and Helpful	47%	
	Not as Helpful as Expected	13%	
	Poor and Not Really Helpful	0%	

Question 13	Excellent and Extremely Helpful	61%	My involvement with the NIU faculty has resulted in valuable professional growth that has been (circle one)
	Very Good and Helpful	34%	
	Not as Helpful as Expected	5%	
	Poor and Not Really Helpful	0%	

Question 14	Yes	72%	The NSF project has expanded my teaching philosophy, enhanced my vision for my students, and expanded my potential opportunities to use more best practices in pedagogy (teaching and learning)
	Feel More Confident	22%	
	Somewhat	4%	
	No	2%	

Table 35.4 Program-Specific Questions (continued)

Question 15	*A. See the connections between levels and courses	94%	The articulation workshop involving middle schools, high schools, RVC and NIU helped me to:
	*B. Understand what content should be covered at the different levels	72%	
	*C. Better align my course content	72%	
	*D. Better understand how community college or university students are assessed on knowledge or concept attainment	49%	
	*E. Better understand how the community college or university uses technology in teaching and learning	62%	
	*F. Better understand how community college and university courses are taught	66%	
	*G. Better understand how to guide students from high school to the community college and on to the university (2+2+2)	49%	
	*H. Better understand the community college and university admissions for high school students	62%	
	*I. Others	6%	
Question 16	*A. Understand the career opportunities directly related to my discipline	53%	The workshop on Ed Paths to Careers at RVC helped me to:
	*B. Increased my knowledge of careers so that I can better inform my students	60%	
	*C. Understand the levels of math, science, English and other disciplines that are required for particular career tracks	66%	
Question 17	*A. Understand the career opportunities directly related to my discipline	98%	The workshop on Ed Paths to Careers at NIU helped me to:
	*B. Increased my knowledge of careers so that I can better inform my students	60%	
	*C. Understand the levels of math, science, English and other disciplines that are required for particular career tracks	68%	

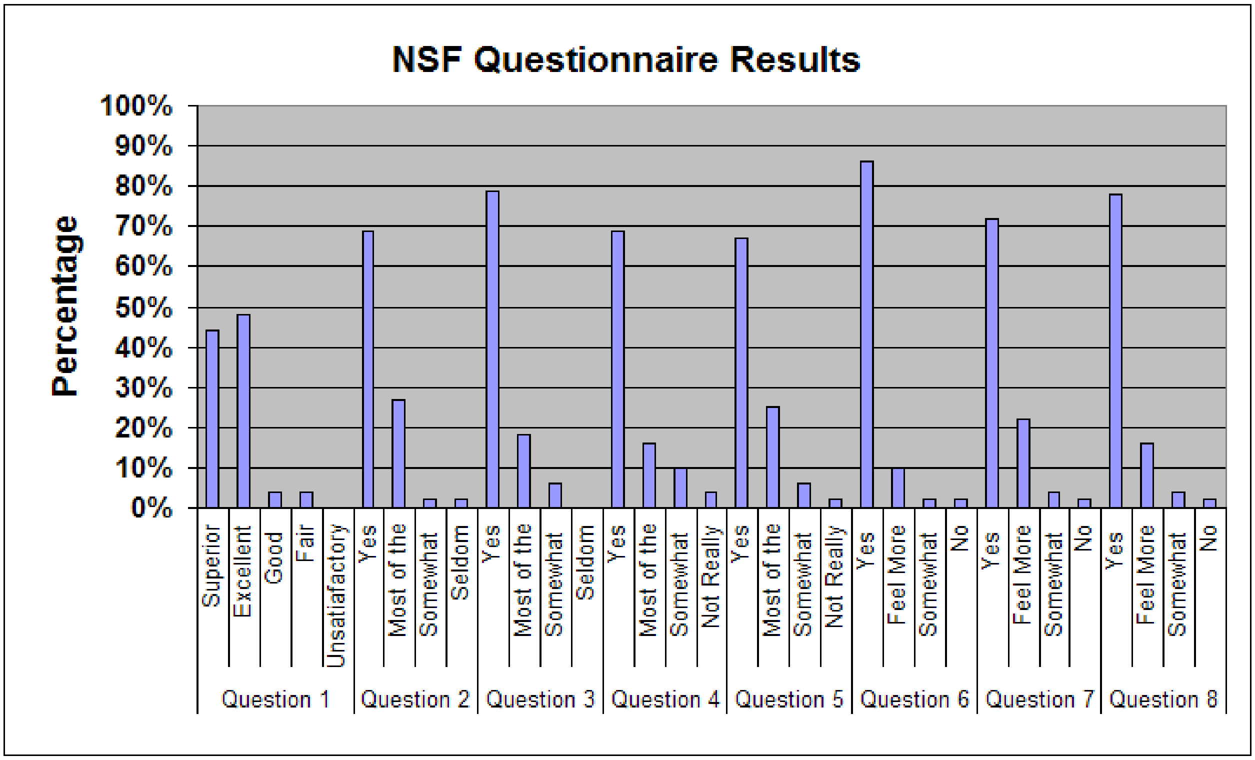

Figure 35.1 NSF Questionnaire Results

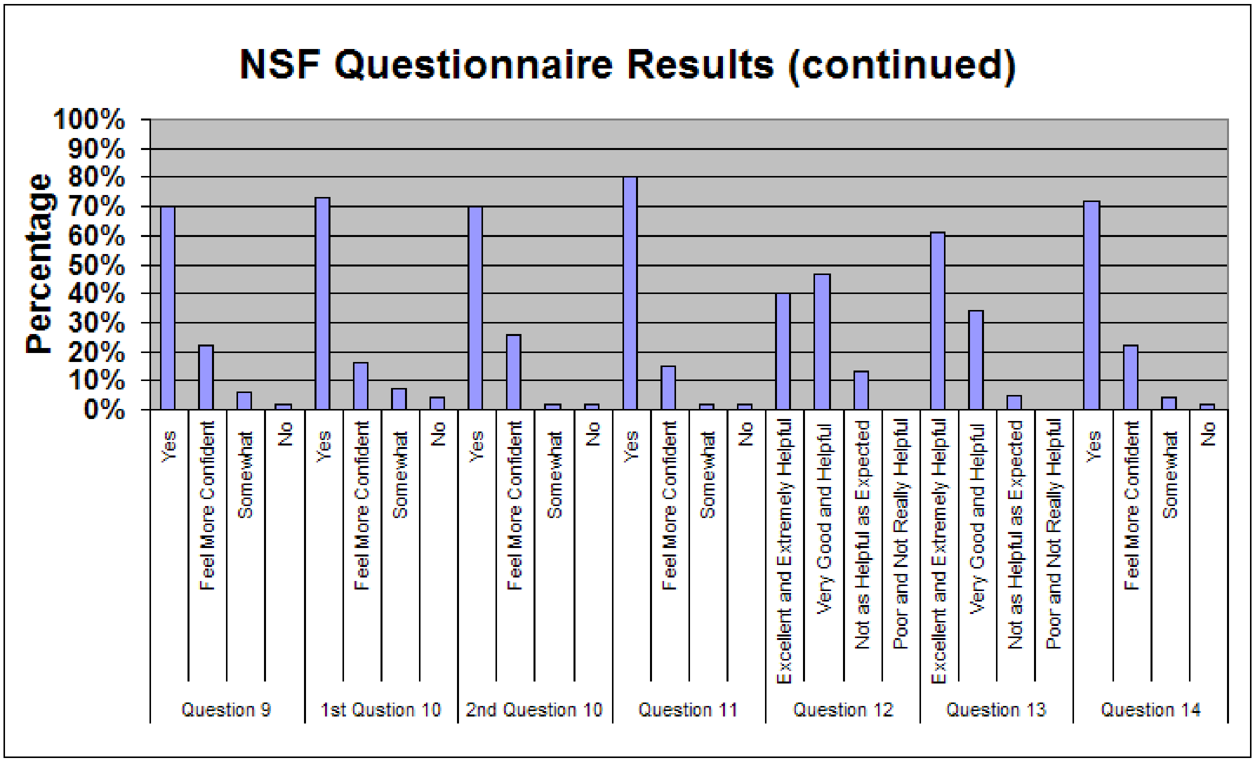

Figure 35.2 NSF Questionnaire Results

Evaluations by Workshops and Comments Using the State-Required Form for Teacher Recertification Professional Development Events: Individual Workshop Feedback

Table 35.5 Workshop Evaluation Response

			Sept '02			
			Integrated Models L1	Industry Articulation	Graphic Organizers	ICD Orientation
Question 1	This activity increased my knowledge and skills in my areas of certification, endorsement or teaching assignment	Strongly Agree	72%	65%	88%	60%
		Somewhat Agree	17%	26%	9%	33%
		Other	11%	9%	3%	7%
			Integrated Models L1	Industry Articulation	Graphic Organizers	ICD Orientation
Question 2	The relevance of this activity to ISBE teaching standards was clear	Strongly Agree	94%	74%	88%	90%
		Somewhat Agree	6%	9%	3%	10%
		Other	0%	17%	9%	0%
			Integrated Models L1	Industry Articulation	Graphic Organizers	ICD Orientation
Question 3	It was clear that the activity was presented by persons with education and experience in the subject matter.	Strongly Agree	94%	92%	88%	87%
		Somewhat Agree	6%	4%	6%	13%
		Other	0%	4%	6%	0%
			Integrated Models L1	Industry Articulation	Graphic Organizers	ICD Orientation
Question 4	The material was presented in an organized, easily understood manner	Strongly Agree	67%	70%	84%	80%
		Somewhat Agree	11%	26%	6%	20%
		Other	22%	4%	9%	0%
			Integrated Models L1	Industry Articulation	Graphic Organizers	ICD Orientation
Question 5	This activity included discussion, critique, or application of what was presented, observed, learned, or demonstrated.	Strongly Agree	72%	87%	88%	80%
		Somewhat Agree	22%	9%	6%	20%
		Other	6%	4%	6%	0%

Table 35.6 Workshop Evaluation Response (continued)

		Oct '02				
Ed Paths to Careers	Share Point	HS Disc Up B/C	HS Disc Up Tech	HS Disc Up English	HS Disc Up Physics	Laser L1 & L2
60%	92%	100%	100%	100%	100%	79%
30%	8%	0%	0%	0%	0%	11%
10%	0%	0%	0%	0%	0%	10%

