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ABSTRACT

This book describes the Maryland Collaborative for Teacher Preparation (MCTP) program which develops and implements interdisciplinary programs for teacher education to develop enthusiastic teachers who continue to be an active learners. Contents include: (1) Foreword (Katherine Denniston); (2) Impact of MCTP on the State of Maryland (Jack Taylor); (3) Research on Teacher Education (J. Randy McGinnis); (4) Voices of MCTP; and (5) Maryland Educators' Summer Research Program. Appendices include Guiding Principles, MCTP Advisors and Participants, MCTP Institutional Programs, MCTP Survey Instruments, Teacher-Written Cases, and MCTP Mentor Teacher Cases. (Contains 39 references.) (YDS)

JOURNEYS OF TRANSFORMATION II

The Impact of the Maryland Collaborative for Teacher Preparation on Science and Mathematics Instruction

Christian Bell
and
Katherine J. Denniston

Editors

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Correction.

Journeys of Transformation II: The Impact of the Maryland Collaborative for Teacher Preparation on Science and Mathematics Instruction (2002)

Page 59, Figure #1, should read as follows:
Figure #1. Beliefs as the filter for teaching (See Blake, In Press).

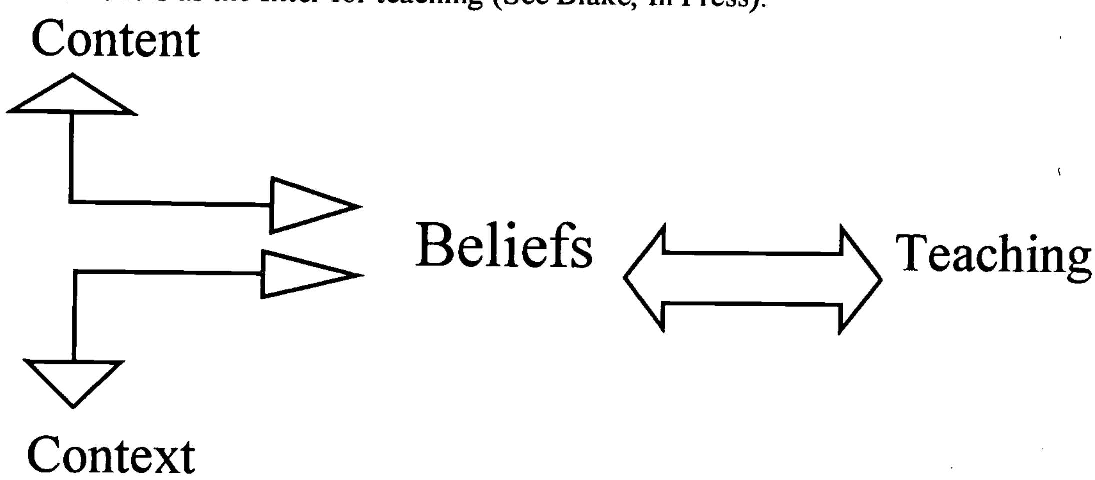

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TABLE OF CONTENTS

FOREWORD

Katherine Denniston
MCTP Project Director
Towson University

In 1993 the National Science Foundation funded the first of the Collaboratives for Excellence in Teacher Preparation. The Maryland Collaborative for Teacher Preparation (DUE#9255745, MCTP) was one of those funded in this first year of the program. The goal of MCTP was to design, develop, implement, and evaluate innovative interdisciplinary programs to prepare teachers who can provide exemplary mathematics and science instruction in elementary and middle schools. This effort involved all of the teaching and research institutions of the University System of Maryland, in collaboration with community colleges and public school systems across the state.

Students who complete a program of study are certified to teach in grades 1 - 8, but they have course work and field and research experiences in mathematics and the sciences that far exceed the traditional requirements for elementary school teachers in those disciplines. The objective is to produce a new *kind* of teacher. One who has enthusiasm for learning, mathematics, and science and continues to be an active learner, furthering his or her own level of expertise in the disciplines and in teaching beyond the undergraduate level.

Program Elements

The MCTP program involves four main features:

- ♦ New kinds of content and pedagogy courses
- ♦ Science and mathematics research internships
- ♦ Field experiences under the guidance of MCTP-trained mentor teachers
- ♦ Support for new teachers during their transition from university study to the world of work to provide better continuity at the critical junction of preparation and professional practice.

Statewide collaboration of faculty and institutions has produced enough innovation within each of these features for several papers. The specifics of courses and programs vary from campus to campus as a result of differences in culture, faculty, and student body. Nonetheless, in all cases, the design and development of content courses, teaching methods courses, and field experiences were guided by basic principles gleaned from the literature on best practices in science and mathematics teaching (Appendix I is a summary of these guiding principles and includes an extensive set of references to support them.)

Teachers should learn science and mathematics through instruction that models the practices they are expected to use in their own classrooms.

Students must be given ample opportunity to discover and use the connections among the disciplines in developing understanding and skill in mathematics and sciences. Research informs us that courses should *integrate* concepts from among the disciplines. The mode of instruction should be *inquiry or discovery-based*, combining outside reading, hands-on experience, group discussion, as well as factual information provided by the instructor. Students should work *cooperatively* and *collaboratively* in groups. They should be expected to devise experiments, discuss and interpret experimental results, and present their ideas. Coursework should help students build a *conceptual framework* within which they can organize and apply scientific information. Course content should be presented within a *context* that establishes a need-to-know in the mind of the student. *Assessment* should be authentic, continuous, and diverse. Student understanding must be monitored routinely because the level of understanding ultimately will determine the progress of the course. Such assessment is needed to uncover student misconceptions so that they can be addressed through constructivist classes that help the student to construct his or her own, accurate, understanding of the phenomenon. Finally, course work and field experiences should consider issues of *cultural diversity*.

At the current time there are approved "MCTP" programs at Towson University, Coppin State College, Frostburg State University, Salisbury University, and the University of Maryland College Park. Students at the University of Maryland Baltimore County, University of Maryland Eastern Shore, and Bowie State University can participate in a variety of aspects of the program, and Baltimore City Community College and Prince George's Community College have approved options for the science and mathematics concentration in their education transfer programs. A number of other community colleges provide gateway MCTP courses to prepare their students to enter the MCTP program at the four-year schools. All of these established programs have a core of new content and pedagogy courses that were designed along the lines of the MCTP philosophy.

Both courses and field experiences should integrate science and mathematics so that teachers can see the connections and use them in their teaching.

Making connections between science and mathematics has been shown to enhance student learning while simultaneously increasing student interest. These disciplines share much in common. Of course, scientific data are frequently gathered in numerical form and are often analyzed through mathematical manipulation. More importantly, understanding fundamental principles of many scientific phenomena requires an understanding of the mathematical principles on which they are based. Both science and mathematics requires logic and both disciplines involve processes of "doing", as well as reflection.

Teachers-in-training should have the benefit of expert mentors in their field experiences.

One of the critical tasks in teacher education today is to find means to provide teacher candidates with appropriate experiences to ease the transition from the world of the classroom to the world of professional practice. One approach to this is to provide the teacher candidates with field experiences in the classrooms of teachers who display exemplary pedagogical practices. MCTP I developed a corps of 75 experienced teachers across the state who have been trained in intensive MCTP Mentor Teacher Summer Workshops. These teachers continue to mentor teacher candidates who are participating in their field-experiences. The experiences of some of these mentor teachers are chronicled in this monograph. (See "MCTP Teacher-Written Cases" and Appendix VI.)

Teachers-in-training should have an authentic research experience either in a business or academic laboratory or in an institution involved in informal science and mathematics education.

Just as a language is learned most thoroughly in an environment peopled only with native-speakers, so too is the process of science learned most readily in the research laboratory. The research experience provides teachers the opportunity to practice the skills and habits of mind of the scientist or mathematician. Class work and laboratories alone cannot teach a student what it means to "be a scientist" or "think like a mathematician." Only an authentic research experience can provide the level of understanding that will allow the teacher to bring the processes of science and mathematics into the classroom. Since the published science and mathematics standards all include elements of process as well as content knowledge, the research experience is a valuable one. Several independent studies have described the powerful effects of teacher research internships. The data clearly show that teacher retention rates are higher among teachers who participate in internship programs.

One of the most striking and innovative successes of MCTP has been the concept and implementation of science and mathematics internships for prospective teachers. The original MCTP internship program has evolved into the Maryland Educators' Summer Research Program (MESRP), which provides inservice and preservice teacher pairs with a paid summer research internship. The details of the MESRP program are found later in this volume. (See "Maryland Educators' Summer Research Program: The Research Experience in Teacher Preparation and Professional Development.")

Teachers should develop their ability to use modern technologies as standard tools for research and problem solving, as well as for imaginative classroom instruction.

In 1993 it could not be assumed that all students had access to computers or to the innovative instructional software and Internet resources that were available. In addition, elementary education majors did not have experience with any of the more sophisticated instrumentation that would be found in laboratories for science majors. It was therefore an important element of the MCTP philosophy to include the use of computers and other instrumentation into the curriculum taken by these students. Only in this way could MCTP teachers become comfortable with tools that could be used in their classrooms to engage students in science and mathematics learning.

Teachers should receive sustained support during the critical first years of their induction to the teaching profession.

The first years of teaching are fraught with difficulties for many new teachers. Often they are assigned the most onerous schedules. The reality of balancing lesson plans, staff meetings, parent visits, and disciplinary concerns can be overwhelming. For these reasons, MCTP established procedures to support new teachers during their transition from the university classroom to the world of work.

MCTP-trained mentor teachers comprise one element of that support system. In addition, MCTP has maintained contact with the novice teachers, providing them with a continued link to experienced university faculty. This has been accomplished by tracking all MCTP-trained teachers as they enter the workforce and maintaining contact by phone and mail. In addition, mentor teachers, novice teachers, and MCTP teacher candidates have participated in one-day workshops during which time they discussed relevant classroom issues. These Saturday workshops are an excellent venue for sharing ideas and solutions to classroom problems.

In reality, in the State of Maryland, the responsibility for novice teacher professional support is being assumed by a number of other agencies. Interest in this problem at the national level and MCTP influence, exerted through interactions with teachers and administrators in school systems statewide and through participation in professional societies including the Maryland Association of Science Teachers (MAST), the Maryland Council of Teachers of Mathematics (MCTM), and the Maryland Association for Teacher Education (MATE), have convinced a number of these agencies that support of novice teachers should be a high priority item on their agendas. In addition, many Maryland county school systems have already instituted mentor teacher programs for all of their newly hired teachers. Thus, MCTP has been instrumental in the institutionalization of statewide programs that will provide professional support for novice teachers, thereby increasing retention of these new teachers to help meet the growing demand for K-12.

Project Evaluation

Throughout the eight years of this project there has been a consistent and rigorous effort to evaluate all aspects of the program. The early studies, carried out by Randy McGinnis and Tad Watanabe, initially focused on the teacher candidates and the transformation of the college and university faculty involved in the program. These studies asked a number of fundamental questions, including the following:

- How do teacher candidates construct the various facets of their knowledge bases?
- How do university faculty model good instruction in mathematics and science content courses and methods courses?
- How do MCTP faculty perceive their own discipline, as well as the other disciplines that they seek to integrate into their courses?

A summary of the results of those studies is presented elsewhere in this volume. (See "Research on Teacher Education in the MCTP.")

As the number of MCTP-trained teachers and mentor teachers grew, a new stream was added to the research program: the success of the MCTP graduates in their own classrooms. Little was known about the induction of novice mathematics and science specialist teachers, trained in innovative teacher preparation programs, into school systems using traditional practices. How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation view their subject disciplines? How do novice teachers enact their teaching roles? What reflections do novice teachers have regarding what they do when teaching science and mathematics with upper elementary/middle level students? How well does the content knowledge of the new MCTP-trained teachers prepare them for their new roles as teachers? What are their attitudes and beliefs about the content and teaching the content? How do the best teaching practices learned by the MCTP graduates translate into the middle school classroom?

University of Maryland College Park and Towson University graduates were selected for these studies because these two institutions had MCTP programs that manifested all facets of the project's ambitious program. Using narratives written by the new teachers (Appendix V), Randy McGinnis has analyzed the problems faced by the new teachers as they worked to institute reform- and standards-based lessons into their classrooms ("MCTP Teacher-Written Cases," this volume). Adopting a similar approach, Bob Blake investigated the use of narrative by MCTP graduates to reflect on their university training and classroom experiences to construct their own personal theory and professional stance on teaching science in upper elementary and middle schools. (See "Becoming a Teacher: Narratives of Elementary-Trained Teachers," this volume)

The National Science Foundation has made a substantial investment in the Maryland Collaborative for Teacher Preparation to improve science and mathematics teacher preparation in Maryland and to demonstrate and disseminate effective practices that might be adopted elsewhere in the United States. In the eight years of this collaborative, formal programs of study have been institutionalized at five universities and colleges and two community colleges, all of which involve an integrated collection of new, innovative content and methods courses. Community college faculty have designed MCTP courses that provide a transfer pathway for students to enter the programs in the four-year schools. A statewide system of mentors has been trained to provide support for novice MCTP teachers and a strong internship program has been developed to provide MCTP teacher candidates with experiences in research and informal science education. The collaborative has brought about significant systemic change in traditional practices in science and mathematics teacher preparation. Research, still on-going, has documented both the disappointments and the successes of these transformations in students and in community college and university faculty. Reflecting on these accomplishments, we are proud that the collaborative has achieved a great impact on the preparation of science and mathematics teachers in the State of Maryland. We recognize that much remains to be done and intend to continue to foster collaborations among universities, community colleges, the Maryland State Department of Education, and local school districts to continue to promote excellence in preservice teacher preparation and inservice teacher professional development.

Finally, we owe a great debt of gratitude to all those scientists, mathematicians, science and mathematics educators, middle school teachers, and research site mentors who worked together to create a statewide network of teacher preparation programs, each unique in form but united in philosophy. These individuals, along with the exceptional MCTP students who merited the honor of being NSF Scholars, are recognized in Appendix II.

IMPACT OF MCTP ON THE STATE OF MARYLAND

Jack W. Taylor
MCTP Co-Principal Investigator
Baltimore City Community College

Introduction

In 1993 the National Science Foundation (NSF) awarded a five-year grant to a group of investigators representing the University System of Maryland. The organization founded with this grant was called the Maryland Collaborative for Teacher Preparation (MCTP I). At the conclusion of the first funding period, in 1998, NSF awarded a supplemental grant to a new group of investigators. This group, MCTP II, sought, among other things, to continue the research on our student scholars as they entered the workplace.

We believe that the total impact of a grant is difficult to quantify. While demographics can be accurately collected for annual reports, it is often qualitative information, such as contributions of people who experience a program and expand their work beyond it, that most reflect the value of that program. This section is a short summary of the current programs and the ones that have fallen by the wayside, as well as an introduction to some of the people whose contributions to education have extended far beyond their efforts in MCTP.

MCTP has had a significant impact on other programs and policies, as well. The Maryland Educators' Summer Research Program (MESRP), a unique research experience for preservice and inservice teachers, grew from the internship requirement of MCTP I. Another example is the recent approval by the State of Maryland of a two-year degree, the Associate of Arts in Teaching. We believe that our early collaborative efforts to provide a smooth transition from two-year schools into four-year schools was very influential in the development of these new degree programs and articulation agreements.

Degree Programs, MCTP I & II

<u>*Four Year Institutions*</u>

Towson University. The program at TU is a track within the Elementary Education major. Students are led to the program by a cross-indexed passage in the undergraduate college catalog. (See Appendix III for program description and a checklist of program requirements.)

In addition to the academic program, a successful research internship program is being offered through the TU Center for Science and Mathematics Education. Having its origins in the MCTP requirement for a research experience, the Maryland Educators' Summer Research Program is a statewide summer program providing both preservice and inservice teachers with the opportunity to carry out authentic research in science and/or mathematics and to transform elements of that research experience into standards– and reform-based classroom activities. MESRP, which served as the model for the National Science Foundation-Department of Energy collaborative Preservice Teacher Internship Program, has continued with funding from the University System of Maryland, the Maryland State Department of Education, Lockheed Martin Corp, and individual research sites. MESRP is discussed in detail later in this volume. (See "The Maryland Educators' Summer Research Program: The Research Experience in Teacher Preparation and Professional Development.")

University of Maryland College Park. The program at UMCP is an area of concentration within the Elementary Education Program. (See Appendix III for program details.)

Frostburg State University. The FSU program continues with strong support from the administration in the form of student scholarship funds.

Salisbury University. The program at Salisbury University was originally established as a minor. Unfortunately it no longer exists because of difficulties in getting the unique interdisciplinary courses that characterized the SU program through the accreditation process. This "failure" is significant because these courses represented some of the most creative interdisciplinary course development achieved through MCTP. It is also significant that these courses were approved as General Education courses, as well. Although they are still listed in the University Catalog, they are not presently offered.

MCTP was fully embraced by SU administrators from the level of Provost to Department Chair. This administration support provided the positive environment for the development of innovative programs.

Coppin State College. The program leader, Dr. Genevieve Knight, has returned to Coppin State College following prestigious appointments at other institutions. Her return promises to revitalize this MCTP program.

Community Colleges

Baltimore City Community College. Students are directed to the program by Professors Kirk DeBeal and Jack Taylor. The program is in the catalog listed as "Teacher Education Math/Science" under Teacher Preparation Programs. (See Appendix III for program details.)