Ed Paths to Careers	Share Point	HS Disc Up B/C	HS Disc Up Tech	HS Disc Up English	HS Disc Up Physics	Laser L1 & L2
70%	92%	100%	100%	100%	100%	69%
20%	8%	0%	0%	0%	0%	21%
10%	0%	0%	0%	0%	0%	10%

Ed Paths to Careers	Share Point	HS Disc Up B/C	HS Disc Up Tech	HS Disc Up English	HS Disc Up Physics	Laser L1 & L2
90%	100%	100%	100%	100%	100%	90%
5%	0%	0%	0%	0%	0%	5%
5%	0%	0%	0%	0%	0%	5%

Ed Paths to Careers	Share Point	HS Disc Up B/C	HS Disc Up Tech	HS Disc Up English	HS Disc Up Physics	Laser L1 & L2
80%	92%	100%	100%	100%	100%	85%
10%	8%	0%	0%	0%	0%	5%
10%	0%	0%	0%	0%	0%	10%

Ed Paths to Careers	Share Point	HS Disc Up B/C	HS Disc Up Tech	HS Disc Up English	HS Disc Up Physics	Laser L1 & L2
65%	100%	100%	100%	100%	100%	90%
30%	0%	0%	0%	0%	0%	5%
5%	0%	0%	0%	0%	0%	5%

Table 35.7 Workshop Evaluation Response (continued)

Nov '02

Elec Port L2	Share Point VSP	Ed Paths to Career L1	Elec Port L2	HS Disc Up L2 B/C	HS Disc Up L2 Tech	HS Disc Up L2 Physics
76%	91%	68%	76%	100%	100%	100%
21%	0%	32%	12%	0%	0%	0%
3%	9%	0%	12%	0%	0%	0%

Elec Port L2	Share Point VSP	Ed Paths to Career L1	Elec Port L2	HS Disc Up L2 B/C	HS Disc Up L2 Tech	HS Disc Up L2 Physics
86%	91%	72%	68%	100%	100%	100%
10%	0%	23%	16%	0%	0%	0%
4%	9%	5%	16%	0%	0%	0%

Elec Port L2	Share Point VSP	Ed Paths to Career L1	Elec Port L2	HS Disc Up L2 B/C	HS Disc Up L2 Tech	HS Disc Up L2 Physics
90%	91%	96%	80%	100%	100%	100%
7%	0%	4%	12%	0%	0%	0%
3%	9%	0%	8%	0%	0%	0%

Elec Port L2	Share Point VSP	Ed Paths to Career L1	Elec Port L2	HS Disc Up L2 B/C	HS Disc Up L2 Tech	HS Disc Up L2 Physics
80%	91%	77%	68%	100%	100%	100%
10%	0%	18%	24%	0%	0%	0%
10%	9%	5%	8%	0%	0%	0%

Elec Port L2	Share Point VSP	Ed Paths to Career L1	Elec Port L2	HS Disc Up L2 B/C	HS Disc Up L2 Tech	HS Disc Up L2 Physics
83%	91%	73%	76%	100%	100%	100%
14%	0%	27%	16%	0%	0%	0%
3%	9%	0%	8%	0%	0%	0%

Table 35.8 Workshop Evaluation Response (continued)

		Dec '02	Jan '03			
GIS L1 & L2	GIS L1 & L2	GIS (GPS) L1 &L2	Agro Innovations	ICD Writing Models	Share Point L1& L2	Mod Writing
59%	68%	77%	100%	84%	76%	81%
14%	16%	14%	0%	14%	21%	14%
29%	15%	9%	0%	2%	3%	5%

GIS L1 & L2	GIS L1 & L2	GIS (GPS) L1 &L2	Agro Innovations	ICD Writing Models	Share Point L1& L2	Mod Writing
50%	53%	68%	100%	88%	76%	88%
32%	16%	18%	0%	12%	17%	12%
29%	31%	14%	0%	0%	7%	0%

GIS L1 & L2	GIS L1 & L2	GIS (GPS) L1 &L2	Agro Innovations	ICD Writing Models	Share Point L1& L2	Mod Writing
68%	74%	77%	100%	92%	93%	83%
14%	11%	14%	0%	8%	7%	15%
18%	16%	9%	0%	0%	0%	2%

GIS L1 & L2	GIS L1 & L2	GIS (GPS) L1 &L2	Agro Innovations	ICD Writing Models	Share Point L1& L2	Mod Writing
32%	58%	73%	100%	78%	93%	83%
27%	5%	14%	0%	20%	7%	7%
41%	37%	13%	0%	2%	0%	10%

GIS L1 & L2	GIS L1 & L2	GIS (GPS) L1 &L2	Agro Innovations	ICD Writing Models	Share Point L1& L2	Mod Writing
59%	53%	68%	88%	88%	93%	78%
9%	21%	23%	0%	10%	7%	12%
32%	26%	9%	12%	2%	0%	10%

Table 35.9 Workshop Evaluation Response (continued)

Feb '03

MS Disc Up Math	MS Disc Up B/C	MS Disc Up English	Brain Research	Green Chem L2	Teach Models L1	MS Disc Up Geology
0%	100%	100%	95%	100%	100%	100%
33%	0%	0%	0%	0%	0%	0%
66%	0%	0%	5%	0%	0%	0%

MS Disc Up Math	MS Disc Up B/C	MS Disc Up English	Brain Research	Green Chem L2	Teach Models L1	MS Disc Up Geology
0%	100%	100%	95%	100%	100%	100%
33%	0%	0%	0%	0%	0%	0%
66%	0%	0%	5%	0%	0%	0%

MS Disc Up Math	MS Disc Up B/C	MS Disc Up English	Brain Research	Green Chem L2	Teach Models L1	MS Disc Up Geology
100%	100%	100%	95%	100%	100%	100%
0%	0%	0%	0%	0%	0%	0%
0%	0%	0%	5%	0%	0%	0%

MS Disc Up Math	MS Disc Up B/C	MS Disc Up English	Brain Research	Green Chem L2	Teach Models L1	MS Disc Up Geology
100%	100%	100%	95%	100%	100%	100%
0%	0%	0%	0%	0%	0%	0%
0%	0%	0%	5%	0%	0%	0%

MS Disc Up Math	MS Disc Up B/C	MS Disc Up English	Brain Research	Green Chem L2	Teach Models L1	MS Disc Up Geology
100%	100%	100%	95%	100%	100%	100%
0%	0%	0%	0%	0%	0%	0%
0%	0%	0%	5%	0%	0%	0%

Table 35.10 Workshop Evaluation Response (continued)

MS Disc Up English	MS Disc Up Math	Cooperative Learning	Electronic Portf	HS Disc Up Bio	HS Disc Up English	Action Research
100%	67%	73%	96%	100%	100%	100%
0%	33%	20%	4%	0%	0%	0%
0%	0%	7%	0%	0%	0%	0%

MS Disc Up English	MS Disc Up Math	Cooperative Learning	Electronic Portf	HS Disc Up Bio	HS Disc Up English	Action Research
100%	33%	73%	86%	100%	100%	100%
0%	33%	14%	14%	0%	0%	0%
0%	33%	13%	0%	0%	0%	0%

MS Disc Up English	MS Disc Up Math	Cooperative Learning	Electronic Portf	HS Disc Up Bio	HS Disc Up English	Action Research
100%	100%	87%	96%	100%	100%	100%
0%	0%	13%	4%	0%	0%	0%
0%	0%	0%	0%	0%	0%	0%

MS Disc Up English	MS Disc Up Math	Cooperative Learning	Electronic Portf	HS Disc Up Bio	HS Disc Up English	Action Research
100%	67%	67%	96%	100%	100%	100%
0%	33%	27%	4%	0%	0%	0%
0%	0%	7%	0%	0%	0%	0%

MS Disc Up English	MS Disc Up Math	Cooperative Learning	Electronic Portf	HS Disc Up Bio	HS Disc Up English	Action Research
100%	33%	67%	96%	100%	100%	100%
0%	67%	27%	4%	0%	0%	0%
0%	0%	7%	0%	0%	0%	0%

Table 35.11 Workshop Evaluation Response (continued)

Mar '03

CAD	CAD	Mod Writing	Green Chem	Teach Models	WebQuests	Student Perf Asses
67%	75%	81%	100%	93%	100%	88%
22%	13%	13%	0%	7%	0%	6%
11%	12%	6%	0%	0%	0%	6%

CAD	CAD	Mod Writing	Green Chem	Teach Models	WebQuests	Student Perf Asses
89%	88%	91%	100%	100%	95%	88%
11%	12%	7%	0%	0%	5%	6%
0%	0%	2%	0%	0%	0%	6%

CAD	CAD	Mod Writing	Green Chem	Teach Models	WebQuests	Student Perf Asses
100%	88%	83%	100%	100%	100%	88%
0%	12%	5%	0%	0%	0%	6%
0%	0%	12%	0%	0%	0%	6%

CAD	CAD	Mod Writing	Green Chem	Teach Models	WebQuests	Student Perf Asses
78%	88%	81%	100%	93%	100%	81%
22%	12%	5%	0%	7%	0%	13%
0%	0%	14%	0%	0%	0%	6%

CAD	CAD	Mod Writing	Green Chem	Teach Models	WebQuests	Student Perf Asses
100%	88%	86%	100%	93%	100%	88%
0%	12%	7%	0%	7%	0%	6%
0%	0%	7%	0%	0%	0%	6%

Table 35.12 Workshop Evaluation Response (continued)

			May '03	June '03		
Student Perf Asses	Student Perf Asses	Navigation	Marco Polo	Webpage	Virtual Tour	Animation
100%	89%	71%	100%	89%	95%	93%
0%	0%	15%	0%	8%	0%	7%
0%	11%	14%	0%	4%	5%	0%

Student Perf Asses	Student Perf Asses	Navigation	Marco Polo	Webpage	Virtual Tour	Animation
100%	89%	57%	100%	81%	95%	93%
0%	0%	29%	0%	12%	0%	7%
0%	11%	14%	0%	8%	5%	0%

Student Perf Asses	Student Perf Asses	Navigation	Marco Polo	Webpage	Virtual Tour	Animation
100%	89%	93%	100%	92%	95%	100%
0%	0%	7%	0%	4%	0%	0%
0%	11%	0%	0%	4%	5%	0%

Student Perf Asses	Student Perf Asses	Navigation	Marco Polo	Webpage	Virtual Tour	Animation
100%	83%	64%	94%	89%	95%	100%
0%	0%	29%	6%	8%	0%	0%
0%	17%	7%	0%	4%	5%	0%

Student Perf Asses	Student Perf Asses	Navigation	Marco Polo	Webpage	Virtual Tour	Animation
100%	89%	57%	94%	89%	95%	100%
0%	0%	21%	0%	8%	0%	0%
0%	11%	21%	6%	4%	5%	0%

Table 35.13 Workshop Evaluation Response (continued)

Tech Help Day	Module Completion
96%	88%
0%	8%
4%	4%

Tech Help Day	Module Completion
96%	90%
0%	7%
4%	3%

Tech Help Day	Module Completion
96%	89%
0%	3%
4%	8%

Tech Help Day	Module Completion
96%	88%
0%	4%
4%	9%

Tech Help Day	Module Completion
96%	90%
0%	3%
4%	7%

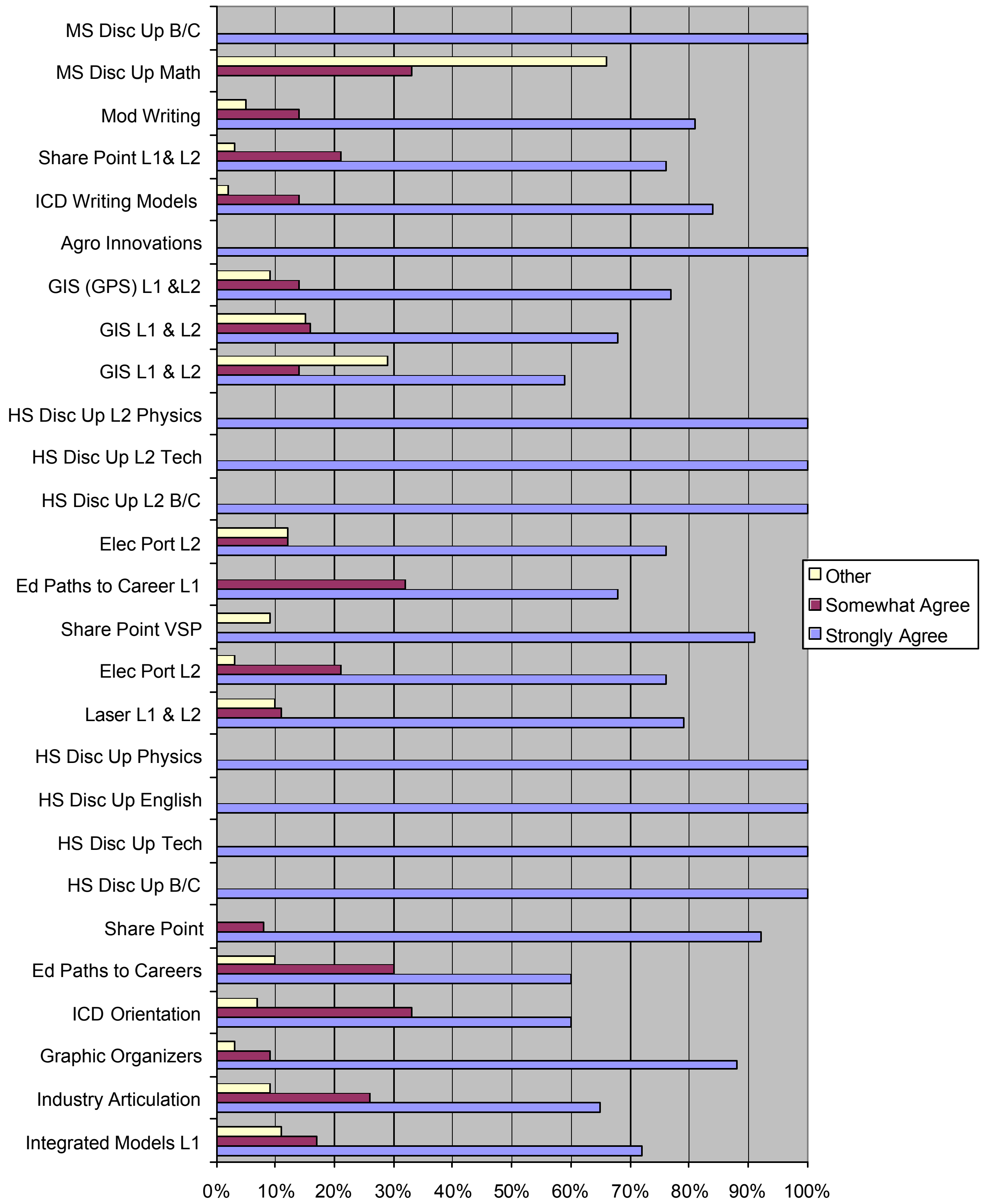

Figure 35.3 Question 1 - Increased Knowledge and Skills (part 1)

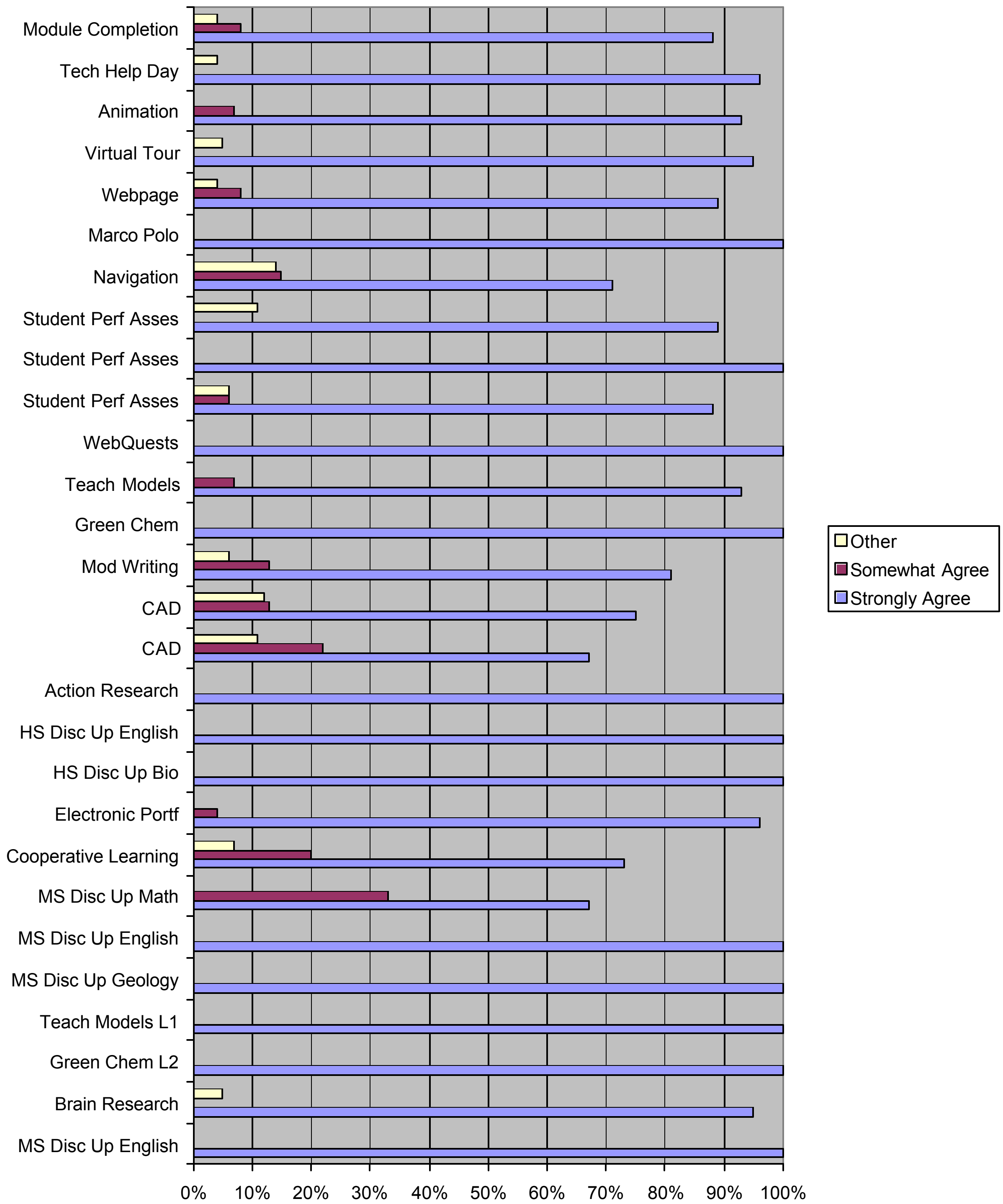

Figure 35.4 Question 1 - Increased Knowledge and Skills (part 2)