Prince George's Community College. Several PGCC faculty were active participants in both MCTP I and II. Dr. Pat Basili, Chair of the Department of Education, received an NSF grant to develop an MCTP-inspired track within their new Associate of Arts in Teaching program. Students in this program will soon be entering the Towson University teacher preparation program through a "2 + 2" articulation agreement between TU and PGCC.

Community College of Baltimore County, Catonsville. Faculty at CCBC, Catonsville developed biology and mathematics courses during the MCTP I grant. These courses continue to be offered. Many of the CCBC students enter University of Maryland Baltimore County (UMBC) upon graduation. UMBC has no Elementary Education program. Students must major in a discipline and receive their teaching certification secondarily.

12

New Articulation Statewide of Education Transfer Program

Last year, the Maryland Higher Education Commission approved a new degree program, the Associate of Arts in Teaching (AAT). Since that time, six community colleges have received approval for AAT programs. Several MCTP I faculty were active in the design and development of this degree program. They have told us that the MCTP philosophy was quite influential in the overall design. We are pleased with this programmatic standardization at the community college level and have been supportive and active in the development of "2 + 2" articulation programs between the community colleges and four-year schools. The first AAT programs are in Elementary Education. However, teams are in the process of designing similar programs in secondary education.

We have been concerned about the articulation difficulties encountered by education students moving from two-year to four-year schools. Much of the difficulty arises from a lack of standardization of the programs. The development of standardized AAT degrees and formal articulation agreements between two– and four-year schools will smooth the way for many more students to enter and complete a degree in education. We are confident that these programs will dramatically increase the number of teacher candidates and, thereby, help to meet the critical need for teachers in the State of Maryland.

Three MCTP participants have been key players in the development of the AAT programs and/or of the "2+2" articulation agreements. They are Dr. Pat Basili, Chair, Department of Education, Prince George's Community College, Dr. Kirk DeBeal, Director of the Center for Teaching Excellence and Coordinator of Teacher Education at Baltimore City Community College, and Dr. Kate Denniston, Associate Dean, College of Science and Mathematics, Towson University.

Summer Internships

The summer internship program was a component of the original grant in 1993. The program was designed to provide MCTP preservice teacher candidates the opportunity to participate in mathematics and science as it is really done, not solely as it is taught in college lectures and stylized laboratory projects. These internships allowed future teachers to experience a sense of discovery and accomplishment in mathematics and science, and, as teachers, they would be able to share this experience with their students. At approximately the same time, the University of Maryland Graduate Fellows program provided research internship experiences for inservice teachers.

In 1998, a new program, the Maryland Educators' Summer Research Program (MESRP) was formed using elements of each of the earlier programs. This successful program, located at the Center for Science and Mathematics Education at Towson University, created a new model for internship experiences. Preservice and inservice teacher interns team with mentor scientists at government, university, and private laboratories throughout Maryland. (See "The Maryland Educators' Summer Research Program: The Research Experience in Teacher Preparation and Professional Development," in this volume.)

13

MCTP I & II Faculty Who have had an Impact in Maryland and Beyond

Part of the impact of the grant was to help faculty and administrators become more aware of the needs and techniques used in science and mathematics courses for teachers. When these people move on to other positions or activities, we are proud that they continue to promote the MCTP philosophy in a larger arena. What follows is a list of some of those participants who have assumed leadership roles that have allowed them to exert a positive impact on education and teacher preparation.

1) Dr. Phillip Creighton. Phil was Dean of the Salisbury University Henson School of Science and Technology at the beginning of the MCTP program. He later became Provost of SU and is currently the President of Eastern Oregon University where he continues to promote reform of teacher preparation.

2) Dr. Don Cathcart. Don was an active participant of MCTP I. He and Tom Horseman designed an Introduction to Mathematical Modeling course for MCTP students that is now a part of the general education curriculum for all students. Don continued to promote MCTP while serving as Chair of the Department of Mathematics, Dean of the Henson School of Science and Technology, and Provost of the university.

3) Dr. Genevieve Knight. Genevieve was one of the original co-PIs of MCTP I and a role model for us all. In 1996 she was named Wilson H. Elkins Distinguished Professor for the University System of Maryland. More recently she has expanded her influence on mathematics education by serving as a Scholar-in-Residence for Mathematics and Computer Science at the Pennsylvania State University. She also served as a Fellow of the Council for Scientific Society Presidents. We are glad to have her back in Maryland in her position of Professor of Mathematics at Coppin State College.

4) Dr. Tom O'Haver. Tom was one of the original co-PIs of MCTP I. He continued to serve as MCTP webmaster until April 2001. Tom was a research analytical chemist with an active research program. Now a Professor Emeritius of UMCP, he and his wife, a retired fifth grade teacher, present professional development workshops for K-12 teachers on the use of technology in the classroom.

5) Dr. James Fey. Jim was the Project Director of MCTP I. He is currently the PI on an NSF-funded Center for Learning and Teaching grant. The "Mid-Atlantic Center for Mathematics Teaching and Learning" (CMTL) is a consortium led by members of the mathematics and education faculties of three research universities and three school-system partners: the University of Delaware, the University of Maryland, the Pennsylvania State University, the Delaware State Department of Education, the Prince George's County (MD) Public Schools, and the Pittsburgh (PA) Public Schools.

6) Dr. Marshall Kirk DeBeal. Kirk, who serves as the Director of the Center for Teaching Excellence and Coordinator of Teacher Education at Baltimore City Community College, joined the MCTP family in 1999. He works closely with the Baltimore City Public School System and is actively involved in the design of

statewide articulation between Associate of Arts in Teaching programs in community colleges and Bachelor degree programs at four-year schools.

7) Dr. Jack Taylor. Jack served as co-PI for both the MCTP I & II grants, representing the community colleges in the collaborative. His influence has been strongly felt in the Baltimore City Public Schools high school Physics program. Jack was instrumental in the selection of a constructivist textbook, delivered workshops to train teachers to use the new curriculum, and worked with school district administration to secure the equipment needed for the courses. He also helped prepare a standardized final Physics examination for the Baltimore City Public Schools.

8) Dr. Katherine Denniston. Kate is a Professor of Biology at Towson University who became involved in MCTP I in 1994. She worked on the development of the MCTP curriculum at Towson University and designed and implemented two introductory biology courses for that curriculum. She served as the TU Institutional Representative and became Director of the TU Center for Science and Mathematics Education (CSME) in 1998. In 1999, she became Project Director of MCTP II, obtaining NSF funding for an extension for the program. She currently serves as Associate Dean of the College of Science and Mathematics, as well as Director of CSME. In September 2002, she begins a one-year appointment at NSF as a Program Director in the Division of Undergraduate Education. She and colleague Joe Topping (TU Chemistry professor and MCTP I participant) also publish a Chemistry textbook, *Principles and Applications of Inorganic, Organic, and Biochemistry*. The book, published by McGraw-Hill, is currently in its third edition.

9) Dr. Gladys Whitehead. Gladys was a faculty member at Prince George's Community College (PGCC), during her involvement with MCTP I. In 1999 she became Supervisor of Mathematics K-12 in the Prince George's County Public Schools. Her goal is to provide professional development opportunities that keep teachers up-to-date with the current trends in mathematics education.

10) Dr. Richard Cerkovnik. Rich was a graduate student working with John Layman (MCTP I co-PI), as well as a faculty member at Anne Arundel Community College during his participation in of MCTP I . He completed his Ph.D. dissertation, "The Effects of a Microcomputer-Based Laboratories Learning Sequence on Students' Concepts of Function in a College Physics Class," during that time. He is now the Chair of the Physical Science Department at Anne Arundel Community College.

11) Dr. Jack Wisthoff. Jack, a Professor of Mathematics at Anne Arundel Community College, was an active participant of MCTP I. He subsequently became a member of the Maryland State Board of Education.

12) Dr. J. Randy McGinnis. Randy, an Associate Professor at the University of Maryland College Park, has led both the MCTP I and MCTP II research programs, investigating the impact of the program on our students and tracking them into the work place. A summary article of this work and his more recent case studies are found in this volume.

13) Dr. John Layman. John was one of the co-PIs of the MCTP I grant. He has officially "retired," but continues to be active in improving Physics courses and the preparation of teachers. His MCTP I course at College Park continues with two sections per semester. John is now the co-PI of the American Physical Society NSF PhysTEC grant. The goal of PhysTec is that University Physics Departments assume increased responsibility for K-12 teacher preparation. This would include reform of the introductory Physics courses. He continues to use material from MCTP I in this effort, including his course PHY 115.

14) Dr. Robert Blake. Bob became involved with MCTP II in 1999. An Assistant Professor in the Department of Elementary Education, he taught teaching methods courses for MCTP. He went on to establish the environmental science-focused Harford Glen Professional Development School, a partnership among Towson University's Elementary Education department, MCTP, selected Harford County elementary and middle schools, and Harford Glen Environmental Education Center. His research, supported in part by the Towson University Faculty Development and Research Committee, has focused on tracking Towson University MCTP students as they enter the classroom.

15) Dr. Pat Basili. Pat is Chair of the Department of Education at Prince George's Community College (PGCC) and has been an active participant in both MCTP I and II. She is currently the principal investigator of an NSF grant to develop a science and mathematics track within the PGCC AAT program. In addition, she has been actively involved in the design of a "2+2" articulation agreement between PGCC and Towson University.

RESEARCH ON TEACHER EDUCATION IN THE MCTP

J. Randy McGinnis
MCTP Researcher and Evaluator
University of Maryland College Park

This chapter presents a review of the research program in the Maryland Collaborative for Teacher Preparation (MCTP). The primary purpose of this research on teacher education was to generate new understandings in reform-based undergraduate mathematics and science teacher preparation. To that end, diverse methodologies were used by the MCTP Research on Teacher Education Group to study multiple aspects of the MCTP program. MCTP research has been reported in a variety of venues (book chapters, journal articles, research conference presentations, masters and doctoral student reports, and teacher conferences).

Structurally, this chapter is arranged to successively orient the reader to the MCTP Program, MCTP Research on Teacher Education Group, the MCTP research questions, studies (large and small scale) and results, and projected studies.

The Research Context

The MCTP is a National Science Foundation (NSF) funded statewide undergraduate program to prepare specialist teachers in mathematics and science for the upper elementary or middle schools. The MCTP was funded originally in 1993 for a five year period, and in 1998 was funded for an additional three years. It is a project in the NSF Collaboratives for Excellence in Teacher Preparation Program (CETP). The CETP program "supports large scale systemic projects designed to significantly change teacher preparation programs on a state or regional basis and to serve as comprehensive national models" (Directorate for Education and Human Resources/National Science Foundation, 1996).

The key assumption of MCTP is that changes in pre-secondary level mathematics and science educational practices require reform within the undergraduate mathematics and science subject matter and education classes prospective teachers take throughout their teacher preparation program (National Science Foundation, 1993). MCTP emphasizes the transformation of instructional practices by undergraduate mathematics, science, and education faculty and by the school-based cooperating teachers of MCTP students. In this way MCTP future teachers experience directly the successful implementation of reform-based pedagogy in mathematics and science learning contexts (Gardner & Ayres, 1998). Since teachers' classroom practices are known to be highly influenced by how they were taught, the ultimate goal of MCTP is to achieve reform by changing the future teachers' instructional classroom practices to reflect reform– and standards-based practices.

Specifically, the MCTP was designed around the following recommendations made by the Association for the Advancement of Science [AAAS] (1993), the National Research Council [NRC] (1996), and the National Council of Teachers of Mathematics [NCTM] (1991):

- Development of new content and pedagogy courses that model inquiry-based, interdisciplinary approaches combined with regular opportunities for teacher candidate reflection;
- The participation of faculty in mathematics, science, and methods committed to modeling best teaching practices;
- The development of field experiences in community schools with exemplary teachers trained to serve as mentors; and,
- Summer internships in contexts rich in mathematics and science.

In practice, the MCTP undergraduate courses are taught by faculty in mathematics, science, and education who make efforts to focus on "developing understanding of a few central concepts and making connections between the sciences and between mathematics and science" (MCTP, 1996). Faculty also strive to infuse technology into their teaching practices and to use instructional and assessment strategies recommended by the literature to be compatible with a constructivist perspective (i.e., address conceptual change, promote reflection on changes in thinking, and stress logic and fundamental principles as opposed to memorization of unrelated facts). (Cobb, 1988; Driver, 1987; Driver, Asoko, Mortimer & Scott, P. ,1994; Tobin, Tippins, & Gallard, 1994; von Glasersfeld, 1989) Salient features of all MCTP reform-based courses are that faculty lecture is diminished and student-based problem solving is emphasized in cross-disciplinary mathematical and scientific applications. Cooperative learning strategies are used extensively. Statewide, the MCTP offers nearly 90 reform-based courses in mathematics, science, and methods.

The MCTP Research on Teacher Education Group

The original MCTP proposal included a description of the NSF-mandated "Support Group for Project Evaluation." This group carried out the formative and summative evaluation of the project. Among the original CETP projects that were funded, only MCTP included a designated "Support Group for Research on Teacher Education." It was proposed that the "project's innovative approaches to teacher preparation will be studied by a research group..." (University of Maryland System, 1993).

In July 1994, Dr. James Fey, MCTP I Project Director, designated J. Randy McGinnis (Science Educator), University of Maryland College Park (UMCP), and Tad Watanabe (Mathematics Educator), Towson University (TU), to share the leadership of the MCTP Research on Teacher Education Group McGinnis maintained this position for the duration of the MCTP project; Watanabe remained active until1996. Anna Graeber (UMCP, and Co-Director of the MCTP Methods Group), served as an internal consultant to the Research Group. Dr. Kenneth Tobin (science educator, University of Pennsylvania) and the late Catherine Brown (mathematics educator) served as external consultants. Doctoral students and graduate fellows who participated in the

MCTP research group included: Amy Roth-McDuffie, Carolyn Parker, Steve Kramer, Gilli Shama, Karen King, Roberto Vilarrubi, and Mary Ann Huntley.

MCTP Research Questions

In essence, the primary purpose of MCTP research was to document and interpret the MCTP undergraduate mathematics and science teacher education program. The unique elements of MCTP, particularly the instruction of mathematical and scientific concepts and reasoning methods in undergraduate content and pedagogy courses that model the practice of active, interdisciplinary teaching, were targeted for study from two perspectives: that of the faculty and that of the teacher candidate.

The following research questions were included in the grant proposal were:

1. What is the nature of the faculty and teacher candidates' beliefs and attitudes concerning the nature of mathematics and science, the interdisciplinary teaching and learning of mathematics and science to diverse groups (both on the higher education and upper elementary and middle level), and the use of technology in teaching and learning mathematics and science?
2. How do the faculty and teacher candidates perceive the instruction in the MCTP as responsive to prior knowledge, addressing conceptual change, establishing connections among disciplines, incorporating technology, promoting reflection on changes in thinking, stressing logic and fundamental principles as opposed to memorization of unconnected facts, and modeling the kind of teaching/learning they would like to see on the upper elementary, middle level?

Answers to those questions were thought to inform the major research questions driving teacher education research in all subject domains:

1. How do teacher candidates construct the various facets of their knowledge bases?
2. What nature of teacher knowledge is requisite for effective teaching in a variety of contexts?

While the original research questions served to orient the MCTP Research on Teacher Education Group to the major areas of inquiry in teacher preparation, over time specific study questions emerged in response to the interest of members of the group and in response to specific inquiries made by NSF staff members about MCTP. The research questions included

1. To what extent can educational research be used for evaluation purposes?
2. Is there a difference between the MCTP teacher candidates' and the non-MCTP teacher candidates' attitudes and beliefs about mathematics and science?
3. Do MCTP teacher candidates' attitudes toward and beliefs about mathematics and science change over time as they participate in MCTP classes?
4. How do MCTP faculty perceive their own discipline as well as the other discipline (mathematics/ science) with which they seek to make connections?
5. How do college faculty "model" good instruction in mathematics

19

and science methods courses for teacher candidates and how is that perceived by the teacher candidates?

6. How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation:
   (1) view their subject disciplines;
   (2) intend to enact their roles as teachers; and,
   (3) compare in their discipline knowledge, beliefs, and intentions concerning mathematics and science with other elementary/ middle level teachers?
7. How do experienced specialist teachers of mathematics and science who graduated from an inquiry-based, standards-guided innovative undergraduate teacher preparation:
   (1) view their subject disciplines;
   (2) enact their roles as teachers; and,
   (3) think about what they do when teaching science and mathematics to upper elementary/middle level students?

Since 1994, the MCTP Research on Teacher Education Group has conducted a research program to investigate these questions. Both hypothesis-testing and hypothesis-generation research strategies have been used. Conceptually, the studies fall into one of two types: investigations that required a large scale focus (program-wide in scope with a large N) and investigations that required a small scale focus (a specific reform-based course or a case study with a small N).

In addition, as the findings from the MCTP Research on Teacher Education Group's studies were becoming more important in project evaluation, a theoretical examination of the role of research to inform evaluation was undertaken.

MCTP Studies and Results

As earlier described, the MCTP project began with two separate groups: one focused on evaluation and one focused on research. However, as the project was implemented, the findings from the Research on Teacher Education group increasingly became prominent in program evaluation. This use of research to inform evaluation posed a theoretical problem within the MCTP Research on Teacher Education Group, particularly as the function of the MCTP Evaluation Group was reduced while the function of the MCTP Research on Teacher Education Group was enhanced. The traditional conception of a dichotomy between evaluation and research with distinct, often incompatible, activities was challenged (i.e., evaluation solely for accountability and research solely for knowledge growth). The research question became "To what extent can educational research be used for evaluation purposes?" (Research Question #1). This question was investigated and reported in McGinnis and Watanabe (1998, 1999).