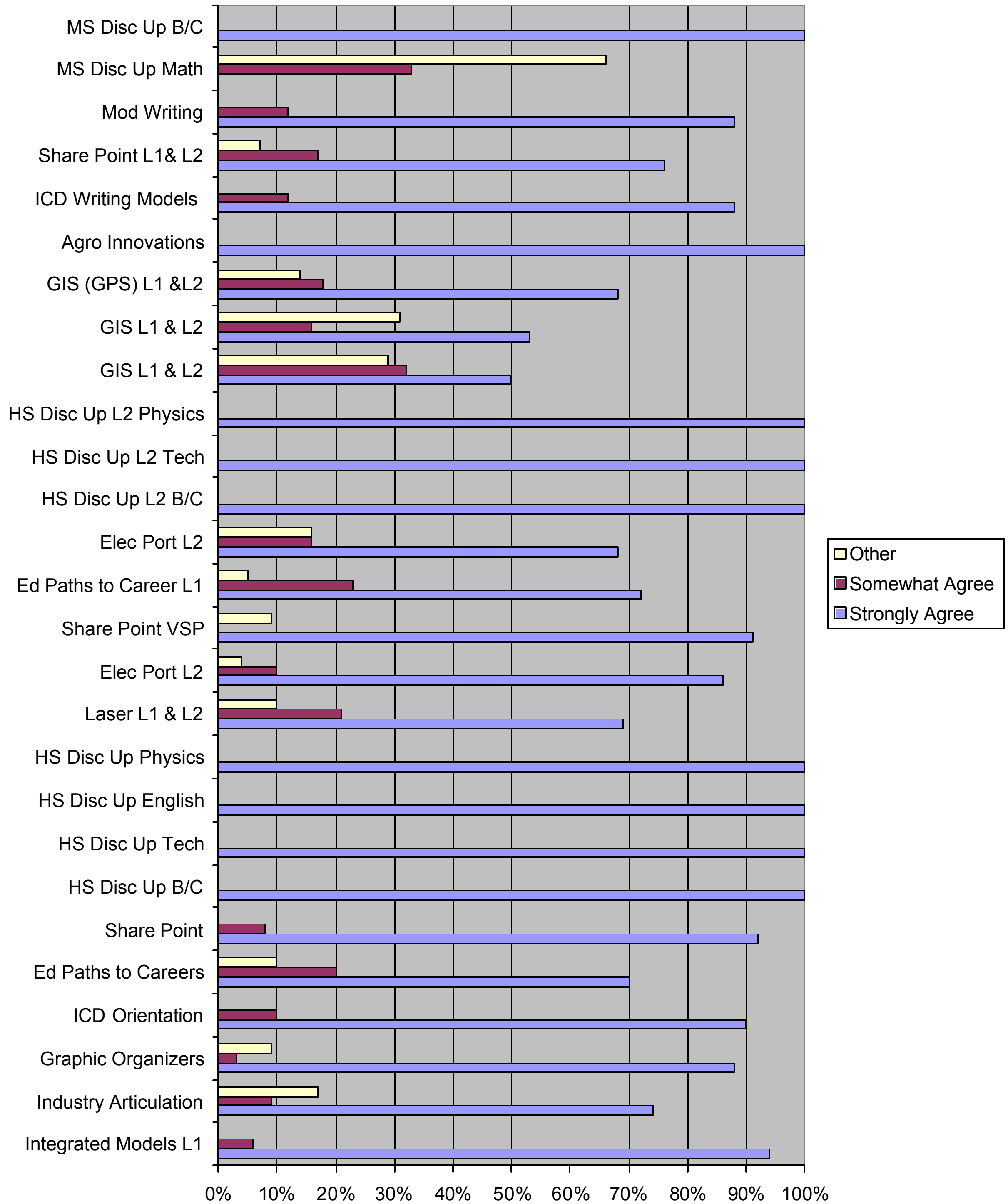

Figure 35.5 Question 2 - Relevance to Teaching Standards (part 1)

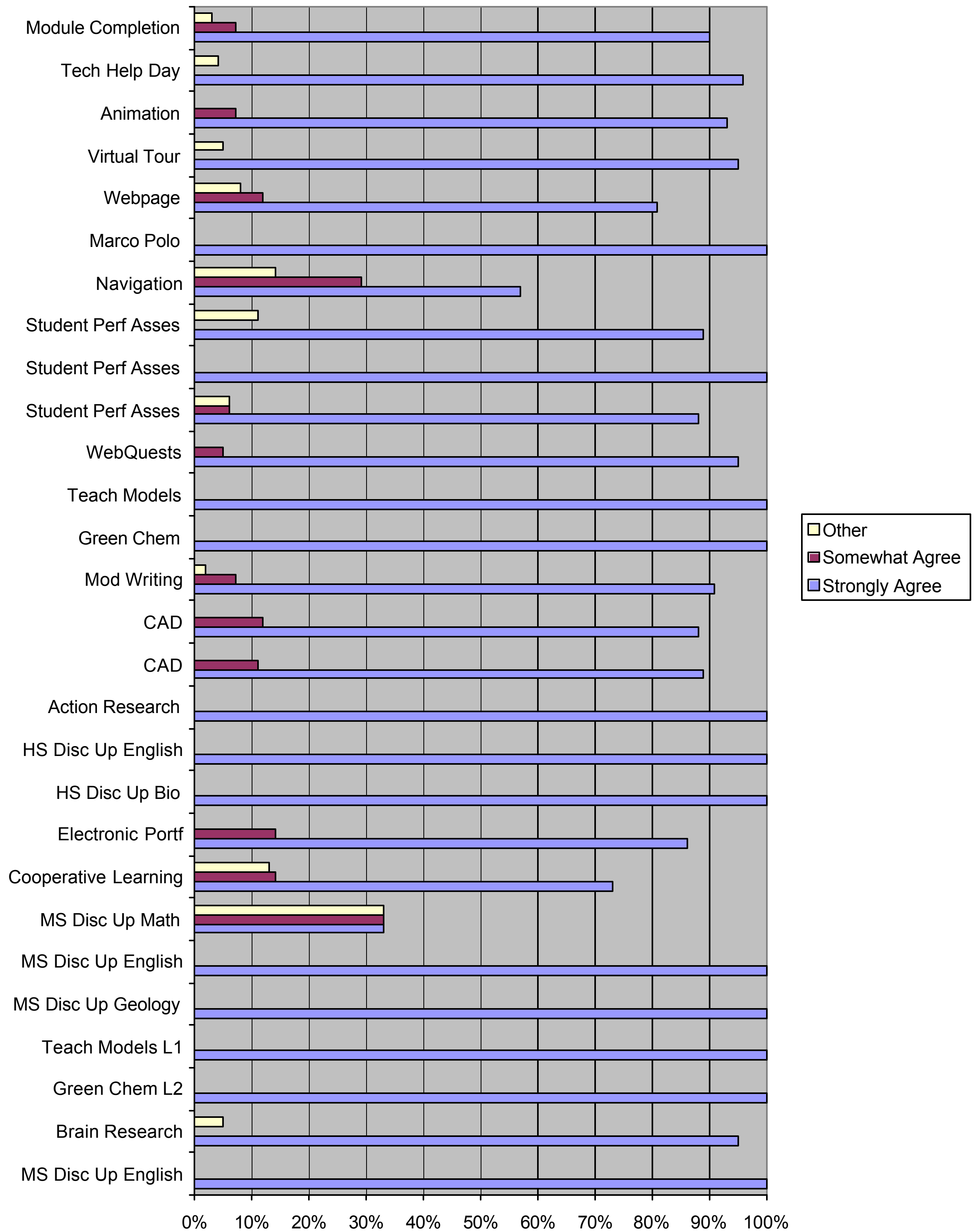

Figure 35.6 Question 2 - Relevance to Teaching Standards (part 2)

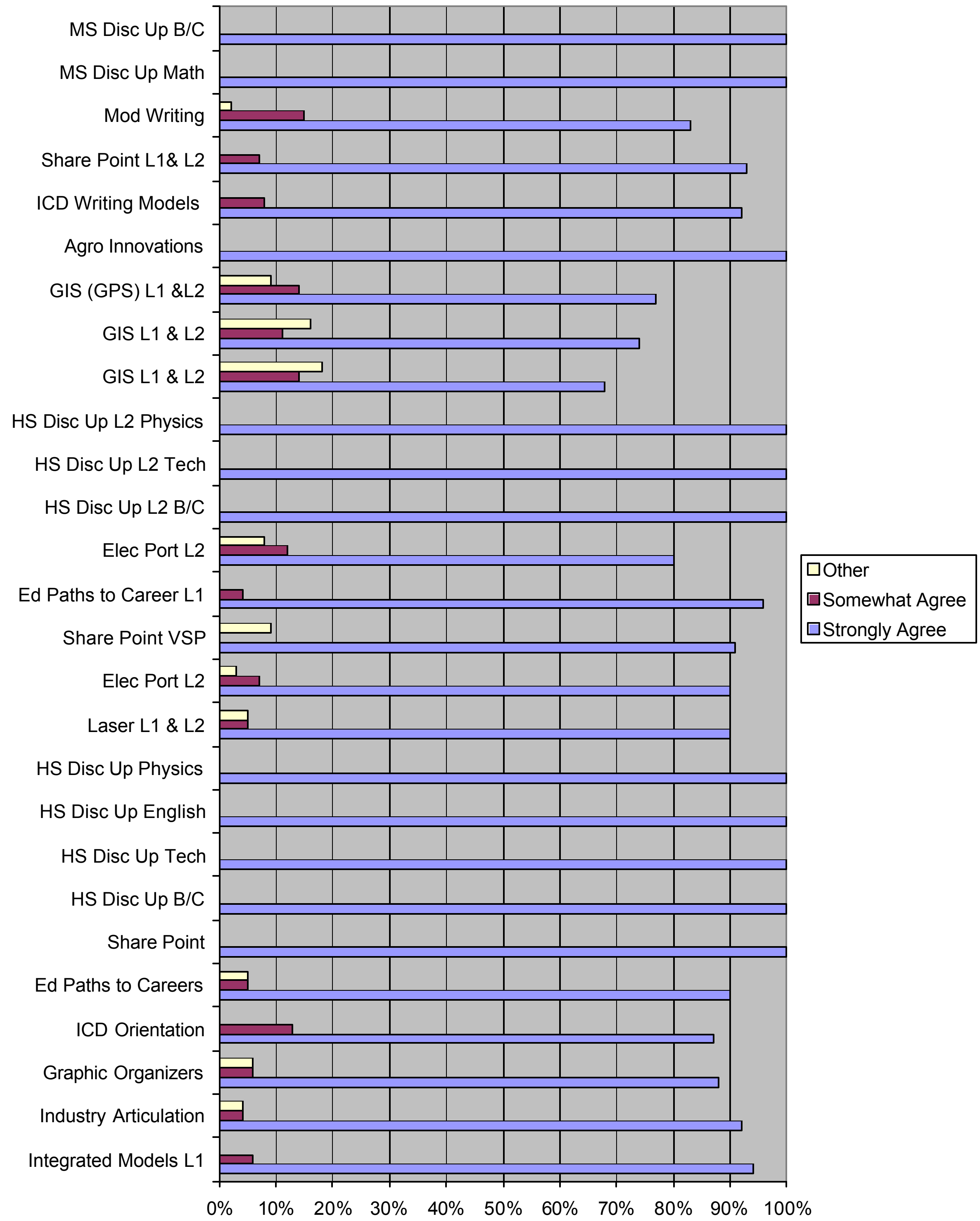

Figure 35.7 Question 3 - Presented by Experienced People (part 1)