What was learned from a select literature review of evaluation theorists and NSF documents was that contemporary thinking on evaluation proposed multiple purposes: evaluation for accountability (measurement of results or efficiency); evaluation for development (information collected to strengthen institutions); and evaluation for knowledge (acquisition of a more profound understanding in some specific area or field). McGinnis and Watanabe (1999) concluded that research could inform evaluation within the CETP projects in a manner that typically was not done, but was critically needed.

Evaluation for accountability, which is often thought to be the primary purpose of evaluation, is important and necessary. However, evaluation for development can be of extreme value to the participants in a large scale teacher preparation project. Moreover, evaluation for knowledge will inform a much wider audience, resulting in long lasting benefits to the educators beyond the specific project. Thus, it appears reasonable that future programs address these multiple perspectives in their evaluation activities.

A. Large Scale Studies.

Many of the MCTP Research on Teacher Education Research Questions (#2, #3, #4, and #6), required a program-wide data collection. Data collection sources were qualitative (participant interviews) and quantitative (survey).

A survey instrument was used to answer research questions #2 and #3 ("Is there a difference between the MCTP teacher candidates' and the non-MCTP students' attitudes and beliefs about mathematics and science?" and "Do MCTP teacher candidates' attitudes toward and beliefs about mathematics and science change over time as they participate in the MCTP classes?"). The history and development of the MCTP survey instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science," as well as results from its administration have been reported (McGinnis, Roth-McDuffie, Graeber, & Watanabe, 1995; McGinnis, Graeber, Roth-McDuffie, Huntley, & King, 1996; McGinnis, Watanabe, Shama, & Graeber, 1997; McGinnis, Shama, Graeber, & Watanabe, 1997; McGinnis, Kramer, Roth-McDuffie, & Watanabe, 1998; McGinnis & Parker, 1999; McGinnis, Kramer, Graeber, & Parker 2001, and McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe, *in press*). See Appendix IV for a copy of the MCTP instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science."

Is there a difference between MCTP teacher candidates' and non-MCTP teacher candidates' attitudes and beliefs about mathematics and science? To answer this question we compared MCTP teacher candidates' responses to non-MCTP students' responses by analyzing survey results from the fall 1995 MCTP courses (thirty-three content and pedagogy courses distributed statewide, N=486). The significance levels reported in Tables 1 and 2 were computed using an Analysis of Variance (ANOVA), with "course" and "MCTP vs. non-MCTP" as fixed effects. We found, in general, that MCTP teacher candidates appeared to have started these courses with attitudes and beliefs more in line with program goals than those of non-MCTP students, and for most subscales the gap between these two groups appeared to have widened by the end of the course. The differences between MCTP and non-MCTP students had substantive as well as statistical significance (as evidenced from inspection of the effect sizes). Positively, the mean values for MCTP teacher candidates during the year indicated they started in the direction the project was aiming, and, in general, they reported an even higher level after a year of college-level instruction in reform-based classes.

An unanticipated finding was that in some cases the gap between MCTP and non-MCTP students widened not because of a move by MCTP students toward higher

Table 1
Attitudes and Beliefs of MCTP vs. Non-MCTP Teacher Candidates, Pre-course Surveys (1995-96)

Variable	MCTP M	Non-MCTP M	SD	Effect Size
Beliefs about Math & Science	3.98	3.81	0.52	0.33
Attitudes towards Math & Science	3.81	3.33	0.86	0.56 [a]
Beliefs about teaching Math & Science	4.11	4.02	0.47	0.19 [a]
Attitudes towards learning to teach M&S	4.51	4.25	0.69	0.38 [a]
Attitudes towards teaching M&S	3.48	3.06	0.84	0.50 [b]

Note [a] Significant beyond the 0.05 level. [b] Significant beyond the 0.001 level.

Table 2
Attitudes and Beliefs of MCTP vs. Non-MCTP Teacher Candidates, Post-Course Surveys (1995-96)

Variable	MCTP M	Non-MCTP M	SD	Effect Size
Beliefs about Math & Science	3.95	3.69	0.56	0 .46 [b]
Attitudes towards Math & Science	3.78	3.34	0.84	0.52 [c]
Beliefs about teaching Math & Science	4.23	4.00	0.50	0.46 [c]
Attitudes towards learning to teach M&S	4.50	3.97	0.79	0.67 [c]
Attitudes towards teaching M&S	3.44	3.14	0.82	0.37 [a]

Note. [a] Significant beyond the 0.05 level. [b] Significant beyond the 0.01 level. [c] Significant beyond the 0.001 level.

scores (i.e., in the direction desired by the program) but because of a move by non-MCTP students in the opposite direction. In particular, at the end of a semester, non-MCTP students were less likely than they had been at the beginning to agree that they wanted to learn how to use technologies to teach either math or science. They were also less likely to say that they expected college mathematics courses they take to be helpful in teaching elementary or middle school mathematics, or that they expected college science courses to be helpful in teaching elementary or middle school science.

Both the MCTP instructors and the project leadership were troubled by the declines in the subscale scores of non-MCTP students taking MCTP courses. Speculations for these declines based on MCTP instructor feedback were made. The most widely accepted explanation was that the MCTP courses were indeed taught differently, with different emphases, compared to traditional science, mathematics, and education courses that these undergraduate students expected.

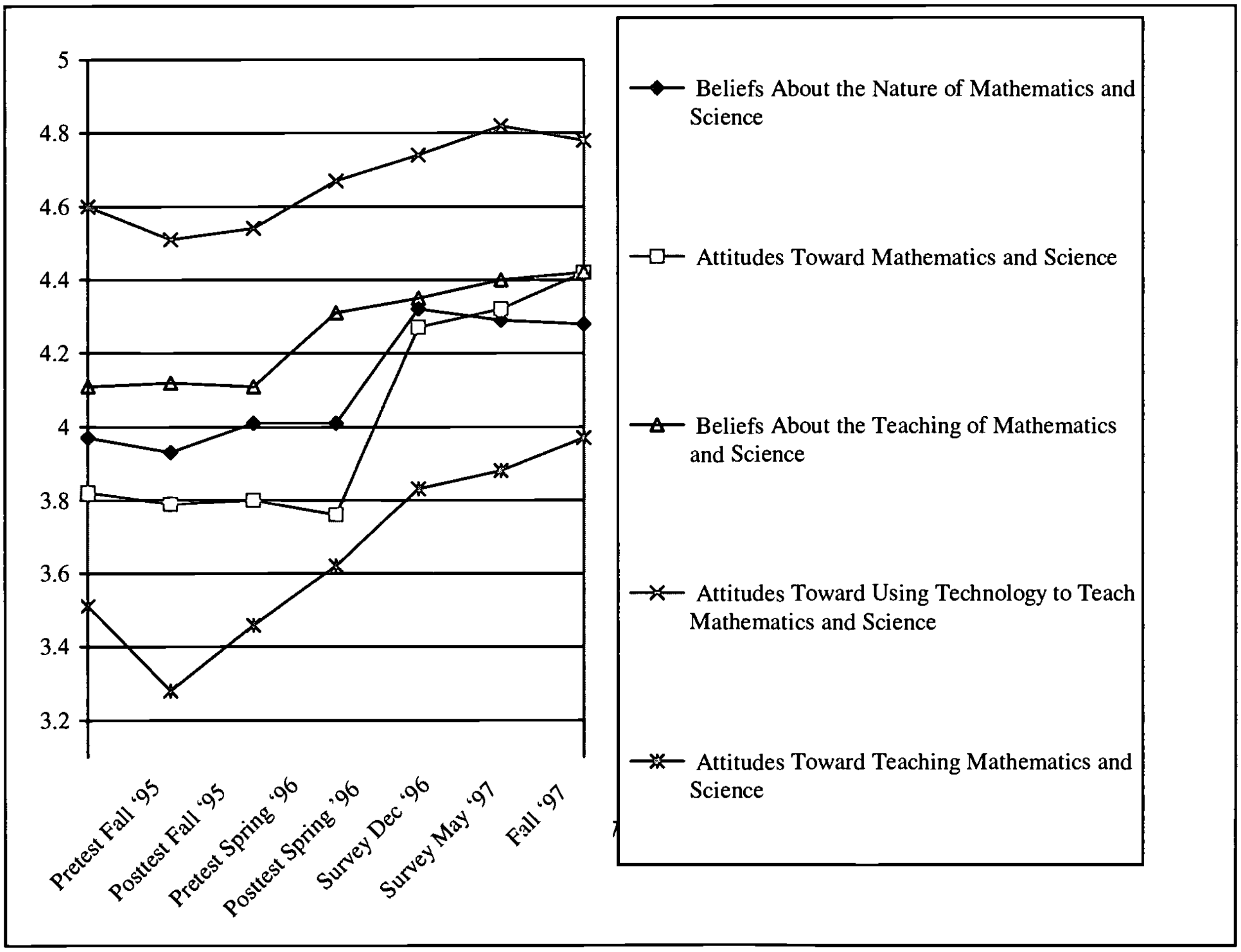
Do MCTP teacher candidates attitudes toward and beliefs about mathematics and science change over time as they participate in the MCTP classes? What we learned from investigating this question was encouraging. We analyzed data from seven administrations of the survey, including four in-class surveys during 1995-96, plus three mail-in surveys, administered in December, 1996, in May, 1997, and in December, 1997. Only responses from MCTP teacher candidates who participated in all seven surveys were used in the analysis. Table 3 summarizes how many MCTP students from each institution in the MCTP responded to each

Table 3
Number Of MCTP Teacher Candidates Surveyed in Each Administration

Institution	Pre -course survey Fall '95	Post -course survey	Pre -course survey Spr '96	Post -course survey	Fall '96 survey	Spr '97 survey	Fall '97 survey
A	9	7	3	3	8	15	9
B	23	13	22	25	5	11	2
C	10	10	8	9	9	12	9
D	34	22	18	20	11	18	17
E	20	8	6	5	15	16	14
Total	96	60	57	62	48	72	51

Figure 1 displays graphically the mean attitude and beliefs scores for MCTP teacher candidates at each of the seven administrations of the survey analyzed.

Figure 1



survey administration.

As is apparent, over the extended period during which we administered the survey, MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales of the MCTP instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science ". A MANOVA comparing the first administration of the survey (pre-course survey, Fall 1995) to the last administration of the survey (mail-in, Fall 1997), after controlling for institution as a fixed effect, showed that the change was significant beyond the 0.001 level. Similarly, an examination of the effect sizes indicated a moderate significant effect. McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe (in press) concluded,

> *Based on our analyses, we believe that the MCTP program achieved success in moving prospective upper elementary and middle school teachers' attitudes and beliefs in the desired direction over the 2.5 years during which they completed our survey. In context of the extensive body of literature that points to how difficult it is to assist elementary teachers to look forward to teach science and mathematics (Starr, Zembal-Saul, & Krajcik, 1997) and in the context of discouraging conclusions emerging from studies that report participants' evaluations of reform-based science teacher preparation programs (McGlamery, Edick, & Ostler, 1999; Simmons, et. al., 1999), this study contributes to a more positive narrative. The results of this study are encouraging, in particular, in that they provide support for the positive impact of reform-based teaching in subject matter courses and in pedagogy courses for prospective elementary and middle level science and mathematics teachers. That is, this study supports the use systemically of standards-based recommendations articulated by Rutherford and Ahlgren (1989) and the National Research Council (1996) to achieve reform in undergraduate science, mathematics, and pedagogy courses. Particularly, this study supports the attention placed on moving prospective teachers' attitudes and beliefs to be in alignment with reform-based perspectives through use of systemic changes in instruction (NRC, 1997).... The findings are educationally significant because they point out which student populations may report differentially the extent that they benefit through systematic reform. For example, our findings suggest that students traditionally resistant to believing that they can teach mathematics and science (i.e., prospective elementary teachers) but who do accept reform-based principles, react positively to standards-based courses as measured on attitude and belief scales. Conversely, students who first encounter reform-based undergraduate courses and who have not endorsed reform-based principles can react in a less positive manner on identical measurement scales.*

Additional large scale studies were qualitative in design. In a study that was designed to answer research question #4 ("How do the MCTP faculty perceive their own discipline as well as the other discipline [mathematics/science] with which they seek to make connections?"), MCTP faculty statewide were interviewed (McGinnis &

Watanabe 1996). Theoretically, MCTP faculty were viewed as constituting a discourse community made of two primary speech communities (each of which contained discipline content experts and pedagogy experts): Mathematics Teaching Community and the Science Teaching Community (Figure 2).

What was learned from the comparison of the mathematics content specialists' and the mathematics methods specialist discourse on mathematics was that they expressed different referents to mathematics in the same speech community. In discussing mathematics, individuals in the mathematics content group referred to mathematics as an immense, hierarchical and logically structured body of knowledge which existed as a separate reality transcending the physical universe. In contrast, individuals in the mathematics methods group referred to mathematics as modeling the physical universe and as a telling determinant of a person's personality or worldview. In both groups the notion of mathematics as something that existed in the mind that was linked with thinking was expressed.

In discussing science, both the mathematics and the mathematics methods content groups expressed that science was linked with the physical universe. This was expressed as science as being found in nature and in particular substances. Individuals in the mathematics groups differed in several ways in which they referred to science. The mathematics content group expressed a broad array of referents to science, many of which were linked to its structure as a discipline as constructed by humans over time. Science was referred to as a type of "truth," a "mind-set," and as "theories." This was in contrast to individuals in the mathematics methods

Figure 2
MCTP Teaching Faculty Discourse

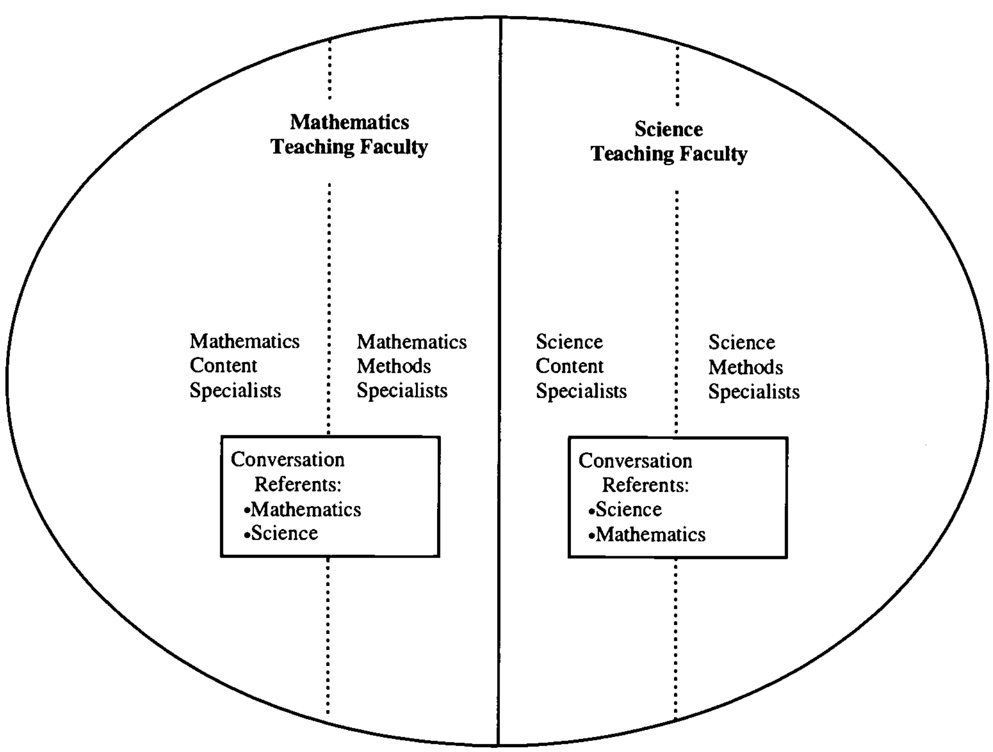


Table 4
Mathematics Teaching Faculty's Talk About Mathematics

Group	Conversation Referents
Mathematics content specialist	Mathematics is different topics Mathematics is hierarchical Mathematics is a body of knowledge/content Mathematics is a form of reality Mathematics is a form of logic
Mathematics methods specialist	Mathematics is a cognitive endeavor Mathematics is modeling Mathematics can define people's personalities

N= 7, 5 mathematicians, 2 mathematics educators.

Table 5
Mathematics Teaching Faculty's Talk About Science

Group	Conversation Referents
Mathematics content specialist	Science is found in nature Science is substances Science is theories and predictions Science is tentative Science is a way of knowing/a view of the world Science explains the experiential world Science is a type of truth Science is a human construction Science is many disciplines
Mathematics methods specialist	Science is patterns in the physical environment Science is a context for problems

N= 7, 5 mathematicians, 2 mathematics educators.

group who expressed a utilitarian vision of science as defined through a mathematics filter: science provided a motivation and a physical context for the doing of mathematics (Tables 4 and 5).

A comparison of the science content specialists' and the science methods specialists' discourse on science revealed both similarities and differences on this same referent. In discussing science, a similarity among some members of the groups was the belief that science was characterized by modeling of physical phenomena. Key differences between the groups discussing science involved some members of the science content specialist group expressing the beliefs that science is information, compartmentalized into discrete disciplines, and specific topics, while some members of the pedagogy content specialist group expressed that science consisted of content and process (the way of doing science). In discussing mathematics, a similarity found among some members of the groups was that they believed mathematics was a tool to be used in science. Key differences between the groups discussing mathematics involved some members of the science content specialist group expressing the beliefs that mathematics is also terms, calculations, operations, the quantification of qualitative explanations, and that mathematics is really more than is perceived by those engaged in doing science (Tables 6 and 7).

McGinnis and Watanabe (1996) concluded,

> *These findings support and extend recent assertions that differences between content discipline experts and content methods experts tend to exist in how they conceive their content disciplines (Mura, 1993, 1995). In collaborative projects*

Table 6
Science Teaching Faculty's Talk About Science

Group	Conversation Referents
Science content specialist	Science is modeling observable phenomena Science is progressive Science is specific topics Science is compartmentalized into discrete disciplines Science is information Science is experimenting
Science Methods Specialist	Science is a lifelong process Science is an inquiry that involves models and explanation Science is questioning Science is content and process Science is a serendipitous thing

N= 11, 8 scientists, 3 science educators.

Table 7
Science Teaching Faculty's Talk About Mathematics

Group	Conversation Referents
Science content specialist	Mathematics is something you can have or possess Mathematics is an equation for straight lines Mathematics is terms Mathematics is calculations Mathematics is measurements of data Mathematics is problem solving Mathematics is basic operations Mathematics is a tool to do science Mathematics is quantification of qualitative explanations Mathematics is really more than as is perceived by scientists
Science Methods Specialist	Mathematics is the visual display of data Mathematics is a tool to be used

N= 11, 8 scientists, 3 science educators.

such as the MCTP in which both content and methods experts equally participate, and in which there are specific project goals that relate to making connections between disciplines and how they are taught, this recognition can assist project directors engaged in sense-making and in devising strategies to implement project goals.

In a study that was designed to investigate research question #5 ("How do college faculty "model" good instruction in mathematics and science methods courses for teacher candidates and how is that perceived by the teacher candidates"), Watanabe, McGinnis, and Roth-McDuffie (1997) analyzed interview data collected statewide from a large sample of MCTP instructors and MCTP teacher candidates. Instructor and student perspectives on modeling good instruction were analyzed. What was learned from that study was that MCTP instructors primarily sought to model good instruction for teacher candidates by connecting classroom discussions and activities to precollegiate contexts and by creating student-focused mathematics and science classrooms. Strategies used by the instructors to model good instruction in mathematics, science, and pedagogy undergraduate courses were cooperative group activities, use of equipment and manipulatives, and extended classroom discussions. The teacher candidates voiced that they noticed the efforts made by MCTP instructors to model good instruction. They stated that they learned the most in MCTP classroom contexts that held an expectation that they would find solutions to student-generated questions. An unresolved issue was whether there was a role for pedagogical conversation in undergraduate mathematics and science coursework designed especially for teacher candidates.

In another study, Watanabe and Huntley (1998) examined MCTP instructors' thoughts on modeling good instruction in their courses by making connections between mathematics and science. What was learned from analyzing many MCTP instructor interviews was that they identified benefits and barriers to making connections between the disciplines at the collegiate level similar to those reported by school teachers. Watanabe and Huntley concluded,

In spite of challenges they have faced, many MCTP mathematics and science instructors appear to have developed an increased respect and appreciation for each other's discipline, and they remain interested in making meaningful connections between mathematics and science....Many continue to grapple with the questions, like "What should be the nature of mathematics and science connections?" and "What is the nature of mathematics or science in relationship to the other discipline?"

Similarly, McGinnis, Graeber, Roth-McDuffie, Huntley and King (1996) reported on a discourse analysis of MCTP faculty conversations regarding making connections between mathematics and science. Figure 3 contains a list of the MCTP faculty's emerging conversation themes by category with elaboration.

A quantitative study by McGinnis and Parker (2001) was designed to answer research question #6 ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation program: view their subject disciplines; intend to enact their roles as teachers; and, compare in their beliefs and intentions concerning mathematics and science to other elementary/middle level teachers). This study was carried out using survey methodology that permitted contrast between self-reports of MCTP new graduates' beliefs and actions with self-reports of a large sample of full-time teachers. A new instrument was crafted to measure the constructs of interest of the program's graduates, "MCTP Teacher's Beliefs and Actions of Mathematics and Science" (Appendix IV). This 51-item instrument included 45 items reported in the *National Science Board's 1998 Science & Engineering Indicators* (NSB-98-1).

Figure 3 **Themes in the integration of mathematics and science in MCTP courses: Faculty perspective**

Theme One: Issue of Boundary
"Discipline integrity"
How much of time/energy, if any, should be spent on the other discipline?

Theme Two: Issue of Competency
"Faculty expertise"
Am I knowledgeable enough about mathematics/science to attempt making connections in my instruction?

Theme Three: Issue of Fit
"Forced or natural"
Is the inclusion of the other discipline appropriate in a particular circumstance?

Theme Four: Issue of Type of Representation
"Discipline or tool"
Does the inclusion of the other discipline lead to new understanding of both disciplines?

Theme Five: Issue of Language
"Semantic concern"
Are identical words/terms used to convey differing meanings in different disciplines?

The survey was administered three times over a three-year period (1999/2000/2001) (N=68). The total response rate was 60%. A nonresponse bias check indicated no significant difference between respondents and nonrespondents. A statistical examination indicated that in a preponderance of areas the MCTP graduates' and newly employed teachers' responses were more in alignment with a reform-based orientation than were responses by the national sample of teachers. A summary of the findings by instrument subscale follows.

Nature and teaching of mathematics. The MCTP graduates' responses differed significantly ($p < 0.05$) from the national sample (N=478) on several beliefs (Table 8-1). Specifically, they were less likely to believe: that mathematics is primarily an abstract subject; that mathematics should be learned as sets of algorithms or rules that cover all possibilities; that a liking for and understanding of students are essential for teaching mathematics; and, that more than one representation should be used in teaching a mathematics concept. A disaggregated analysis of the MCTP middle school mathematics teachers' responses (N=14) compared with a national sample of middle school teachers (N=246) on the same construct found that the MCTP middle school mathematics teachers differed significantly ($p < 0.05$) from the national sample on two beliefs (Table 8-2). They were less likely to believe that mathematics is primarily an abstract subject, and they were less likely to believe that if students are having difficulty, an effective approach was to give them more practice by themselves during the class.

Nature and teaching of science. The MCTP graduates differed significantly ($p < 0.05$) from the national sample (N=478) on several beliefs. Specifically, they were less likely to believe: that science is primarily a formal way of representing the real world; that science is primarily a practical and structured guide for addressing real situations; that a liking for and understanding of students are

Table 8-1. Comparison of MCTP Graduates' Beliefs about the Nature and Teaching of Mathematics with A National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	χ^2	*p*
1. Math is primarily an abstract subject.	10.4%	31.0%	12.19	0.0005*
2. Math is primarily a formal way of representing the real world.	74.2%	79.1%	0.81	0.3678
3. Math is primarily a practical and structured guide for addressing real situations.	85.3%	88.8%	0.71	0.3989
4. Math should be learned as sets of algorithms or rules that cover all possibilities.	19.7%	35.2%	6.27	0.0123*
5. A liking for and understanding of students are essential for teaching math.	86.8%	96.5%	12.56	0.0004*
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	13.2%	22.4%	2.99	0.0839
7. More than one representation should be used in teaching a math concept.	66.7%	98.3%	5.06	0.0245*
8. Some students have a natural talent for math and others do not.	73.1%	81.4%	2.55	0.1106
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	26.5%	17.3%	3.33	0.0681

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), N=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), N=478.

Table 8-2. Comparison of MCTP Middle Level Teachers' Beliefs about the Nature and Teaching of Mathematics with a National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	*t*	*p*
1. Math is primarily an abstract subject.	0.0%	31.0%	-7.95	0.0000*
2. Math is primarily a formal way of representing the real world.	57.1%	79.1%	-1.60	0.1332
3. Math is primarily a practical and structured guide for addressing real situations.	85.7%	88.8%	-0.32	0.7511
4. Math should be learned as sets of algorithms or rules that cover all possibilities.	14.2%	35.2%	-0.210	0.0558
5. A liking for and understanding of students are essential for teaching math.	92.9%	96.5%	-0.52	0.6132
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	0.0%	22.4%	-7.47	0.0000*
7. More than one representation should be used in teaching a math concept.	100%	98.3%	1.70	0.1149
8. Some students have a natural talent for math and others do not.	92.9%	81.4%	1.55	0.1448
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	14.3%	17.3%	-0.30	0.7711

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. N=14.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade mathematics teachers. N=246.

essential for teaching science; that it is important for teachers to give students prescriptive and sequential directions for science experiments; and, that students see a science task as the same task when it is represented in two different ways. However, they were more likely to believe that if students get into debates in class about ideas or procedures covering the sciences, it can harm their learning (Table 9-1). A disaggregated analysis of the MCTP middle school science teachers' responses (N=9) found that, in comparison with the national sample of middle school science teachers (N=232), MCTP middle school science teachers differed significantly ($p<0.05$) on two beliefs (Table 9-2). They were *less likely to believe* that it is important for teachers to give students prescriptive and sequential directions for science experiments. However, they were more likely to believe that science is primarily a practical and structured guide for addressing real situations.

Perceptions of Student Skills Required for Success in Mathematics. The MCTP graduates differed significantly ($p< 0.05$) from the national sample on several beliefs. Specifically, they were *less likely to think:* it is very important for students to remember formulas and procedures, and to think in a sequential manner (Table 10-1). A disaggregated analysis of MCTP middle school mathematics teachers' responses compared with the national sample found that the MCTP teachers differed significantly from the national sample on one belief (Table 10-2). Specifically, they were less likely to think it is very important for students to think in a sequential manner.

Perceptions of Student Skills Required for Success in Science. The MCTP graduates differed significantly ($p< 0.05$) from the national sample on several beliefs (Table 11-1). Specifically, they were *less likely to think*: it is very important for students to remember

Table 9-1. Comparison of MCTP Teachers' Beliefs about the Nature and Teaching of Science with A National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	χ^2	*p*
10. Science is primarily an abstract subject.	15.4%	18.2%	0.31	0.5782
11. Science is primarily a formal way of representing the real world.	70.8%	84.3%	7.32	0.0068*
12. Science is primarily a practical and structured guide for addressing real situations.	77.9%	88.0%	5.24	0.0221*
13. Some students have a natural talent for science and others do not.	55.2%	62.0%	1.14	0.2865
14. A liking for and understanding of students are essential for teaching science.	79.4%	89.6%	6.00	0.0143*
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.	45.5%	75.8%	26.56	0.0000*
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	41.2%	32.0%	2.26	0.1326
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	7.4%	2.8%	13.38	0.0003*
18. Students see a science a task as the same task when it is represented in two different ways.	27.4%	42.8%	5.37	0.0205*

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), N=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), N=478.

Table 9-2. Comparison of MCTP Middle Level Teachers' Beliefs about the Nature and Teaching of Science with a National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	*t*	*p*
10. Science is primarily an abstract subject.	44.4%	18.2%	1.55	0.1590
11. Science is primarily a formal way of representing the real world.	88.9%	84.3%	0.43	0.6811
12. Science is primarily a practical and structured guide for addressing real situations.	100%	88.0%	4.14	0.0033*
13. Some students have a natural talent for science and others do not.	33.3%	62.0%	-1.79	0.1112
14. A liking for and understanding of students are essential for teaching science.	88.9%	89.6%	-0.06	0.9500
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.	33.3%	75.8%	-2.64	0.0299*
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	55.5%	32.0%	1.38	0.2036
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	11.1%	2.8%	-1.59	0.1509
18. Students see a science a task as the same task when it is represented in two different ways.	33.3%	42.8%	-0.58	0.5752

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers. N=9.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade mathematics teachers. N=232.

Table 10-1. Comparison of MCTP Graduates' Perceptions of Student Skills Required for Success in Mathematics with Those of National Sample by Percentage Responding "Very Important."

Item	MCTP[1]	National[2]	χ^2	*p*
19. Remember formulas and procedures?	26.5%	43.0%	6.73	0.0095*
20. Think in sequential manner?	42.6%	79.5%	43.02	0.0000*
21. Understand concepts?	95.6%	88.9%	2.89	0.0891
22. Think creatively?	55.9%	65.4%	2.35	0.1255
23. Understand math use in the real world?	89.7%	81.7%	2.67	0.1025
24. Support solutions?	89.7%	80.8%	3.19	0.0743

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), N=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), N=478.

Table 10-2. Comparison of MCTP Teachers' Perceptions of Student Skills Required for Success in Mathematics with Those of MSEG Sample by Percentage Responding " Very Important."

Item	MCTP[1]	National[2]	*t*	*p*
19. Remember formulas and procedures?	42.9%	43.0%	-0.01	0.9943
20. Think in sequential manner?	28.6%	79.5%	-4.11	0.0012*
21. Understand concepts?	92.9%	88.9%	0.53	0.6024
22. Think creatively?	42.9%	65.4%	-1.63	0.1275
23. Understand math use in the real world?	85.7%	81.7%	0.41	0.6879
24. Support solutions?	85.7%	80.8%	0.48	0.6394

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. N=14.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade mathematics teachers. N=246.

formulas and procedures, and to think in a sequential manner. A disaggregated analysis of the MCTP middle school mathematics teachers' responses compared with the national sample found that the MCTP middle school mathematics teachers differed significantly ($p < 0.05$) from the national sample on one belief (Table 11-2). Specifically, they were more likely to think it is very important for students to support solutions.

Teachers use of instructional practices in mathematics. The MCTP elementary school teachers (N=29) differed significantly from the national sample of elementary teachers (N=473) on all practices (Table 12-1). They were *more likely to*: assist all students to achieve high standards; provide examples of high-standard work; use authentic assessments; use standards-aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 93.1% stated that would make connections with science in their practices. The MCTP middle school mathematics teachers (N=14) differed significantly from the national sample (N=396) on several actions (Table12-2). They were *more likely to*: assist all students to achieve high standards; provide examples of high-standard work; use authentic assessments; use standards-aligned curricula; and, use telecommunication-supported instruction. Also, 92.3% stated that they made connections with science in their practices .

Teachers use of instructional practices in science. The MCTP elementary school teachers differed significantly from the national sample on all practices (Table 13-1). They were *more likely to*: assist all students to achieve high standards; provide examples

Table 11-1. Comparison of MCTP Graduates' Perceptions of Student Skills Required for Success in Science with Those of National Sample by Percentage Responding "Very Important."

Item	MCTP[1]	National[2]	χ^2	p
25. Remember formulas and procedures?	14.7%	25.5%	3.79	0.0517
26. Think in sequential manner?	39.7%	79.6%	50.04	0.0000*
27. Understand concepts?	88.2%	84.0%	0.82	0.82
28. Think creatively?	61.8%	73.0%	3.70	0.0546
29. Understand math use in the real world?	88.2%	79.2%	3.08	0.0795
30. Support solutions?	89.7%	86.1%	0.66	0.4148

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), N=68.

[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), N=478.

Table 11-2. Comparison of MCTP Teachers' Perceptions of Student Skills Required for Success in Science with Those of MSEG Sample by Percentage Responding "Very Important."

Item	MCTP[1]	National[2]	t	p
25. Remember formulas and procedures?	11.1%	25.5%	-1.28	0.2349
26. Think in sequential manner?	44.4%	79.6%	-2.09	0.0696
27. Understand concepts?	88.9%	84.0%	0.46	0.6611
28. Think creatively?	66.7%	73.0%	-0.39	0.7065
29. Understand math use in the real world?	88.9%	79.2%	0.88	0.4052
30. Support solutions?	100%	86.1%	4.63	0.0017*

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers. N=9.

[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade science teachers. N=232.

Table 12-1. Comparison of MCTP Elementary School Teachers' Use of Instructional Practices in Mathematics with Those of National Sample by Percentage Responding "Yes".

Item	MCTP[1]	National[2]	*t*	*p*
34. Assisting all students to achieve high standards.	100%	77%	7.67	0.0000*
35. Providing examples of high-standard work.	100%	63%	8.81	0.0000*
36. Using authentic assessments.	100%	55%	10.00	0.0000*
37. Using standards aligned curricula.	100%	64%	9.00	0.0000*
38. Using standards-aligned textbooks and materials.	92.9%	66%	4.28	0.0002*
39. Using telecommunication-supported instruction.	64.3%	20%	4.61	0.0001*
40. Making connections with science.	93.1%	-------	-------	-------

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Elementary school teachers. N=29.
[2] Public School Teacher Survey on Education Reform (1996). N=473.

Table 12-2. Comparison of MCTP Middle School Mathematics Teachers' Use of Instructional Practices in Mathematics with Those of TSER Sample by Percentage Responding "Yes."