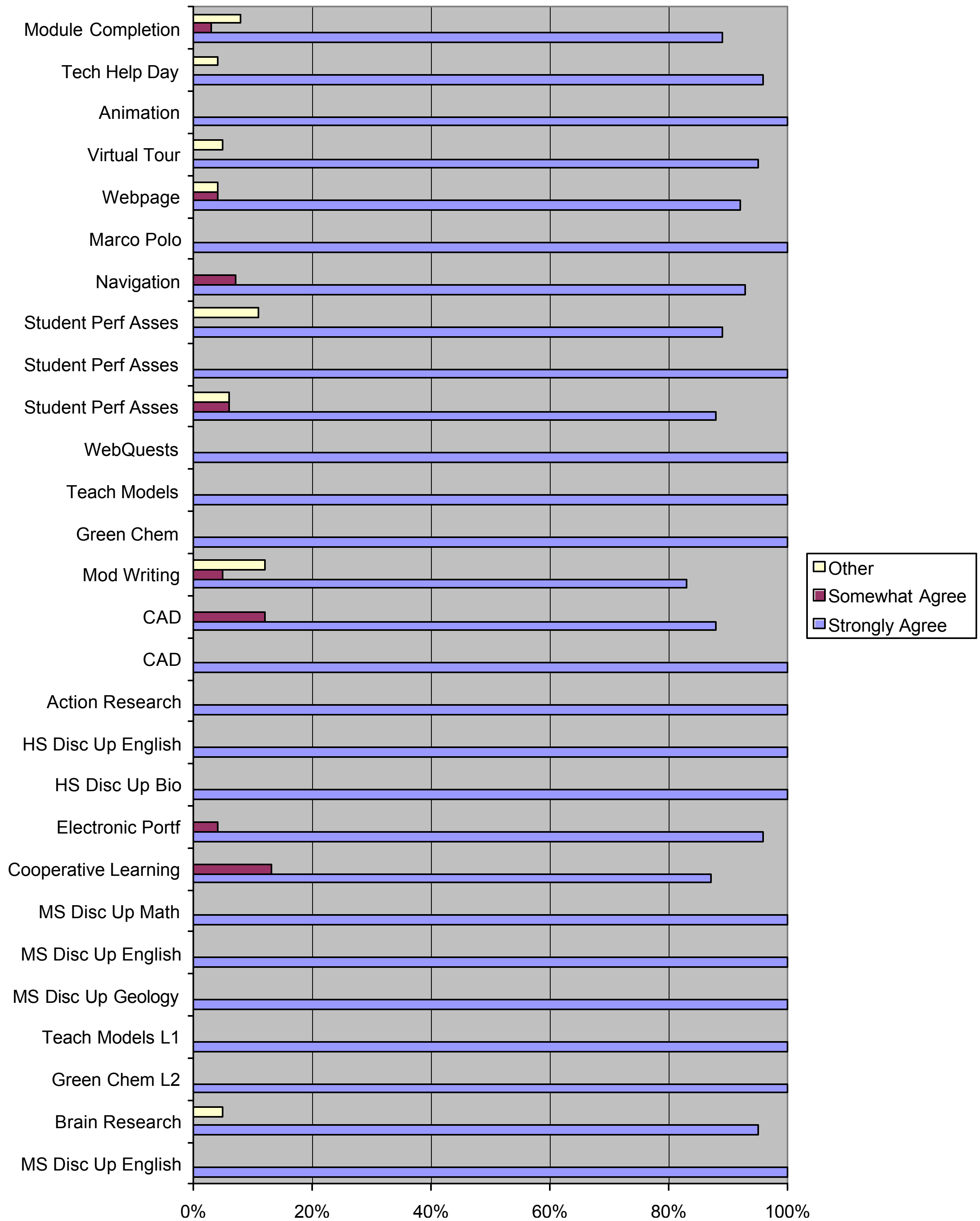

Figure 35.8 Question 3 - Presented by Experienced People (part 2)

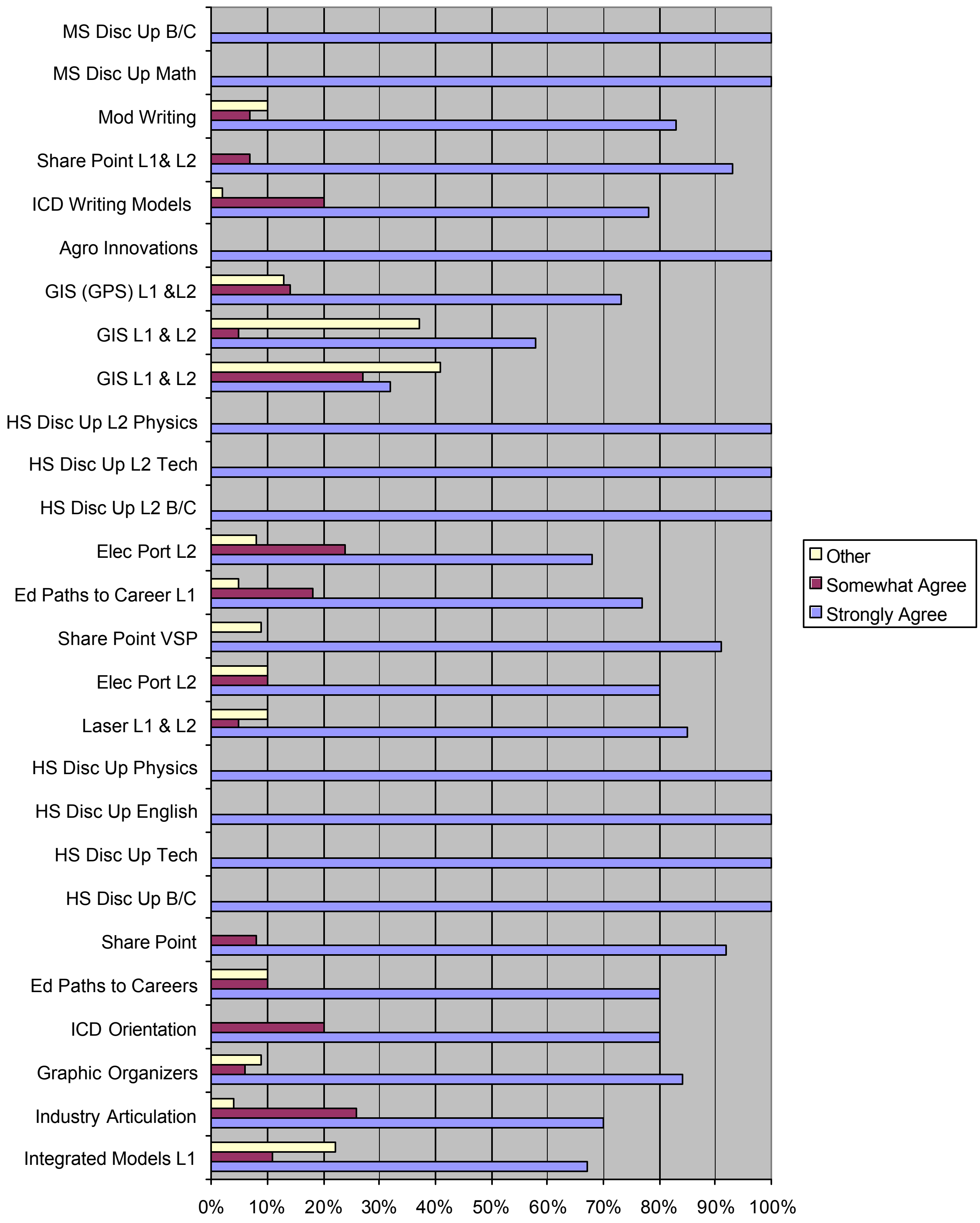

Figure 35.9 Question 4 – Organized (part 1)

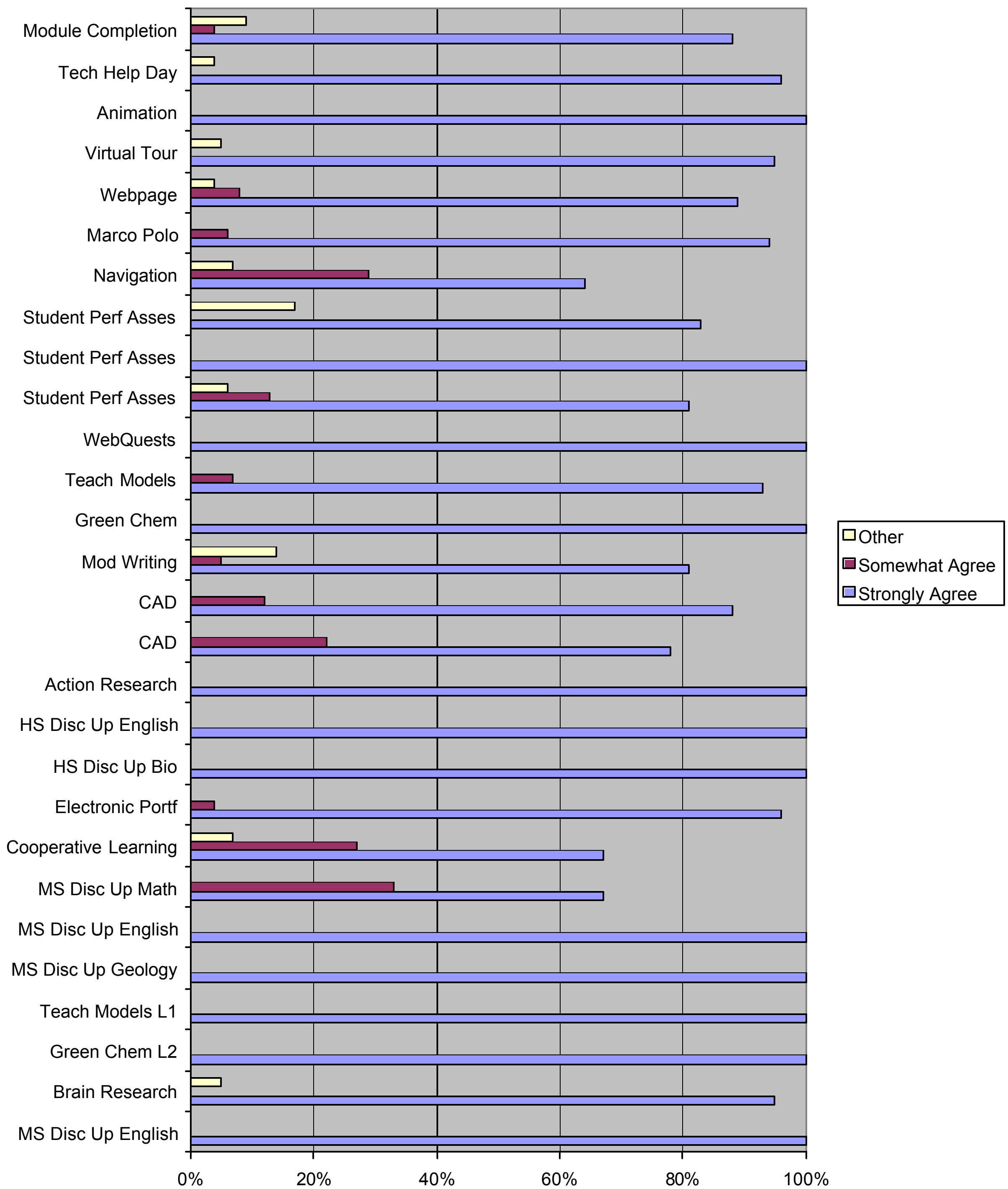

Figure 35.10 Question 4 – Organized (part 2)

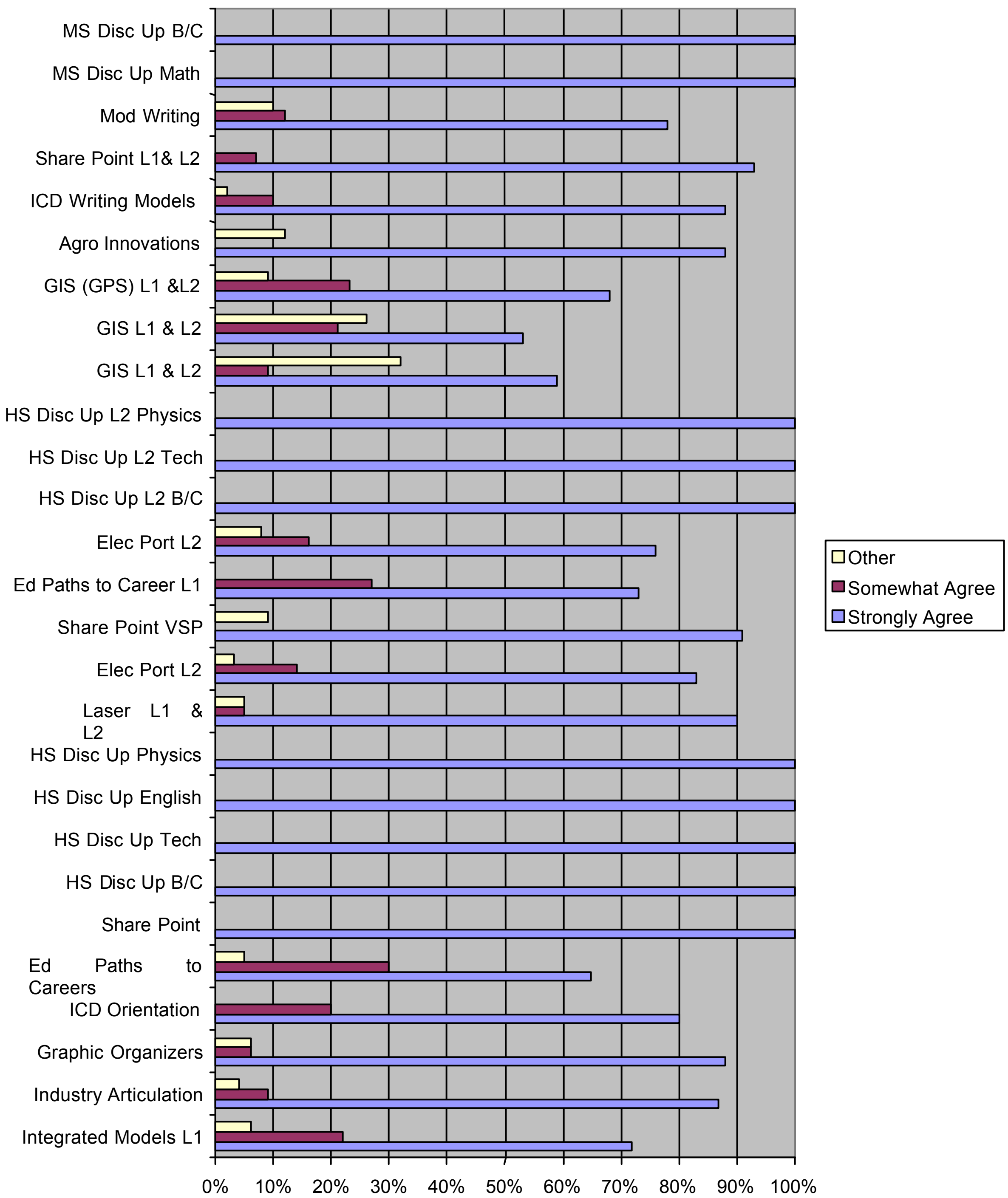

Figure 35.11 Question 5 - Application Oriented (part 1)

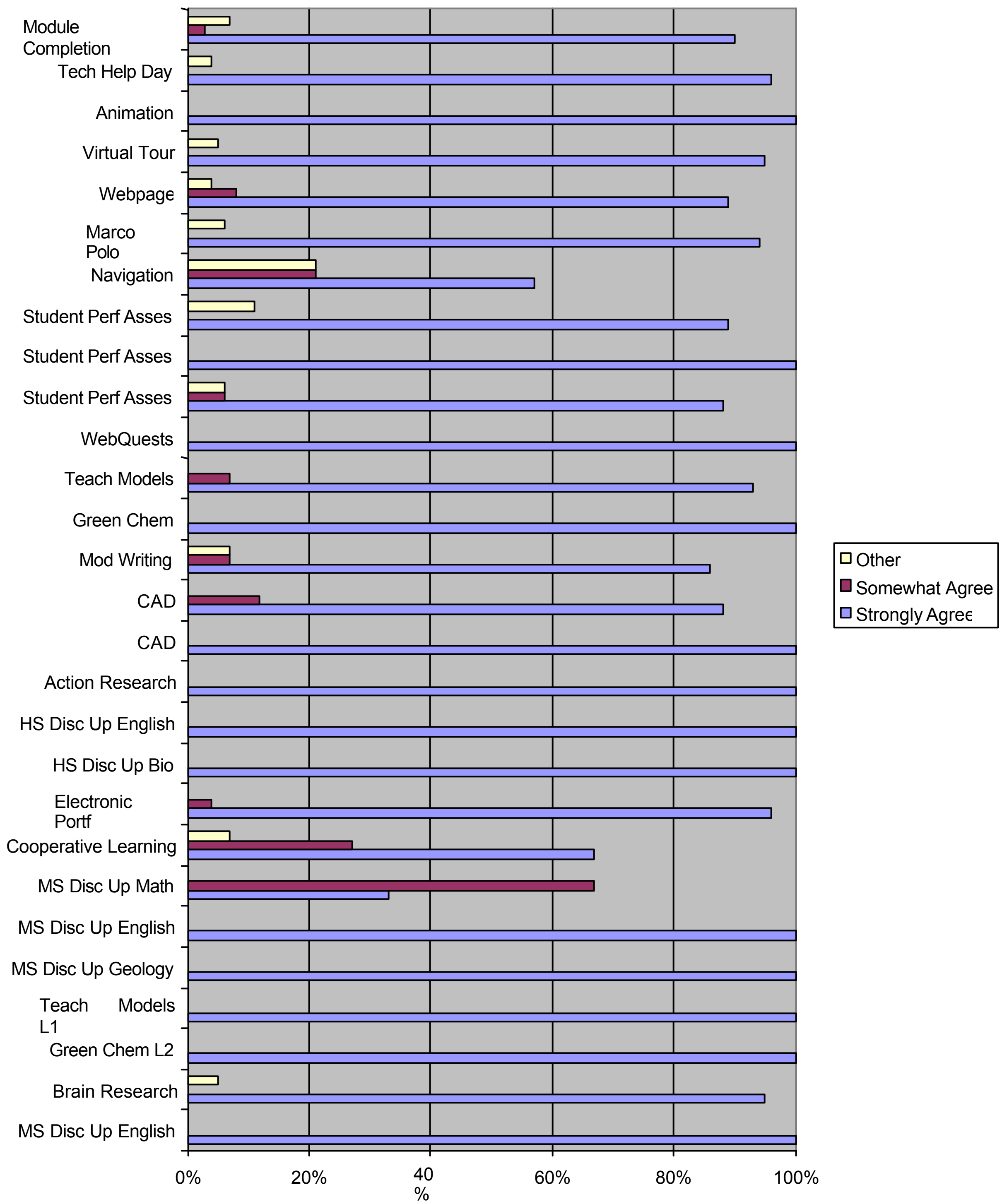

Figure 35.12 Question 5 - Application Oriented (part 2)