Item	MCTP[1]	National[2]	*t*	*p*
34. Assisting all students to achieve high standards.	100%	85%	7.14	0.0000*
35. Providing examples of high-standard work.	100%	66%	8.10	0.0000*
36. Using authentic assessments.	100%	49%	9.27	0.0000*
37. Using standards aligned curricula.	92.9%	72%	2.63	0.0208*
38. Using standards-aligned textbooks and materials.	85.7%	72%	1.33	0.2062
39. Using telecommunication-supported instruction.	69.2%	27%	3.09	0.0093*
40. Making connections with Science.	92.3%	-------		

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. N=14.
[2] Public School Teacher Survey on Education Reform (1996). N=396.

of high-standard work; to use authentic assessments; use standards-aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 96.6% stated that they made connections with mathematics in their practices. The MCTP middle school science teachers (N=14) differed significantly from the national sample (N=396) on several practices (Table 13-2).

They were *more likely to*: assist all students to achieve high standards, to use authentic assessments; use standards-aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 100% stated that they made connections with mathematics in their practices.

Table 13-1. Comparison of MCTP Elementary School Teachers' Use of Instructional Practices in Science with Those of National Sample by Percentage Responding "Yes."

Item	MCTP[1]	National[2]	*t*	*p*
41. Assisting all students to achieve high standards.	100.0%	71%	9.06	0.0000*
42. Providing examples of high-standard work.	100.0%	48%	14.86	0.0000*
43. Using authentic assessments.	100.0%	44%	13.33	0.0000*
44. Using standards aligned curricula.	96.4%	66%	5.71	0.0000*
45. Using standards-aligned textbooks and materials.	85.7%	58%	3.70	0.0010*
46. Using telecommunication-supported instruction.	75.0%	17%	6.57	0.0000*
47. Making connections with mathematics.	96.6%	-------	-------	-------

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Elementary school teachers. N=29.
[2] Public School Teacher Survey on Education Reform (1996). N=473.

Table 13-2. Comparison of MCTP Middle School Science Teachers' Use of Instructional Practices in Science with Those of National Sample by Percentage Responding "Yes."

Item	MCTP[1]	National[2]	*t*	*p*
41. Assisting all students to achieve high standards.	100.0%	78%	5.00	0.0011*
Providing examples of high-standard work.	88.9%	64%	2.06	0.0730
43. Using authentic assessments.	100.0%	42%	10.36	0.0000*
44. Using standards aligned curricula.	100.0%	65%	8.14	0.0000*
45. Using standards-aligned textbooks and materials.	100.0%	60%	9.09	0.0000*
46. Using telecommunication-supported instruction.	75.0%	29%	2.85	0.0247*
47. Making connections with mathematics.	100.0%	-------		

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. N=14.
[2] Public School Teacher Survey on Education Reform (1996). N=396.

McGinnis, Parker, and Graeber (2000) concluded:

> *The goal of the MCTP is to produce new teachers who are confident teaching mathematics and science using technology, who can make connections between and among the disciplines, and who can provide an exciting and challenging learning environment for students of diverse backgrounds. Along all measures, the present analysis provides evidence that the graduates of this program hold perspectives that support these aims. The present analysis also provides a striking comparison between the perspectives of practicing MCTP teachers and other teachers at the same level and subject specialization. Along all measures (many determined to be statistically significant) the MCTP new teachers express more reform-oriented perspectives concerning subject matter and instruction. These findings suggest strongly that a systematic, reform-based undergraduate science and mathematics program can produce new teachers who enter the workplace with desired perspectives. Whether these perspectives impact instructional choices over time in the desired direction of the reform movement remains undetermined. However, our results suggest that at least initially the reform-oriented perspectives do convey to the workplace.*

B. Small Scale Studies

Small case studies qualitative in design were also used to inform research question #5 ("How do college faculty "model" good instruction in mathematics and science methods courses for teacher candidates and how is that perceived by the teacher candidates?"). Studies reported by Roth-McDuffie & McGinnis (1996) and Roth-McDuffie, McGinnis & Graeber (2000) examined the students', professor's, and researchers' perspectives on a reform-based introductory undergraduate mathematics class and the efforts of a mathematics professor to teach such a class. Analysis of the data indicated that both the teacher candidates and the mathematics professor took an important first step toward enculturation into a reform-based vision of mathematics learning and teaching. Roth-McDuffie, McGinnis & Graeber (2000) concluded,

> *A major implication gained from this study is that the college students who experienced a reform-based mathematics classroom early in their undergraduate program completed a first step in achieving the vision for reform of mathematics education: constructing an initial model of mathematics teaching*

and learning which embraces the ideals of the reform movement. The students' prior conceptions and experiences of mathematics instruction was that mathematics teaching and learning is procedural and rule-based. However, being in a classroom where reform-based teaching was modeled and where students were engaged in active learning through meaningful problem solving and collaboration enabled the students to construct a new model of mathematics teaching and learning.... Another major implication is that professors teaching a reform-based class in which they model reform-based teaching practices consistent with the reform documents should anticipate taking on many aspects of a "pioneer" venturing into new territory....In contrast to his teacher candidate students, [the MCTP mathematics professor] was enculturated into the practice of reform-based teaching and learning by experiencing it as a teacher. He was "learning by doing."

The studies reported by McGinnis, Roth-McDuffie, and Parker (1999) and McGinnis, Roth-McDuffie, Graeber, and Parker (2000) also focused on research question #5. In this study an elementary science methods course instructor made efforts to connect mathematics and science. The class included both MCTP, as well as non-MCTP students. The content knowledge of these two groups and their perceptions about a) their preparedness to teach science, b) appropriate science learning environments, c) a rationale for connections between mathematics and science, and d) the role of a science methods course were contrasted. Also included in this practitioner-research study were the perceptions of the science methods instructor, the mathematics methods instructor, and two graduate research assistants. McGinnis, Roth-McDuffie, Graeber, and Parker (2000) concluded,

In regard to [the MCTP science methods professors'] goal of helping students understand the connections between mathematics and science, while he achieved some level of success in this goal, we need to consider Steen's (1994) warning. While McGinnis's course did not promote the idea of mathematics only as a tool for doing science, the teacher candidates did not seem to view mathematics as more than this when discussing the discipline of mathematics... This finding serves as evidence that by viewing the disciplines from a connected perspective, a limited view of mathematics can emerge even when that view is not held or promoted by the science methods instructor. However, when discussing the processes of science and mathematics, the students perceived many commonalties (e.g., investigation and problem solving) and demonstrated a more developed understanding of these processes in each discipline. Again, this finding is consistent with Steen's (1994) recommendations that in making connections between mathematics and science we should focus on the methodologies of the disciplines (i.e., focus on the commonalties of how we do mathematics and science) rather than on what is common between mathematics and science.

When comparing the two groups of teacher candidates, at the beginning of the semester we see fairly stark contrasts in their perceptions about their preparedness to teach, their vision of an effective learning environment, and their understanding of connections between mathematics and science. Quite *predictably, the CETP teacher candidates had perceptions that were consistent with their experiences in the CETP program, while the non-CETP candidate relied on more traditional, lecture-based preparation. However, at the end of the semester, after sharing the common experience of being in a science methods course which was based on CETP goals, both groups expressed similar ideas on the above issues. The difference at the end of the semester was not in the basic terminology used or the fundamental ideas expressed, but rather, in the depth and sophistication of understanding conveyed in the comments. Consistently, the CETP teacher candidates offered comments that were more developed in the way they explained their ideas, and they provided more specific examples of their thinking as compared to the non-CETP candidates. With a background of more experiences in this type of learning environment and with more opportunities to reflect on their thinking and learning (and the implications for their own teaching), the CETP students articulated a well-developed philosophy of teaching science. Whereas, the non-CETP students just had begun this process. This study suggests that this one-semester course was enough to influence the perceptions (and, by implication, their beliefs) of both groups of teacher candidates. However, we believe the impact was not enough to allow the non-CETP teacher candidates to "catch up" to the CETP teacher candidates in developing a carefully thought-out philosophy of teaching and learning. Clearly, the efforts made by the CETP mathematics and science content instructors to teach in a reform-based manner made a difference in how receptive the CETP teacher candidates were in the science methods course to the pedagogical innovation of making connections between science and mathematics. The question remains as to whether either group has been affected enough by the reform-based CETP courses and only the reform-based science methods course to bring about reform-based teaching in their future classroom practices.*

To answer the sixth research question ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation: view their subject disciplines; intend to enact their roles as teachers; and, compare in their beliefs and intentions concerning mathematics and science to other elementary/middle level teachers?"), an interpretative methodology was also used. In McGinnis, Parker, and Graeber (2000a, 2000b, 2000c) a case study was conducted of a small sample of MCTP new teachers (N=5 first year, N=3 second year) in their first two years of full-time teaching. The purpose of this exploratory longitudinal qualitative study was to present a detailed description and interpretation of what happens in schools to new teachers who are prepared to enact reform-based practices in mathematics and science. The researchers documented differential experiences and perceptions of new specialist teachers of mathematics from both inside (the teachers' and their students') and outside (principals' and investigators') perspectives. Documented discussion centered on a teacher socialization framework as suggested by Veenman (1984). Insights were framed in two components: the individual's intentions, needs, and capabilities, and the institutional demands, supports and constraints. The major finding was that from the new teachers' perspective, the school culture was a major factor in whether reform-aligned mathematics and

37

science teaching was regularly implemented by the new MCTP teachers. In instances where the new teachers perceived that their school cultures offered a lack of support for their intent to implement reform-based practices, the new teachers exhibited differing social strategies (resistance, moving on, *etc.*). McGinnis, Parker, and Graeber (2000c) concluded,

> *First, our research suggests that a reform-based mathematics and science teacher preparation program can recruit, educate, and graduate a cadre of new teachers who are employed by school districts. Our rich documentation presents evidence that new teachers from such a teacher preparation program have the capabilities and intentions to teach mathematics and science in a reform-minded manner that makes connections between the disciplines by using high quality science and mathematics. Second, our research suggests that the school context in which the new teachers began their teaching practices is a major factor in whether reform-minded mathematics and science teaching is regularly implemented. The supports and constraints an individual teacher encounters on a daily basis, particularly from individuals with potential coercive power over their work lives, are noticed by new teachers and influence their curricular, instructional, and assessment actions. Finally, if our findings are supported by future research, to enact reform and to retain new reform-prepared teachers a key implication is that the new teachers fare better when they are employed in supportive, reform-oriented school cultures rather than in other environments. While our findings show that in situations in which reform-based teaching is discouraged some reform-prepared new teachers do not leave but elect to continue their careers by altering their practices to fit in with extant traditional practices, the loss of reform in those contexts is a costly impact. We posit that if better matches are made initially between reform-prepared teachers and school cultures, the extent and the quality of reform-based practices in mathematics and science teaching will increase as will the retention of more newly prepared teachers within school cultures. We also wonder what can reasonably be done in teacher preparation to more adequately prepare new, reform-minded teachers to enact reform-based practices in school cultures that are not initially supportive? We believe a first step would be to alert them to the process of socialization in school cultures.*

In addition, McGinnis (2001) reported on the use of teaching cases to provide insight on what happens to MCTP new teachers in the workplace. Eight MCTP elementary and middle level new mathematics and science teachers reported their first hand diverse perspectives on the successes and challenges they faced in implementing reform-based pedagogy.

Projected Studies

Future studies are needed particularly to answer the seventh research question ("How do experienced specialist teachers of mathematics and science who graduated from an inquiry-based, standards-guided innovative undergraduate teacher preparation program: view their subject disciplines; enact their roles as teachers; and, think about what they do when teaching science and mathematics with upper elementary/middle level students?").

Specifically, from the new teachers' perspective, what is the degree of influence of the school level (elementary vs. middle level), the district's curricula in mathematics and science, the differing teaching responsibilities of mathematics or science, and the inservice induction professional development experiences on the new teachers' perception of school culture as a receptive environment in which to implement reform-based practices. That is, an examination of the construction of school culture (over time) by new, high quality teachers and its connection with the teachers' implementation of reform-oriented content classroom teaching was incomplete. What is required is a similar study that examines a range of MCTP graduates, diverse in years of teaching experience, by level of practice (elementary or middle level), and by subject concentration (mathematics or science).

It also remains to be determined whether MCTP graduates will maintain their initial reported beliefs. Future plans are to survey the MCTP graduates who participated in the first studies after they have gained significant full-time classroom teaching experience. This research strategy will permit the researchers to compare MCTP graduates' first survey responses (made primarily during the first few months of full time teaching) to responses made after significant teaching experience (up to three years). Movement away from reform-oriented beliefs and instructional practices will be identified, along with continued reform-based classroom practice.

Finally, an additional study relating to research question #6 ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation program compare in discipline knowledge concerning mathematics and science to other elementary/ middle level teachers?") is in progress. The subject focus is mathematics. This study will complement the science subject focus reported in McGinnis, Roth-McDuffie, and Parker (1999) and McGinnis, Roth-McDuffie, Graeber, and Parker (2000).

Conclusion

As shown, the research program conducted within MCTP has endeavored to examine all aspects of this innovative undergraduate upper elementary/middle level teacher preparation program for specialist mathematics and science teachers. What has been learned from these studies applies directly to the evaluation of MCTP, and more generally, to the other CETP projects and science and mathematics education in general. The expectation is that the MCTP research findings will assist in future examination of and progress in mathematics and science teacher preparation.

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40

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42

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MCTP TEACHER-WRITTEN CASES

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In the context of the contemporary national science education standards movement, major documents such as the *National Science Education Standards (*National Research Council, 1996) and *Principles and Standards for School Mathematics* (2000) articulate the need for all teachers to engage in continuous professional development. Inquiry and reflection on practice are two learning experiences for teachers of science that are identified by prominent reform documents as necessary to include in a teacher's professional education. Inquiry and reflection are the hallmarks of practitioner-research. Educational theorists such as Hollingsworth (1997) define practitioner-research as a broadly defined research methodology that enables those who teach to reflect in a systematic manner on their own teaching.

In mathematics and science education, action research has represented most applications of practitioner research. Action research typically is a problem-oriented research methodology that is conducted in four discrete steps by the practitioner: planning, enacting, observing the plan, and reflection (Carr & Kemmis, 1986). Theorists such as Collins & Spiegel (1997) have promoted action research as a form of practitioner research that connects historically with the research genre promoted by Kurt Lewin (1946) and Stephen Corey (1953). However, a less prominent form of practitioner-research that shows much promise in the current effort to enact standards-based continuous development recommendations is known as "teacher-written cases" (Far West Laboratory, 1991). Cases are firsthand, candid, dramatic, highly readable accounts of events or a series of events in teaching. Kagan (1993) has pointed out that, while the use of case-based pedagogies in education is not common, they do have a long history in education (stretching back to 1927).

The teacher-written cases presented here were written by new teachers who have graduated from the Maryland Collaborative for Teacher Preparation program (MCTP) or by MCTP-trained mentor teachers . From the perspectives of new MCTP teachers, the teaching cases illustrate both the rewards of enacting reform-based mathematics and science pedagogy in their practices, as well as the ongoing struggles that newly prepared reform-based teachers face. From the perspective of MCTP-trained mentor teachers we see illustrations of the experiences they had assisting in the professional development of reform-prepared MCTP new teachers.

An Explanation of Cases

Case narratives offer snapshots of teaching that are deliberately designed to provoke discussion that can be used for critical reflection, instruction, or as a tool for research/evaluation (Koballa & Tippins, 2000). As a tool for critical reflection, cases must include features associated with reflective inquiry. Theorists such as Zeichner and Tabachnik (1991) have argued that reflection that is critical is evidenced by considering "social, political, ideological, moral and ethical commitments of one's assumptions...."(as cited in Koballa & Tippins, 2000). As a tool for instruction, cases are assumed to "be more motivating," "promote more transfer to all learners," and potentially be more effective in transforming "all learners into better problem solvers and critical thinkers" than conventional methods (Ertmer, Newby, & MacDougal, 1996, as cited in Koballa & Tippins, 2000). The educational value of cases for instructional purposes is achieved when readers engage in identifying a pedagogical problem, analyze the problem, and propose solutions guided by educational theory. Discussion of such cases is a focus on analysis, with student-generated solutions the goal. Finally, as a tool for research and evaluation, cases serve potentially as a source of data for accountability and for knowledge growth in the study of teacher's thought processes and pedagogical beliefs. As such, cases have been used as a forum to investigate classroom assessment, curriculum development, professional development and preparation, discipline-based teaching methods, ethical dimensions of teaching, and other aspects of teaching practice.

Context of the Cases

The aim of the MCTP is to promote the development of teachers who are confident teaching upper elementary/middle level mathematics and science using technology, who can make connections between and among the disciplines, who can use alternative ways to assess learning, and who can provide an exciting and challenging learning environment for all students (University of Maryland System, 1993). To that end, program goals include: (a) introduce future teachers to reform– and standards-based models of mathematics and science instruction; and, (b) provide courses and field experiences that integrate mathematics and science. Since the MCTP program was funded in 1993, the program has graduated over 200 new teachers and influenced many thousands more who enrolled in mathematics, science, and pedagogy courses taught by MCTP faculty.

The MCTP teacher candidate's program of study is distinguished from non-MCTP teacher preparation study programs by the requirement for additional mathematics and science content courses and a summer research internship. For example, both the UMCP and TU MCTP elementary programs (grades 1-8 certification) require 36 hours of mathematics and science courses (18 hours of each discipline) and a summer research internship in a mathematics or science rich environment. This contrasts starkly with two programs for elementary teacher candidates who choose not to emphasize either mathematics or science as a field of concentration. They are required to earn a total of 11 credits in mathematics and 8 in science as well as 18 in their chosen field, and they do not have to take a summer internship. Non-MCTP elementary teacher candidates who choose to emphasize mathematics only must earn 18 credits in mathematics and 8 in science. Candidates with a science only emphasis must earn 18 credits in science and 11 in mathematics. The MCTP content courses (open to all teacher candidates) have been reformed to conform to the MCTP program goals. Mathematics courses are distributed across four areas: algebra/numbers, probability and statistics, geometry, and calculus. Science courses are distributed across three areas: physical science, biological science, and earth and space science.

The MCTP mentor teachers, experienced elementary and middle level mathematics and science teachers who taught primarily in Montgomery and Prince George's Counties, Maryland, participated in a two-week mentor teacher summer workshop. The workshop was conducted at the University of Maryland College Park under the guidance of Drs. Anna Graeber, Loretta Molitor, and Sharon Clark. In this workshop, funded in 1995 and 1996 by MCTP (NSF) and in 1997 by the Dwight D. Eisenhower Professional Development Program and MCTP, a total of 69 teachers received extensive professional development in standards-based mathematics and science pedagogy, the use of technology, and intern supervision. The teachers also became fluent in the programmatic aspects and goals of MCTP. Each cohort of mentors also participated in two days of follow-up activities, primarily focused on mentoring, during the school year following their summer workshop.

Development of the Cases

It was recognized early in the MCTP program that considerable attention would be placed on the graduates of such an innovative and programmatically ambitious program. It was anticipated that interest would focus on documenting whether newly graduated MCTP teachers taught mathematics and science in ways that aligned with the reform-based goals of the program. There was also considerable interest in learning how the new teachers thought about the successes and challenges of introducing new ideas into elementary and middle level schools. Finally, it was recognized that reflections on practice by the MCTP teachers (new and mentors) would contribute to the their continuous professional development by encouraging a critical analysis. Therefore, in addition to more accepted data collection sources such as survey and in-depth researcher conducted case studies of MCTP teachers, teacher-written cases were included as one component of the extended MCTP research and evaluation initiative.

Beginning in spring 1999 and extending to fall 2000, MCTP solicited and received cases from new MCTP teachers. Included in survey mailings sent to each new MCTP graduate was an invitation to write a reflection on their teaching. Specifically, the new teachers were asked to reflect on successes and challenges of instituting the MCTP reform-based "style" of teaching in their practices. In appreciation for their efforts to write cases, each case writer was offered a $200 honorarium.

To provide an example of a written-case and to promote the idea of MCTP teacher-generated cases, McGinnis (MCTP II PI for Evaluation and Research) crafted a case from his perspective as an MCTP faculty member. He presented that case at a statewide conference for MCTP teacher candidates, new teachers, and MCTP mentor teachers during the winter of 1999 (McGinnis, 2000a). Upon learning of the case strategy, several mentor teachers expressed interest in writing cases from the perspective of a cooperating teacher. Subsequently, additional MCTP-trained mentor teachers were recruited by mail. These mentor teachers were asked to reflect on the successes and challenges of mentoring MCTP students during the field-based component of the MCTP program. From summer 1999 through summer 2000, the MCTP program received cases written by MCTP mentor teachers.

List of the MCTP Cases

Only minor editorial changes were made in the cases presented in this chapter. The goal was to represent as much as possible the actual voices of a select sample of MCTP new teachers and MCTP mentor teachers. Appendix V contains the MCTP teacher cases. Appendix VI contains the mentor teacher cases.

I. New Teachers:

1. "Science Fair Projects" by Kristina Clark
2. "Me? A Middle School Math teacher?" by Josephine To
3. "Mathematics and Science Teaching as a Voyage of Discovery" by Jessica Ort
4. "My Challenges as a Private School Mathematics and Science Teacher" by Stephanie Colby
5. "Bringing the MCTP into my Teaching World" by Holly A. Nevy
6. "Differentiation of Instruction" by Autumn Moore
7. "My First Year of Teaching as a Graduate of the MCTP" by Jessica Phelan
8. "Becoming a Good Teacher by Being Open to Learning" by Kate Walder

II. Mentor Teachers:

1. "Mentoring in an 'Up and Down' Component of Teacher Education: The Student Teaching Experience" by Cynthia Sadula
2. "Teaching for Understanding in Math and Science" by Janet Leonard-Walker
3. "A Comparison of Interns" by Mary Beth Johnson

A Reference Guide to the MCTP Cases

Teaching Cases. The teaching cases were analyzed using the following categories that align directly with the goals of the MCTP:

- New teachers who are confident teaching mathematics and science using technology;
- New teachers who can make connections between and among the disciplines;
- New teachers who can use alternative ways to assess students' learning; and,
- New teachers who can provide an exciting and challenging learning environment.

Since the guidelines for the MCTP teacher-written cases were broad in scope (the new teachers were asked simply to reflect on "successes and challenges of instituting the MCTP reform-based "style" of teaching") each individual case may or may not bear upon any particular MCTP goal. For example, while Clarke in her case "Science Fair Projects" articulates a narrative that applies to all four of the MCTP goals, To in her case "Me? A Middle School Math Teacher?" presents a narrative that applies to a limited number of MCTP goals. Similarly, the other six MCTP teacher case narratives apply differently to the MCTP goals. To assist in locating cases that reflect on particular MCTP goals, Table 1 contains a case reference guide.

For instance, if the prime interest is to read cases that apply to the MCTP goal that "New teachers should be confident teaching mathematics and science using technology," the reference guide in Table 1 identifies the cases written by Clark, Nevy, and Walder. Clark in her case narrates the way in which she engaged her fourth grade students in a

Table 1

Reference Guide to MCTP Teaching Case Studies: Cases Illustrating Realization of Project Goals

MCTP Goals For New Teachers	Cases Illustrating Realization of Goals
New teachers who are confident teaching mathematics and science using technology	Clark, To, Nevy, Walder
New teachers who can make connections between and among the disciplines	Clark, Nevy, Walder
New teachers who can use alternative ways to assess students' learning	Clark, To, Moore
New teachers who can provide an exciting and challenging learning environment	Clark, Nevy, Moore, Walder

sustained science inquiry project that made connections to mathematics and used technology,

> *The students infused the use of technology with* [sic] *their projects because we were able to use computers to make our charts, record data, and type reports. The use of the computers allowed the students to make more professional looking projects and it also made the students take more pride in their work.*

Nevy in her case narrates her determination to use technology with her challenging middle level mathematics students,

> *I still use my calculators and computers when I can and try my best to closely monitor the students. I feel that depriving the kids is not the solution and that we must stress over and over that these are "the students' things". When one is stolen, then it is stolen from the students. I hope that as we continue to learn how to use these pieces of technology, the students will begin to have more respect for them and enjoy using them; thus, leading to less* [sic] *damaged and stolen pieces. I cannot, as a teacher, deprive the students of a needed area of education, no matter what.*

And Walder in her case narrates her developing comfort level (starting in her MCTP teacher education program and continuing in her peer instruction at her school) with the use of technology in her seventh grade mathematics practice,

> *In addition, the use of technology was incorporated in many of the lessons. While I did not have a great deal of knowledge (although I was introduced to a broad range of technology in my MCTP teacher preparation program) of the graphing calculator and Computer Based Labs (CBL's), several teachers in the department were very well versed at* [sic] *the use of these devices. Therefore, they were of great assistance to me in teaching students how to use the graphing calculator and CBL. Students enjoy these activities and learning experiences, and without the collaboration with my colleagues, my students may not have experienced these wonderful opportunities. However, because we were planning together I learned how to better incorporate technology in my classroom. Now I feel like an expert when it comes to using the graphing calculator and CBL.*

Table 2

Reference Guide to MCTP Teaching Case Studies: Cases Illustrating Challenges of Realizing Project Goals in Schools

MCTP Goals For New Teachers	Cases Illustrating Challenges
New teachers who are confident teaching mathematics and science using technology	None
New teachers who can make connections between and among the disciplines	Colby
New teachers who can use alternative ways to assess students' learning	Colby, Ort, Phelan (math),
New teachers who can provide an exciting and challenging learning environment	Colby, Ort, Phelan

Table 2 cross-references individual case studies with instances of challenges in realizing the MCTP goals in school practice.

For example, Colby in her case narrates poignantly the challenges of making connections between disciplines, using alternative ways to assess students' learning, and providing an exciting and challenging learning environment for all learners in her private middle school. She has this to say about her mathematics and science classrooms,

> *Math was so hard for me to teach because it was too structured. The lessons were dry and direct and I found myself standing up at the overhead lecturing for each lesson. That was exactly the opposite of what I wanted to be doing. I couldn't find a way to change it though because it was so controlled and limiting and I had to get through the lessons to get to the tests. I would look out at the girls as I was delivering what I found to be very boring lessons, and could see that they felt the same way. Even though they were not at all inspired by these lessons, they continually copied down the notes I put up. I was glad that they could stay on task through these lessons, but felt awful because I wasn't able to teach the way I wanted to. I wanted to be able to use manipulatives, let students discover concepts, and provide them with discussions and projects. However, the program didn't often allow for these kinds of activities, and thus I struggled yet again.*
>
> *My difficulties with science once the school year started were at the opposite end of the spectrum from mathematics. Where I felt restricted with math, I felt I had too much freedom with science....I found I didn't have the resources or the knowledge base to go out and create these spectacular lessons on my own. It was too much to ask for me to start from the bottom and be able to build everything up from there. I had great ambition to go out there and make learning fun, but my ambitions were quickly squelched by a lack of guidance and an overwhelming amount of work. In our summer efforts, we planned many interesting science lessons, but the planning was much easier than the implementation. My room was about the farthest thing from a science classroom, and both space and equipment were limited.*

Similarly, Phelan in her case discusses her challenges in implementing the MCTP goals in her public middle school mathematics and science classes,

> *My first two months of teaching really killed me. I wanted so badly to incorporate all of the strategies that I had learned through MCTP. I really wanted all of my lessons to be hands-on and meaningful. I tried to incorporate math into science lessons, and science into math lessons, so much that my students would often say, "This isn't science class, this is math class," or vice versa. I also wanted to incorporate technology into my lessons, but dragging six computers into a classroom where you will only teach one period just didn't seem like an efficient use of time. Taking a class to the library to use the computers was virtually impossible, because teachers sign up for the lab six months in advance and then stay there for two or more weeks at a time. I would get to school at 7 a.m. and often stay until 7 p.m. planning lessons, gathering materials, writing e-mails to parents, and grading. All the while, seeing other teachers leaving the building as soon as the afternoon bell rang.*

Mentor Cases. The three mentor cases tell individual MCTP cooperating teachers' experiences supervising MCTP (and other) teacher candidates during their final semester, field-based experience. For reference guide purposes, the key insight from each case is identified below. Interested readers are invited to read in their entirety the mentor teachers' cases for elaboration. Sadula, in her case of an MCTP intern placed in her seventh grade science class, discusses the imperative need for mentor teachers to monitor the confidence level of even the most highly prepared teacher candidates in mathematics and science. As she states, open communication between the mentor teacher and the intern is essential in a productive relationship between the two,

> *The open communication that we had (and still have) helped me to understand the depth of the questioning that even the very best teaching intern goes through during their internship. As I work with more and more teaching interns I am repeatedly reminded of this low point in the internship. I now watch for it and try to stem it off before it gets to the point that Chris [her MCTP intern] suffered.*

Leonard-Walker, in her narration about an MCTP intern in her fourth grade class, discusses the need for the mentor teacher to model reform-based practices in the classroom and to engage in ongoing reflection. Leonard-Walker's professional development experiences with MCTP and another NSF-funded project enabled her to articulate comprehensively to her intern a reform-based teaching/learning philosophy that was represented throughout her instruction. As she states, the cooperating teacher modeling reform-based professional practice was essential,

> *Since Stacy [an MCTP intern] had been observing and listening to me reflect on lessons I taught, heard me discuss the pedagogical experiments I took, the successes I experienced, and the future improvements I identified, she felt the freedom to do the same with me. I believe that since I was open with her and enlisted her help and suggestions, she was able to reciprocate. Hence, she began to understand the reasons for instructional decisions; was able to analyze past, present, and future teaching/learning situations; and could plan accordingly.*

Johnson, in her case of two MCTP interns placed at different times and in different classrooms and schools (third and fourth grade), discusses the complexity of context (curriculum, instruction, and student diversity) that impacts the relationship between a mentor and her intern. In discussing possible reasons for the different experiences with her two interns, she states,

> *I don't know what made the difference in the interns' experiences. Perhaps it was seeing me at my strength -- science in the lab rather than struggling to learn a new curriculum. Perhaps the milder make-up of the first class versus students with emotional problems made a difference. The disruption in the flow of teaching styles and locations could have made a difference. Individual expectations and attitudes towards the diverse requirements of elementary teaching could have also clouded the experience. I felt I gave both interns as much time and energy as I had.*

Uses of the MCTP Cases

The most conspicuous uses of the MCTP cases have been for program documentation purposes (McGinnis 2000b, 2001). A fundamental assumption of MCTP is that changes in pre-secondary level mathematics and science educational practices require reform within the undergraduate mathematics and science subject matter *and* education classes teacher candidates take throughout their teacher preparation programs (NSF, 1993). A critical need has been to document, interpret, and evaluate reform-efforts being conducted in science teacher education (undergraduate and in the workplace). As a result, the new MCTP cases have been presented as data sources in crafting a "useful or interesting" (Becker, as quoted in Peskhin, 2000) depiction of how the MCTP graduates see their professional lives unfolding. The cases have illustrated as a body of narrative expression instances of realization in instituting reform-based practices in mathematics and science, as well as instances of challenges in realizing the project's goals in elementary and middle level schools.

In addition, one of the new MCTP teacher's cases ("Differentiation of Instruction" by Autumn Moore) has been used repeatedly for instructional purposes in the MCTP program at UMCP. Moore's teaching case has added an educational context and increased the motivation of both MCTP and non-MCTP students in learning methods to implement inclusive-education in mathematics and science contexts. The Moore case has promoted more active student learning and engagement by requiring prospective teachers to discuss a specific example of real world mathematics and science teaching in a reform-based classroom. Table 3 contains a list of questions that assist in guiding discussion of Moore's case.

Initial questions such as "How do you react to Autumn's initial conception of differentiation of instruction? and "Does she voice sentiments you hold (or once did)?" enable prospective teachers to voice any apprehensions they may also hold toward teaching mathematics and science with differentiation. More critical questions such as "What additional strategies would you suggest to Autumn and others interested in this educational initiative?" prompt prospective teachers to use the methods and theories they encounter in their teacher preparation courses to solve real classroom problems. This example suggests that many, if not all, MCTP cases hold valuable instructional potential in teacher education learning environments providing that appropriate guiding questions are crafted to accompany each case.

Table 3

Autumn Moore's Teaching Case: Questions for Reflection and Discussion

1. Autumn mentions that during her first year of teaching that she struggled with the concept of differentiation of instruction. What was her primary source of frustration with this educational initiative?
2. How do you react to Autumn's initial conception of differentiation of instruction? Does she voice sentiments you hold (or once did)?
3. Autumn states that another teacher "pointed out that [her] thinking was wrong" about how to enact differentiation in her teaching practice. How do you interpret what Autumn learned about differentiation of instruction from that conversation with another teacher?
4. From the examples Autumn provides in her teaching case, what new strategies have you learned to achieve differentiation of instruction in your teaching? What additional strategies would you suggest to Autumn and others interested in this educational initiative?
5. Autumn touches on the challenges she still faces as a teacher who is committed to achieving differentiation of instruction. What new challenges do you think the students also face in this type of educational environment?

Finally, the cases have been identified by new MCTP teachers and mentor teachers as important opportunities for professional development. This use of the cases may be the most significant to the professional lives of the case writers. In informal conversations with MCTP personnel, the case writers have expressed how valuable they found the process of writing the cases. In a profession that is characterized by time pressures and considerable daily responsibilities, an opportunity to critically reflect on professional practice as a new teacher or as a veteran mentor teacher is not common. It is appreciated, however. As expressed eloquently by one new MCTP teacher in a note attached to her completed case,

> *I want to thank you for the opportunity to reflect on my first year as a whole. While I reflected on many pieces of it, I never found the time to look at it as a whole. I found it very moving as I recalled special moments and very encouraging as I considered the growth. (Jessica Phelan)*

Discussion and Conclusion

Shulman (1992) has argued repeatedly that teachers can write compelling narratives that do not have to go through researcher case study "translations". As illustrated by the MCTP cases written by new teachers and mentor teachers, the power of the insider's perspective, as presented by the teacher's voice, is apparent. We believe that these cases contain the ring of authenticity that reaches out to those interested in entering the professional lives of MCTP teachers and mentors.

The teaching cases detail the complexities of implementing reform-based practices in elementary and middle school environments.

From these cases we learn that achieving reform in existing school cultures is an extremely intricate process, full of great possibilities (as told, particularly, by Clark, To, Moore, and Walder), as well as of challenges (as told by Ort, Nevy, and Phelan), and even of seemingly impenetrable barriers (as told by Colby). We come once again to the conclusion that if the learning/ teaching environment context is open for reform, the reform-based practitioner is essential for it to occur.

The mentor cases all depict honestly the relationships between the more experienced reform-based teacher and the aspiring teacher candidate. We learn that dilemmas emanating from reform have an impact on even the most experienced and capable of teachers as they interact with individual prospective teachers. Ultimately, we conclude from the MCTP teacher-written cases that the teachers' unique perspectives must be considered as we investigate the impact of an innovative, reform-based teacher preparation in enacting systemic mathematics and science reform in our nation's schools.