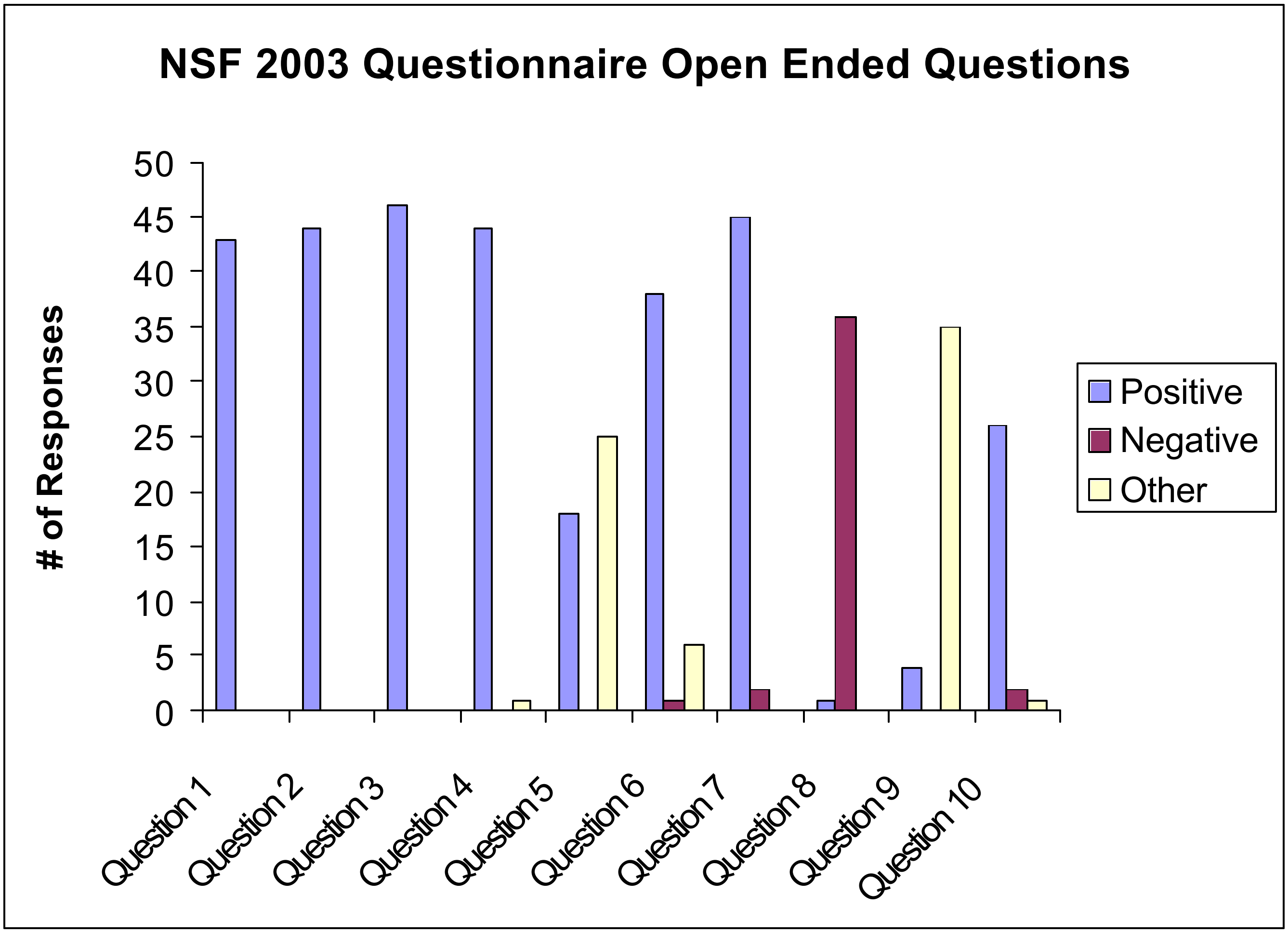

Figure 35.13 NSF 2003 Questionnaire, Open-Ended Questions and Responses

End-of-Grant Questionnaire, 2003

Open-ended questions and responses by teachers

1. What components of the NSF program had the greatest positive effect or potential to enhance your knowledge, skills, or best practices related to teaching and student learning? How has this program changed your teaching practices, or how will it change your teaching practices?

- *It has made me do things that will help me be a better teacher, and to implement the area of career education will be very helpful to the students.*
- *Learning how to use the internet more effectively, Using laptop computer - what a labor/time saver, learning about different ways of incorporating English, writing, reading, and technology.*
- *Teaching models and learning technology were the greatest.*
- *Workshops on assessment were superb, I will design lessons with student products and assessment methods in mind.*
- *I think that the technology training will have the biggest impact on my teaching.*
- *This gave me the time to consider learn and practice new technology skills. This helped me examine what I was going to teach and what was the best way to accomplish that. So really the important thing was the process.*
- *By incorporating more resources to learning, I can do a more thorough job.*
- *Introduced new ways of approaching learning styles.*
- *Use of rubrics, exposure to latest teaching/learning strategies, alternative assessments all have enhanced my classroom. Students are exposed to greater experience.*
- *The one-on-one conference with the NIU professors was the most interesting.*
- *Learning how to use Web pages and create Web pages.*
- *I enjoy working with the different disciplines in a group module.*
- *I've incorporated portfolio + authentic assessment.*

2. Describe discipline-specific enhancements to you that are a result of program participation.

- *The incorporation of technology and my comfort level.*
- *It gives me an idea to develop a lesson that has a link to the community.*
- *Greater computer literacy, ability to present material in new more interesting ways.*
- *I learned about Palm handhelds for myself and further explored them in the classroom.*
- *I am much more confident and competent to teach lessons that I have always wanted to add to my curriculum.*
- *Understand learning standards better.*
- *There will be more writing in the health ed. course.*
- *Incorporating content and individuals from the industry.*
- *GPS/GIS = science and incorporate geography.*
- *Computers in class, updated curriculum, and more worthwhile projects.*
- *Focusing my teaching more on the necessary skills for success in high school.*
- *Use of in-class Internet and rubrics.*
- *Rubrics and multiple intelligences to create lessons, making them more valuable to students.*
- *Green chemistry was very useful in all my topic areas.*

3. How has this program changed you as a teacher? Describe how being involved in this program has benefited you personally. How have you personally grown from participation in this program? Describe the program's value you to as a teaching professional.

- *I really appreciated the format structure of this module and lesson plans. These have really improved my formalized approach to teaching and classroom preparation.*

- *I have made friends and developed relationships with people not only from my school but also across the district and the community - so valuable.*

- *Helped me get better organized and various programs.*

- *Technology, new ideas in class, and new devices in my classroom.*

- *The program has enlightened and enhanced my understanding of state standards. The program developed an expansive network of supportive teachers + peers. The program has helped me become more organized + focused as a teacher.*

- *Projects, technology, higher-level thinking skills, tied to ed. standards, more interdisciplinary, more strategies.*

- *The hardware and access to the Web.*

- *More in tune with the standards techniques, with incorporating other disciplines and technology into my lessons.*

- *Made me feel more confident about "teaching," motivating students and increasing student participation. I feel more knowledgeable about the teaching profession than other teachers who have not been through the NSF program.*

- *This program has enhanced my awareness of resources and the importance of making curriculum relevant to my students. I benefited by working together as a team to complete a project. The value is immeasurable. The articulation between the different levels is essential.*

- *More open to new technological innovations; I have more confidence in my ability to use the computer. I hope to pass along my knowledge to other educators.*

- *The connections made have been the biggest "enhancement."*

- *My concept of what content to teach + how to have a multidisciplinary approach to my lessons. I also plan on utilizing my connections in the industry too strengthen my course content + the real world.*

- *It has made me realize that the lecture-note-taking form of instruction is not the be all, end all. There are many new ways of delivering instruction. Personally, I feel much more compatible with technology.*

- *Each time I have been involved with NSF, I find when I return to school, I have broadened my technique and enhanced my style of teaching. I keep adding and updating to improve. It has made me into a more knowledgeable teacher in science and in the area of technology. I have developed a closer working relationship with Barbara and we have even done team teaching with regular education and special needs students. I did not know enough to turn on a computer when I started NSF.*

- *Being involved with NSF has made me more selective of activities + lessons I choose to use in my classes. I focus more on district objectives + state standards as I plan my curriculum. I also try to use authentic learning experiences more often.*

- *Latest methods for teaching and evaluation have changed my teaching strategies; students benefit from greater variety of experience.*

- *More focus.*

- *I now am able to look at software and evaluate its practicality and usefulness for my students.*

- *I have learned how to work with other teachers.*

- *I feel this program has given me valuable insight to learning styles. My personal growth comes from the confidence gained by working with other teachers.*

- *There is no way a teacher can produce such an involved, thorough module such as this and still have time to keep up with the day-to-day duties. This provides us time to develop an exciting, engaging module. This energizes me!*

- *This program has helped me become a more passionate teacher.*

- *I've grown comfortable with computer usage. Made me realize students are "afraid" when what is being taught doesn't come easy to them.*

- *I feel that I know a lot more techniques than I did when I started. I also use many more strategies than I did before. I have grown technologically; teachers in my building ask me for computer help. I feel privileged to have been a part of this program.*

- *I see myself prepared to become a master teacher. The benefits of this program are immeasurable.*

- *I like the flexibility that the standards offer. They allow me to be creative and to have fun. If teaching were boring, I would stop. This program encourages one to step out of the box. NSF, in sum, challenges you so that you can challenge your students.*

- *This program has assisted me by keeping current professionally. I loved learning and using the Palm handhelds.*

- *Again, by forcing me to look at my discipline differently, it has had a positive impact on me as a teacher. I also have had several student teachers while in the program and it allowed me to work with them "outside the box."*

- *I am much more at ease with technology + various programs.*

4. How will what you have learned help your students learn or achieve more?

- *Use a variety of teaching styles to meet students' different learning needs.*

- *Increasing the number of practical, hands-on, and role-playing activities makes students learn more.*

- *By informing the students that our lessons are of significance to the community, students will have a better sense of belongingness or [becoming] excited.*

- *Students will learn more because they are interested in the units that we developed.*

- *Can better integrate a sequence of topics in the progression from middle school to college.*

- *I hope my students will be more motivated to learn.*

- *Students will be able to use technology and the Internet to do more effective research and projects.*

- *Exposure to wider variety of teaching models, learning strategies, multiple intelligence concepts, technology, software, and assessment.*

- *It will give them a more authentic educational experience.*

- *It will open more doors to further their understanding about technology and health.*

- *I am not driven by the state standards. Our lessons utilize technology more - I would not have had access to handhelds without this program.*

- *Rubrics & projects.*

5. How would you like to see this kind of project or professional development program continue?

- *This kind of professional development should continue. Teachers need to have opportunities to learn + enhance their own teaching styles.*

.

- *Yes it should continue just the way it is.*
- *It would be beneficial if the workshops + programs were available to social studies teachers as well.*
- *Updated workshops on computer skills. A newsletter that may include websites for specific subject matter that has been helpful to others.*
- *A shorter yearly update in both technology and teaching.*
- *Parameters should be outlined up front. Participants should select module topics in the beginning to narrow focus. I would like to see more continual collegiate-level involvement.*
- *Advanced workshops in "tweaking" Web pages + similar such workshops would be useful.*
- *Add more components and technology.*
- *Every teacher should take or be involved in a program like this.*
- *NIU profs were for the most part good.*
- *To be able to retake courses for pay for refresher courses.*
- *I would like to see this project develop more particularity on the technology aspect so we teachers can keep up with it.*
- *I intend to use the template in developing all three topics of my encore course in the three-year rotation.*
- *Network with other participants; compare and steal ideas.*
- *I would like it to be done in teams within each school.*
- *This should become a part of new teacher training.*

- *Offer this program with more functional components and with more articulation with college/university personnel.*

- *I would like to see it more usable in the current curriculum.*

- *I would like to see the program continue next year with more people involved.*

- *It would help me grow as a person and teacher.*

6. Comment about being able to participate in the program by levels or for more than one year with workshops changing each year. Is that important?