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BECOMING A TEACHER: NARRATIVES OF ELEMENTARY-TRAINED TEACHERS

Professional Stances of Teaching Middle School Science

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Towson University

...narrative inquiry is a way of understanding experience. It is a collaboration between researcher and participants, over time, in a place or series of places, and in social interaction with milieus. An inquirer enters this matrix in the midst and progresses in this same spirit, concluding the inquiry still in the midst of living and telling, reliving and retelling, the stories of experiences that make up people's lives, both individual and social. (Clandinin and Connelly, 2000)

Good narrative is full of human factivity—wanting, opining, decrying—and the writing of scientists and logicians is sparse in this respect. . . . One [mode of interpreting action] is in terms of working out human intentions in ***real or possible work****; the other is through the operations of causes, structural requiredness, reasoned correlation. (Bruner, J., 1985, emphasis added)*

What are Narratives?

This paper looks at how written and oral narratives can be used as a means to construct a *personal theory* and a *professional stance* of teaching science by elementary-trained teachers. In its simplest form, a narrative is any spoken or written means of presentation. More specifically they can be any "organizational scheme expressed in story form" (Polkinghorne, 1988). People have ". . . recapitulated and reinterpreted their lives through [the process of] story telling" or narratives (Kohler-Riessman, 1993). Using narratives as a means of story telling, recounting of actual events, and creating personal meaning and understanding relative to real life contexts has had a long history in human society (Bruner 1985, 1986; Kohler-Riessman, 1993; Lyle, 2000, Polkinghorne, 1988; Strobel, 1998). For example, in *The Case for Christ* (1998), Strobel points out that narrative, as an oral tradition, pre-dates written books and the printing press and that narratives, or stories, were passed along for the purposes of lessons to be learned. In the case of the gospels, the purposes were mainly to document the history and chronology of the life of Jesus Christ. While obvious differences occur among these accounts, (Strobel suggests anywhere from ten to forty percent), the argument is that the stories preserve the main components and importance of Jesus' life and the differences are related to the individual writer/story teller as he viewed the story through the contexts of his own experiences. Thus, the lens through which a story is told is embedded in the lived experiences of the storyteller.

In studying modes of thought Bruner (1985, 1986) insists that the narrative and paradigmatic, are "irreducible modes of cognitive functioning" (1985). The paradigmatic, or logico-mathematical, is context free, universal, and seeking objective truth. Such a mode of thought is evident in traditional scientific inquiry. Narrative, on the other hand, is context sensitive, seeking meaning and "truth-likeness" through personal experiences. The goal of narratives is not necessarily to produce "truth" in an objective, empirical, scientific sense, but to create truth through "believability," by the construction of good stories. Kohler-Riessman (1993) asserts that "narrativization assumes point of view. . . . [where] . . . . facts are an interpretive process," with differing accounts about the same event evident from different authors. As with the *telling* of stories one importance in creating meaning through narratives rests with the individual reader as she relates meaning to her personal contexts and experiences in life. The closer a reader is to "living" the context of the narrative, or having experiences within that setting, the more the story will have personal meaning and purpose for that individual. Unfortunately, a narrative mode of thought, one that is embedded in a person's world and experiences, is often not deemed important, or fruitful, in the traditional paradigm of scientific inquiry. As Bruner (1985) states:

> *The nature and growth of thought that are necessary for the elaboration of great stories, great histories, great myths—or even ordinary ones—have not seemed very attractive or challenging to most of us.*

Why Narratives?

> *Few would argue that the beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, or that understanding the belief structure of teachers and teacher candidates is essential to improving their professional preparation and teaching practices.* (Pajares, 1992)

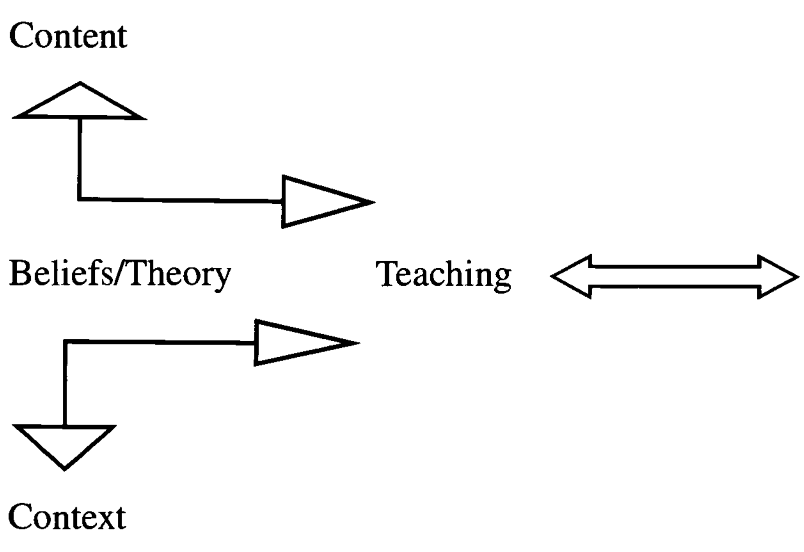
<u>A Relationship to Teacher Beliefs</u>

The question here is "Why Narratives?" Why use narratives as a means or an aid in constructing personal theories of science teaching? One reason relates directly to an understanding of "teacher beliefs." Pajares's (1992) statement reflects a common conclusion of research on teacher beliefs: mainly, that what teachers believe, in regards to teaching and learning, will ultimately manifest itself in their practice (Clark & Peterson, 1986; Kagan, 1992; Munby, 1982, 1984; Nespor, 1987; Tabachnick, Pokewitz, & Zeichner, 1979). In attempting to discover a source of teacher beliefs, Nespor (1987) argues that beliefs are structured from previous events and experiences. A teacher's past events create "guiding images" that act as a filter for new information. A belief structure created from an earlier experience may also be resilient enough to be a standard that newer information is compared to. For example, if a teacher changes conceptions of what quality teaching is, from a traditional whole group approach to a cooperative learning orientation, all new information about practice will be filtered through the cooperative learning belief structure. Or, if, as a child, she had positive experiences with a specific teacher and these experiences influenced her viewpoint of how to deal with students, then this history may motivate her to act in a similar manner and thus treat her students as she once was treated. Based on these ideas a person's memory serves as a template for future action and that revealing these memories through interviews and narratives can provide insight as to the belief structure that guides a teacher's practice.

Pulling from work on teacher metaphors is also helpful in ascertaining how beliefs mold practice (Tobin, 1993; Tobin & Espinet, 1989; Tobin & Gallagher, 1987; Tobin, Tippins, and Gallard, 1994; Tobin & Ulerick, 1989). Metaphors may be used to help define a teacher's role in the classroom and thus guide her practice. A "teacher as intimidator" (Tobin & Gallagher, 1987) may be one who is authoritative, demanding respect, and squelching any potential misbehavior. A "teacher as preacher" (Tobin & Espinet, 1989) is one who may use sermon-like lectures as the dominant teaching technique. A teacher who views herself as a resource may then structure the classroom for collaborative and independent work, where students ask for help and guidance when needed (For a detailed description of metaphors and beliefs, see Tobin, et al., 1994). These studies also suggest that a teacher may use more than one metaphor to fit certain classroom contexts (Policeman, Mother Hen, or an Entertainer). Use of metaphors may also aid in teacher change as a teacher attempts to alter traditional practices to those that fit more with contemporary views of science education (Fawcett, 1992; Tobin & Ulerick, 1989).

Studying beliefs is problematic because they cannot be directly observed and must be ascertained by what people say and do. A variety of terms are used to define teacher beliefs. These include *preconceptions*, *implicit theories*, or *orientations*. Teacher perspectives, described by Clark and Peterson (1986), are ". . . a combination of beliefs, intentions, interpretations, and behavior that interact continually." Tabachnick and Zeichner (1984) suggested that these perspectives include not only beliefs about work as a teacher but also how these beliefs are given meaning through behavior and classroom practice. Past studies of teaching and learning science have focused on the relationship between teacher beliefs and their practice and how personal experiences influence what happens in the classroom (Chun & Oliver, 2001; Blake, in press; Blake, 1999 a & b; Bryan & Abell, 1999; Trumbull, 1999; Abell & Roth, 1994; Korthagen & Kessels, 1999; Stofflett, 1994). Whatever the definition, it is generally agreed that what teachers believe in, as it relates to their philosophy of teaching, their role within that process, the role and expectations of the students for learning, and the role of the school, science curricula, and context for instruction will be an essential foundation for what occurs in the classroom (Figure 1).

Figure 1. Beliefs as the filter for teaching (See Blake, In Press).



Narratives as means of understanding beliefs

Inquiry into teacher beliefs is, therefore, central to a complete and useful understanding of the thought processes of teaching. While research on teachers' implicit beliefs is considered the smallest and the youngest part of the literature, there are a number of ways of "getting at" teacher beliefs (questionnaires, observations, interviews [structured, semi-structured, and/ or open-ended], and narratives). Narratives, through interviews and writing, pose a particular challenge as a research tool because of the breadth of material obtained. Many times we tend to fragment the interviews and writings into manageable "chunks" or themes, ones that the researcher identifies. In discussing the use of the text as a whole, Kohler-Riessman (1993) asserts that making sense and meaning of a particular passage, understanding why a person acts or reacts in a certain way, or just plain listening to a person's story cannot necessarily be segmented and fractured into small, manageable chunks. Taken as a whole the full story, one that is embedded within the experiences of the individual, can provide valuable insight into that experience. For example, when Trumbull (1999) looks at new biology teachers and how they "become teachers," she does so by viewing the teachers embedded within their school context, or as Clandinin (1999) calls it, their "professional knowledge landscapes". It is through these teacher narratives and reflective stories that the reasons and purposes of their actions are revealed. Conflicts may arise, and how these conflicts are resolved are often played out in these stories.

A reason for the use of reflective narratives for preservice and new teachers is to provide them opportunities to make explicit the struggles they may have between the theories and beliefs of teaching science and their actual practice. Results of studies on teacher education suggest that the ways teachers are taught, whether by content or through pedagogy, have a great influence on the way they teach children (Korthagen &Kessels, 1999; McGoey & Ross, 1999; Stofflett, 1994). To counter the didactic practices (Stofflett, 1994) of traditional teacher education, Korthagen and Kessels (1999) suggest that teacher educators move from the "application–of–theory model" to "reflective approaches" in which students are provided opportunities to consider their teaching experiences in the context of their developing notions of what it means to teach. Bryan and Abell (1994) also suggest that incongruent messages from the university and school cultures may interfere with the ability of preservice teachers to reflect on practice and how beliefs inform such practice. Generally, teacher preparation programs focus on theory, the ideal of teaching in which students are expected to transfer what they have learned into their classroom experience. The school culture, on the other hand, focuses on pragmatic experiences and the day-to-day reality of teaching, which may often lack an explicit coherent theory. Often preservice teachers find they are expected to incorporate college theory into actual classroom practice as they struggle between the practical demands of public schools compared with theories presented by university professors. Trumbull (1999) points this out in her study by commenting that

> *Once they [preservice teachers] complete teacher education programs, new teachers enter schools where practices engender particular conceptualizations of biology teaching. The conceptualizations of biology teaching that are promulgated in these different settings are not all consistent. A lack of consistency across contexts can impose*

stresses on new teachers and render their professional development complex. . . . ***How do they manage the contradictions across different conceptualizations? How do they succeed in their contexts of practice as new teachers?*** (emphasis added)

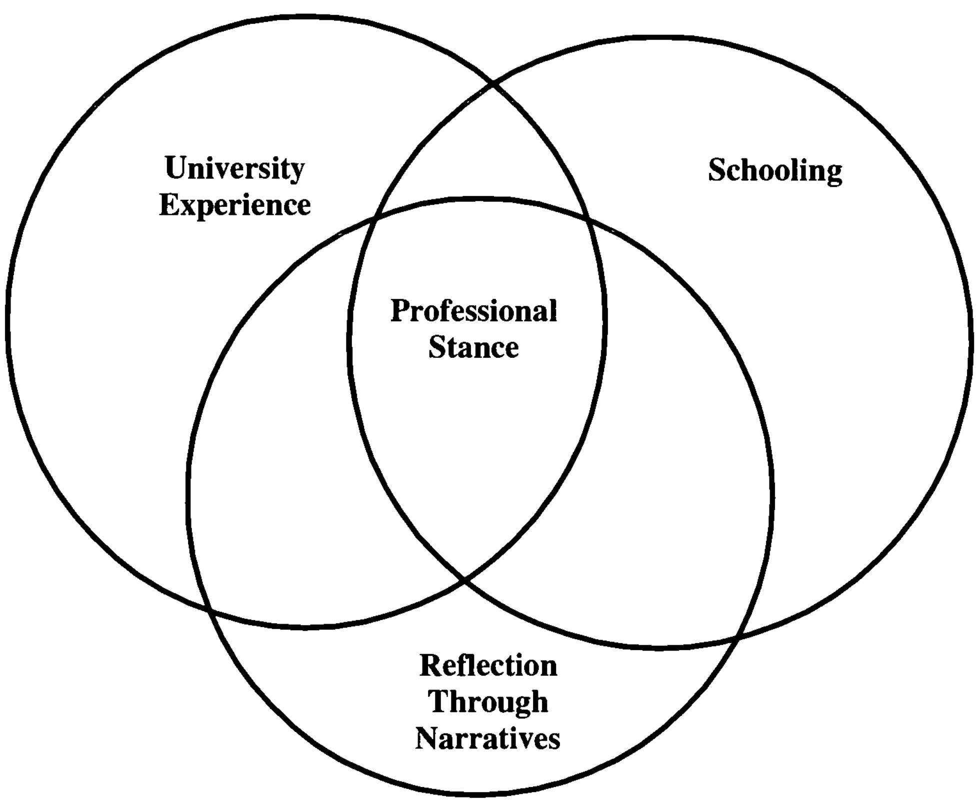
The purpose of using narratives as a means to articulate beliefs is but one way to aid preservice and inservice teachers in linking beliefs with actual classroom practice. As a new teacher gains experience, the personal theory is reconstructed relative to the culture of schooling. This "new" theory, or *professional stance* is what the teacher uses to guide her teaching (Figure 2).

Purpose, Context, and Method of the Study

Purpose

Presented in this paper are narratives of two participants from three phases of a three-year longitudinal study that began in the pre-student teaching coursework, through the student teaching internship, and into the first and second years of actual classroom practice. The purpose of this study is to focus on the use of written reflective narratives by elementary-trained teachers as a means to construct personal theories of teaching science. Ultimately, and similar to Trumbull's (1998) study, the goal is to use narratives as a means to aid in the construction of a *professional stance* of teaching science as each teacher bridges the span between theory and classroom practice.

Figure 2. Constructing a Professional Stance Through Narratives.



University and School Contexts

The University. Participants in this study were enrolled in Towson University's elementary education program. All were white females, ages 20-25 with student teaching and full-time teaching experiences in surrounding county and private school systems. Phase I, the pre-student teaching experience, had 13 participants, phase II, the student teaching semester, had 9 and phase III had 4. Phase III encompasses the first and second years of each teacher's initial experiences.

School Contexts. Of the four teachers in phase III, one was teaching four seventh-grade science and one seventh-grade mathematics class, one had an even split seventh and eighth-grade science and mathematics, with two classes each, one was teaching all sixth-grade science and one was in a fifth-grade self-contained setting (with a one month rotating schedule between social studies and science). One of the four began her first year as a full-time middle school teacher in a parochial school. She resigned that position after three weeks and began to substitute teach and work at a for-profit tutoring center.

Demographics of each school varied from 20% free and reduced lunch and a 40% minority population for one school, to an all-girls private Catholic college preparatory middle school with low diversity and no students on free and reduced lunch.

Data Collection

Data collection during phase I was in a variety of formats. Students responded to instructor writing prompts, responded freely to issues and concerns centered around their teaching of science, and responded via electronic mail to weekly questions posed by the instructor and/or individual students. Each student also completed an historical survey, a belief in teaching science paper, a response to *Teaching is, Science is, and Teaching science is* writing prompt, and numerous self-analyses about teaching

Figure 3. Electronic Log From Middle School Teaching Experience (Posner, 2000)

Theme: Becoming a Teacher: Stories of Preservice Teachers Teaching Science

A. Part One: (Minimum: 2 times/week)
   1. Heading
   2. Event Sequence
   3. Elaboration of two significant events.
B. Part Two: Weekly Analysis
   1. Analyses (@ End of Listed Weeks)
      a. Week 1
      b. Week 2
      c. Week 3
      d. Week 4-5 (Or during Full time teaching)
      e. Week 7 (Overall Analysis of Log Entries and Teaching Experience)
C. Write (After Readings but before Student Teaching Begins)
   1. Expectations, concerns, and issues relative to upcoming student teaching experience as they relate to *Becoming a Teacher.*

episodes and coursework. Phase II (student-teaching) utilized a more formal reflective log sequence suggested by Posner (2000), *Field Experience: A Guide to Reflective Teaching*. Logs were submitted electronically based on the format described in Figure 3. In addition, before student teaching began, participants were asked to complete a written narrative that explained expectations, concerns and/or other issues relative to the ensuing student teaching experience. In addition to weekly writings a minimum of three classroom observations with immediate debriefing sessions were all recorded on audio tape.