- *Networking between the levels was great. It gave chances to everyone to become a leader.*

- *This method was better, I felt more confident the second year.*

- *Switching from one day to two for questions that emerged from the first day and trying it out.*

- *Yes, this is important because it can build on the year before and then go to higher levels.*

- *Building a year at a time is good because it is enhancing but is not overwhelming.*

- *Assigning different levels is beneficial and can enter into a previous level for a good review.*

- *It is easier to work together when you already know the process.*

- *Letting me repeat workshops would have been more helpful.*

- *I understand this is the last year. It is successful, the program should continue.*

- *I only had one year, but I think that extending would be beneficial.*

- *During the second year, I felt more self-directed. I had clearer goals and my confidence was greatly enhanced.*

- *Level 1 is a bit overwhelming, but level 2 is more manageable.*

- *Professional growth is important. I benefited from levels 2, 3, etc.*

- *Yes, I have continued to climb on the tech scale of accomplishments, to the point of becoming a TEEL trainer for the district thanks to NSF.*

- *Yes - the gap between technology standards is huge.*

- *Attractive aspect.*

7. Describe the program's overall strengths.

- *Knowledgeable people leading workshops. Prepare you to experiment with new teaching methods. Books - resource materials - computer/software. Leaders/teachers helpful + approachable.*

- *Organizationwise, is an excellent idea to bring the public school, local college and NIU together; just from there, it is a combination of talent and resources both personnel and technical.*

- *Teachers improve their skills and students become more engaged.*

- *The strength is the collaboration between the university and secondary and middle schools.*

- *The program has become extremely organized and easy to implement. It covers a wide variety of education topics. Networking with other teachers throughout the district.*

- *The quality of instructors and organization is good and the program is excellent.*

- *Technology and networking with other teachers.*

- *Technology programs, computer instructions.*

- *Presenters and technology.*

- *Many different choices of classes were available. The teachers were involved and shared ideas with each other.*

- *The hardware benefit is good, but one day is not enough training.*

- *The ability to pull together the different levels of education. The information on careers. The courses taught were very well done.*

- *Having professors presenting us with the latest information and guidance. Being on the cutting edge of using the latest technology and incorporating it into my lessons. Work time with professors here to guide us.*

- *Helping teachers plan together and learn technology from patient instructors.*

- *Diverse teaching subjects, styles, and methods.*

- *Improving my technology knowledge and skills for my class content with real-life material.*
- *Great work to everyone who was involved; the instructors, professors, directors, and grant writers.*
- *the variety of activities, speakers and programs.*
- *Software and hardware available to us. Jan Jones lends great credibility + organization.*
- *technology and creation of the module.*
- *Strong, positive teachers/professors - very knowledgeable. Jan Jones - excellent, supportive administrator links to careers - this is always changing. Treating teachers as important people.*
- *overall strength in support and experience provided.*
- *the bond that formed between teachers and the instructors, solid foundation in "theory and instruction."*
- *The flexibility and opportunity to create are the strengths of the program.*
- *Everything about it was very positive with the exception of working with the NIU professors. They really had no idea how to help us and that in itself was frustrating.*
- *Technology learning and standards.*

8. Describe the program's overall weaknesses.

- *Not enough explicit linkage and integration of what we were learning to the module rubric and expectations.*
- *Most of the industry visits that were preplanned didn't relate to my field. But NSF allowed me to attend an OSITT conference that was extremely valuable.*
- *So much information crammed into each session - hard for me to absorb and retain + difficult this past year to practice, go over.*
- *Wrong focus in education.*
- *A lot of information in a short period of time. Overwhelming.*
- *During some workshops, the pace was slower than I was comfortable with.*

- *Module completion time on the clock would be better for teachers and be less stressful. It is my understanding teachers used to get more on-clock time. Basic level of computer competency before other classes would make learning at less of frustration level.*
- *No presence of building administration.*
- *Too much time expected outside of workshop.*
- *Facilitators tried to control flexibility, creativity, bliss…*
- *When working with a team, members could use more time to develop module with all of its components.*
- *Some of the communication was lacking when we had to go to the NIU campus but weren't sure exactly where to go!*
- *More involvement by administration and counselors. Trips to NIU were not always beneficial - the same thing could have been done here.*
- *The first year is confusing.*
- *There were times I needed more practice and we just ran out of time.*
- *enough time to really learn all the technology.*
- *The possibility or probability of its end.*
- *Provide us with a workshop or a day to work on our module during the middle of the year - rather than the end.*
- *It would have been nice to have a few more days for our group to get together. We tried to on our own but found it difficult.*
- *Some participants came in late repeatedly + some have not turned in modules in a timely fashion. Perhaps more monitoring is needed.*
- *I felt like aspects were continually added that we weren't previously aware of. Disorganized scheduling of industry visits. I wish I would have had a broader scope about this whole process before beginning.*
- *One workshop - lasers - was totally inappropriate to the public school system. Cost is astronomical and the additional supervision required when classes are up to 33 students is unavailable.*

- *Industry visits were not well planned (i.e., dates/times were not the same as info given to participants).*

- *Lack of individual help in learning computer skills.*

- *very intense - at end.*

- *Some of the programs + workshops had too many participants - the pace was too fast to comprehend everything.*

- *The only weakness would be not enough resources to help during technology classes.*

- *better plan - of instruction dates.*

- *It was a bit time consuming, and instructions for the module were vague until the last week, when we really figured out what we were supposed to be doing. Also workshop instructors did not always implement the practices they were teaching.*

9. How would you improve the overall program?

- *Have the module format and rubric out and referenced in each class, identifying how what we're learning fits into the introduction and the lesson plans.*

- *More time.*

- *See the completed modules at the beginning to get the big picture.*

- *Developing a program with the community - education and its industry.*

- *Keep it going. Also offer a workshop on what worked, what didn't work, how it can be changed.*

- *Increase opportunity for feedback (earlier in the process).*

- *More vegetable meals for some teachers. The food was very good for the majority of teachers. I wouldn't change overall program.*

- *Make it more curriculum- and discipline-specific.*

- *More tech experiences, extended times in learning the technologies, paid chance to take refresher courses.*

- *I thought it was great this year.*

- *Some of the district's policies make the program less than attractive. Though I take my ideas and energy everywhere I go, [it means] enthusiasm without resources.*

- *I would encourage more teachers to participate, and encourage present participants to advertise the benefits of the program. NSF provides a win-win situation for teachers and students.*

- *Schedule of distributing the classes throughout the year end and then concentrating the work at the end helped me to get my module in on time.*

- *Do it again.*

- *I really liked working on the module as I was teaching my program. This helped me have a much better module.*

- *Involve principals, counselors, superintendents.*

- *Ways to update equipment or select equipment, depending on what is needed at your school.*

- *Expand programs already presented - Dreamweaver/Flash - to learn all of the program.*

- *Scheduling is always a problem for busy people who overextend, but thanks for being so flexible!*

- *Maybe two days instead of three on assessment.*

- *More group/individual work time.*

- *Offer workshops on systems - Win NT, 98, XP, OS9, etc.*

- *I would make industry visits in the beginning relevant to the module. Have mini-deadlines for module completion set up during the school year. Have previous modules available for viewing.*

- *Shorter time and updates.*

- *It would be nice to choose our industry visits based on our module, to be able to tie all of the visits into the module, and bring the community into our classrooms.*

- *More help during class + more practice going over steps that need to be followed in order to conquer a specific skill.*

- *The industry visits should be more module specific.*

- *More opportunity for teachers to suggest workshop topics.*

- *More tech based projects. A new variety of professors, don't get rid of the old ones - just add new ones.*

- *Don't really need NIU visits, more time with WebQuest, Palm, etc. Better defined and examples of modules at the start of program.*

- *I would have different levels of technology days - beginning + advanced.*

- *At program end, require participants to present module to participants and business community.*

- *Add industry visits after module topics are set. This would make them more valuable to both parties.*

- *Let teachers have input on the scheduling.*

- *It might work to start during summer.*

10. Other Comments

- *It might work to start during summer, most of the stuff by first week of August.*

- *It was a great opportunity for me to grow as a teacher - thank you!*

- *I have enjoyed this time; learned more about teaching than in my college experiences. Thank you so much!*

- *Thank you very much for this experience - I appreciate all of the hard work that has made this program a success.*

- *I hate to see this program ending. I am very grateful special education was allowed in at the end of program. I have grown as a teacher and have become more excited to try new things with the students. This renewal is necessary for teachers. New things to try, keeps life from getting boring.*

- *This program has been an excellent opportunity and I hope that it is offered again.*
- *This was a great experience. I was so glad I could participate even though I could only do some of the sessions due to time constraints. I do hope some form of NSF might continue because I would be interested in participating.*

- *I can't use everything I encountered. I need more time to write lessons.*

- *Thank you for five positive years of learning, planning, teaming, implementing, and evaluating curriculum, students, and/or myself.*

- *I grew as a teacher and I made new friends. I learned new things and I shared new experiences. This has been only a "win-win" experience for me. I hope Jule and associates will continue this experience to improve all teachers to become "masters."*

- *I'll miss you all. Take care and great four years. Thanks.*

- *NSF has only improved, I have been involved for three years. The money is not as much an incentive as the knowledge, the software, hardware, + dedication of people involved.*

- *Good job. Great program. Bring it next year.*

- *It was a great opportunity, Thank You!*

- *This was a lot more complex and involved than I ever imagined. Offering extensions and refresher courses on the technology would be very beneficial. Thank you for the opportunities offered.*

- *Thank you so very much for this wonderful opportunity. Because of the love I have developed for writing curriculum, I have begun my quest for a PhD in education with specific learning in curriculum.*

- *This class opened a whole new universe to me, which will be transferred to my students. I will no longer be constrained by "text material or budgets."*

- *Keep up the good work.*

- *I enjoyed this workshop. The second year was better than the first only because I knew what I was doing this year.*

- *Perhaps a "rubric" of the final project could be pointed out early on. Several workshops were refreshers for me and affirmed what I've already been doing.*

- *Scatter the Saturday schedules all throughout the year, twice a month, not one after the other.*