In phase III each participant was first provided with copies of her written material from phases I and II. The purpose was to read and analyze previous notions of teaching science, compare these ideas to her current theory, and to write a statement about teaching as each now viewed it as a full time teacher. At least once per week, each teacher was asked to write narratives based on school and classroom experiences. Follow-up observations of teaching and interviews were conducted in the spring of 2001, fall of 2001, and spring 2002. Data collection is ongoing. The data presented in this paper are from written narratives from student teaching logs and full-time teaching narratives.

<u>Data Analysis</u>

Initially, as general themes became apparent and as specific observations and de-briefing sessions were warranted, Spradley's (1980) developmental research sequence was used as a guiding framework for data analysis and follow up "focus questions." However, as the methods of narrative analysis became more apparent and better understood, I began focusing on the texts as a whole (Kohler-Riessman, 1993), without an "a priori hypothesis" or "question" as in traditional research (Lieblich, Tuval-Mashiach, and Zilber, 1998). Therefore, my questions and analyses were, and are, ongoing, as proposed by Glaser and Strauss's (1967) conception of "grounded theory." To ensure "validity and reliability" of the meaning I interpreted from the text, I shared drafts of my writings with the participants and incorporated their review and feedback in subsequent manuscripts. This method ensures accuracy of the meanings intended by the participants and also ensures that I "got it right." (Eisner, 1991 and Wolcott, 1975, 1990a and b, 1994). Therefore, the data analysis, or the reading of narratives, focuses on how the written and oral stories are used to better understand the teaching and learning of science, to construct personal theories and professional stances of teaching, as well as to identify tensions among teacher beliefs, experiences, and practice, or the notion of *Ideal vs. Reality* (Bryan and Abell, 1999).

The Narratives

Presented here are examples of written narratives from Stephanie and Jennifer as each writes from experiences spanning all three phases of the project (pre-student teaching, student teaching, and first year teaching). Both women demonstrate a variety of emotions and expectations as each struggles with becoming a teacher. Stephanie, struggling with the student teaching in a middle school science classroom and teaching in an all-girls Catholic middle school, focused primarily on her understanding of the content of science and her ability to then teach that to her students. Focusing on the "what" of teaching with less emphasis on the "how" she rarely discussed management or behavior issues. Jennifer, on the other hand, teaching in a public middle school with almost 30% of her students obtaining free and reduced lunch and with few students even caring about, or wanting to learn science, focused almost entirely on her struggle between her theory of teaching (the ideal of a constructivist framework proposed at the university) and the reality she faced in a classroom and school that provide little support for inquiry-oriented learning. For Jennifer, a primary concern became the issue of "how" to teach and struggling with the conflict with *"discovery learning"* (her words) as a non-feasible method of teaching for her students' class.

Eventually, each women began to express emotions of frustration and fatigue towards teaching and a loss of interest in pursuing her dream. In response to these stories, we need to ask ourselves: "What can we learn from each teacher's story? How can we affect change in preservice teacher education? How can we gain insight into the construction of a professional stance and how that stance is influenced by the constraints[1] of full-time teaching?" Finally, in reviewing this small but telling sample of narratives we may need to ask what we, as teacher educators, can do to aid in the construction of these professional stances and how we can alleviate some of the stresses that arise as college graduates leave the classroom and enter the profession of teaching.

Stephanie: Content IS Linked to Self-Confidence

> *Teaching is like the spring time. There are many showers you must endure throughout the season, a lesson that flops, a discipline problem, or an unexpected change in the schedule. Some days the showers will be light, perhaps a slight drizzle here and there, other days the rain will fall hard and pour down on your plans, and still yet there will be days of sunshine and brightness and hope. Those are the days you need to focus on, for they make it all worthwhile. In the end, when the rains have ceased and summer is on the horizon, the fruits of all the labor and endurance are paid off as you observe the beautiful bloom of the flowers.* (Stephanie, 4/2/00, Metaphor of Teaching)

The Semester Before Student Teaching: Beginning Struggles of Teaching Science (Fall 1999).

In reflecting on her science methods semester, Stephanie talks about "many struggles" she had: struggles with finding the "best way " to teach science.

> *These included struggles of what grade and subject I wanted to teach, whether I would be able to handle the complexities of middle school education, and most of all a struggle with my belief system of how science should be taught. I had read many articles and heard many lectures that proclaimed "the best way to teach science . . ." but I had yet to come to my own conclusion as to what that "best way" was.*
>
> *The main issue I struggled with throughout the different aspects* [of] *this course. . . was finding the balance between teacher-directed instruction and student-centered learning. The literature presented student-centered learning as*

[1] Which include but are not limited to the mandating of school and district curricula and teaching methods, the adherence to professional content standards (both state and national), the perceptions of veteran faculty of classroom and school climate and student behavior, the support or lack of support from administrators (science supervisor, department chair, and/or principal) and parents, the struggle between university training and the reality of the classroom, and the sense of self-efficacy of her ability to effectively teach science.

ideal, but I doubted the reality of being able to have a completely student centered science class. It didn't seem realistic to me that one would be able to hand their class over to the children and still produce clear scientific understandings and fulfill all the curriculum requirements. Then on the other end of the spectrum, I had been through many completely teacher directed classes, and thus knew from first hand experience that this was definitely not the "best way" to instruct science. Having figured this out, I was left with the difficult task of finding how to balance the two in order to create the optimal learning environment, one that promotes scientific inquiry and exploration and still provides connections and understanding. (Narrative on "Self-View" of Teaching Science. 9/99)

At this stage of her college career, Stephanie was struggling with the construction of her personal theory of teaching science, one that would fit her and her students. She felt that the 5E instructional model (BSCS 1992), a model based on the "learning cycle" that incorporates student exploration and investigation before teacher explanation, *"to be one of the most enlightening tools in the construction* [of] *my self-view of a science teacher."* As she continued to write, she began to make links between her experiences in the classroom with her own theory of teaching, proclaiming the 5E model to be *"Second only to my actual experience"* in influencing how she wanted to teach science.

I began with the idea that I wanted to construct a completely student centered lesson, but realized as I went along that there were parts where the students probably wouldn't be able to get it own their own. If I just pushed them through those parts to continue on with their exploration, their understandings would not be complete and my allowance for discovery would have done more harm than good.

From all of this, I have begun to form the philosophy that will direct my future teaching in science. As a science teacher I believe you need to be a guide, a knowledgeable source who provides the necessary instruction, but also allows for the students to explore and discover on their own. A science teacher is there to provide direction, to help wrap up and connect lessons, but by no means are they to be captains of the ship filling the "empty vessels" of their students' minds with facts that are meaningless without the opportunity for exploration or application. Though discovering the proper balance between teacher instruction and student exploration is one of the most vital components of successful science teaching, it is also probably one of the most difficult, and requires much time, energy, and practice to attain. (Narrative on "Self-View" of Teaching Science. 9/99)

<u>Pre-Student Teaching Narrative. Expectations, Concerns, and Anxieties (1/13/2000).</u>

In her pre-student teaching narrative, Stephanie raises many issues regarding her concerns and anxieties of teaching. She again struggles with her notion of how she will structure the learning and continues to ponder her ability to teach science in light of her self-analysis of her lack of content knowledge.

Having already visited with my classes and cooperating teacher previous to writing this paper, I find that many of my *other anxieties about my specific classroom situation are eased, though not completely gone. In previous field placements, I have worried a great deal about stepping on the toes of my supervising teachers. As a student teacher it's really going to be a struggle to find a balance between the kinds of things you want to do and the way the teacher has already established things in the classroom. Take group work for example. If the cooperating teacher holds the belief that in the science classroom the teacher provides all the knowledge and students work individually on their lessons and assignments, then implementing the kinds of exploratory, hands-on, cooperative lessons that we have become so familiar with could prove to be quite a challenge. Though it remains a concern that I may not be able to meet up to all of Mrs. Petri's classroom standards, my meetings with her have helped to alleviate some of my concerns about that. From what she has already shared with me about her teaching beliefs, I am comforted by the fact that our beliefs seem to correlate well.*

. . . In middle school many students are struggling to figure out a multitude of complexities in their lives, and in this struggle, as I remember, it is possible to lose a lot of self-confidence. From my own personal experience, I really began to doubt myself and my abilities, especially in science and mathematics. I began to think that I couldn't do it on my own and lost interest in these subjects. Eventually, I learned that I was capable of succeeding independently, but only after a period of great difficulty. During this period of time, mistakes in my science courses caused me great frustration. It never seemed to fail that my lab results would always come out different from the others reported in the class, and I could never understand what I was doing wrong. It took me a long time to figure out and believe, that I wasn't necessarily doing anything wrong, things just weren't always working out right. While it only took a short time for me to begin to doubt my abilities, it took a lot of reassurance to reinforce it. This semester, during my student teaching, I hope to discover some way of instruction that encourages the students, helps them to find success, and increases their interest in science. I realize, however, that this is one large undertaking and will probably be one of the biggest challenges of my experience.

. . . Classroom management is another big concern. If you have the respect of the students, classroom management is not likely to be a problematic issue. But coming in as a student teacher, I know that I will have to work hard to earn the respect of the students. I expect that I will learn a great deal about classroom management this next semester being that I am in a science classroom that promotes hands-on, minds-on science. To me, that means that the teacher serves the students more as a facilitator of knowledge, rather than the sole provider. However, taking this role can be somewhat of a challenge. Allowing the students to explore and discover scientific concepts on their own necessitates the teacher giving up some of their control over how things go. As "Alice" described in Teacher Lore *[Schubert and Ayers, 1992], I fear that I may become trapped between my need to hold some control in the classroom and my inclination to provide the students with creative lessons that allow them the freedom to explore on their own. As a*

student teacher, I expect that my control and authority in the classroom will be limited to begin with and I can foresee that giving up that little bit of control will be very frightening for me.

Post Student Teaching. Responding to Prompts (4/2/2000).

At the completion of her middle school placement, Stephanie responded to a number of writing prompts that allowed her the opportunity to reflect on her recent teaching experiences. Again, she continued to express doubts about her content understanding and thus her ability to teach science. The "lack of content" theme is one that remains a topic of debate for middle school teachers. Practitioners who support content, and thus, a degree in a one of the sciences with a concentration in science education (certificate, grades 7-12) argue that knowing "what" to teach takes precedent over "how" you teach it. However, there are those educators who favor having elementary-trained teachers in middle school because these teachers understand the teaching of the whole child and the needs of diverse learners. Stephanie continues to struggle with this issue.

Prompt #1: What could you have used more help in?

The biggest area that I feel that I could have used more help in can be said in one simple word: content. From this one solitary area of difficulty stemmed many of my problems. I had some difficulty with comfortability [sic] *in front of the class due to the fact that I wasn't comfortable and confident with all the material I was presenting to them. I had problems sometimes with classroom management because since content made me uncomfortable my hesitation showed through to the students and some of them jumped on my insecurities. Also, with a lack of confidence in content I had difficulty letting my students explore scientific concepts through activities on their own and often clung to* [sic] *tightly to the control and structure of the classroom. In other words, my lack of content seriously inhibited my confidence and thus my ability to teach.*

***

Dealing with the "reality" of teaching is a recurring theme throughout almost all student and novice teacher narratives as they discuss the struggle between the theory and practice of teaching science. Here, Stephanie is no exception and she begins the first stages of constructing her *Professional Stance.*

Prompt #2: "However, I live in the REAL world and I have to deal with that reality. Due to time constraints and other things, a teacher must have some lessons that are more teacher-directed."

I agree with this quote and I can definitely sympathize with it. Though I know it is not my quote, it seems very similar to something I thought many times during my experience. This is something I struggled with greatly as we worked through our first experience. I went in so excited with all these aspirations to be a constructivist science teacher with many hands-on activities to provide children with the opportunity to construct their own learning. I wanted to design interesting and exciting activities to inspire the children and encourage their interest in science. I was eager to put theory into practice and apply all the lessons I had learned in my methods classes.

But even with all my excitement and

aspirations I couldn't jump in with both feet and start off running right away. That would have been perfect in the ideal world, but as the quote says, this is the real world, and perfect isn't realistic. Therefore I had many struggles to deal with, battling between my theories and my ideals and what was actually practical and possible. Being human with a limited energy supply, I had to face the fact that I couldn't put together an amazing lab activity everyday. I couldn't design every lesson to be hands-on and exploratory, and that was very frustrating. There simply wasn't enough time in the day or energy in my body to be able to do this all the time.

With this in mind, I began to focus more on the reality of providing a variance of lesson formats. I would have to present some lessons through direct instruction, have some group work activities, and finally, make sure to incorporate some elements of exploration throughout the unit. It was difficult to face this fact though because I really desired to deliver all the lessons in an exploratory fashion, which I believe to be one of the most effective methods of delivery.

***

Finally, Stephanie talks about her role as a teacher. It is interesting to note here, and in Jennifer's narratives, that teaching science is not necessarily about "teaching science." It becomes so much more as each teacher decides what is important for her

Prompt #3: What is your role as the teacher in the classroom? Think generally and as it relates to content area.

Referring back to a previous answer, the role of teacher encompasses so much more than the role as a facilitator or provider of knowledge. In this job, you can't just jump in and start delivering lessons with the expectation that children are going to learn right away. It is not that simple. You have to not only consider and be aware of so many other factors, but you must also deal with them before you can hope to be effective in your teaching. So many students come to class hungry or hurting, angry or extremely excited, and you, in your role as a teacher, have the responsibility to deal with all of these feelings and emotions. The toughest part of this aspect of the job is that no one can teach you or tell you how to do it. You can't be taught how to care and comfort, it is an innate ability you must possess. It requires you to be able to handle many different things at one time and also requires the ability to carry a large amount of emotional baggage. ***Once you get past all of this stuff*** *(emphasis added), you move more into the role you play in regards to your content area. Here, while you still must maintain the nurturing role, you must become the performer, the disciplinarian, the assistant, and the expert. Playing all these roles at once can not only become quite confusing but is also very tiring. As the performer, you are charged with the task of entertaining the students, finding some way to make the content interesting and exciting for them. This is a large task and can not always be done on a daily basis. One is not always able to provide up and out of your seat active learning experiences, but one must not exclude them altogether.*

Your multifaceted role as a science teacher is not only determined by your students and your content, but also by your belief system and the methods of instruction you utilize. If you believe that constructivism is the way to go, then you *shouldn't be standing up in front of the class all the time. You have to relinquish your starring role in the spotlight and allow for some audience participation. A director may be needed at times to bring focus back to the performance, and some actors (students) may forget their lines, and while it is okay for you to intervene and relieve complete frustration, some struggle must be allowed. If you believe that there is more to teaching than direct instruction, then students need to have the opportunity to exercise their minds and to discover some concepts on their own. Following with these beliefs, the role of a teacher as an assistant is quite important. Again, you need to know how to step out of your controlling shoes and into your helping shoes where instead of giving the students the answer, you provide them with the necessary time and tools and guide them in finding the answers on their own.*

Ultimately, in your role as a teacher you need to realize that you can't just go in there and be the teacher, students need and expect more than that. I have had too many teachers in the past that stuck solely to their role as teacher, who stood up in front of me during my science and mathematics classes spewing out to me all the knowledge they believed to be "pertinent" to that particular course. Where was the meaning in that for me? What if my definition of pertinent didn't match with theirs? Unfortunately I conceded, and became very good at taking my notes and memorizing them for the tests, on which I generally performed well. However, much of the information they presented to me became just another compilation of meaningless facts that I often had difficulty applying later. Even today, I know that knowledge is stored somewhere in my memory, I just am not always successful at recalling it. I am determined to not be that kind of teacher for my students. I want to be more than just a fountain of knowledge spewing out the facts for them to collect and memorize. I want to be able to help them to discover the big ideas behind scientific concepts, to create meaning for themselves, and to bring science to life for them.

"The day I have been waiting for...the day I become the teacher."

The following narratives are from Stephanie's first year of teaching science and mathematics. Her first teaching position was in an all-girls Catholic school where she had four preparations, teaching seventh and eighth grade mathematics and science. Stephanie struggled from the very beginning with too many lessons to plan, too little pre-designed curriculum, and too little confidence in her ability to handle the responsibilities. In fact, the stress of achieving excellence became too much for her, and her first year lasted only three weeks. She resigned her position before September was complete.

In the following, Stephanie talks about her experiences in her first few days and then reflects back on how what she had anticipated for so long, came tumbling down.

Fall 2000: First Year of Teaching.

The day I have been waiting for...the day I become the teacher...the day I am in charge...the day I finally have my own classroom. All through student teaching that's what they told us: WIGMOC—When I Get My Own Classroom. That was supposed to sustain us throughout our struggles with the differences between what we wanted to do in the *classroom and the reality of what our cooperating teachers would allow us to do. Soon, they reassured us, we would have our own classroom where these types of decisions would be ours. And now that day is upon me. It's my first day of my first year teaching and I'm filled with a mixture of feelings. Here's what happened.*

Day One

Reality sets in. I've got my own classroom and soon the students will be arriving. So many questions rush through my head. Am I ready? Will they like me? Will they know I'm their teacher or because I look so young will they consider me a peer? How do I assert my authority? What kinds of questions will they ask? Will I be able to get through all the first day stuff with them?

Quickly the minutes pass by and before I know it it's 7:45 and eighth grade bright faces are trickling into my homeroom. "Are you Miss Colby?" they ask almost as unsure as I feel. "Yes, good morning, and who would you be?" I respond. I try to greet each one of them personally, knowing full well I'll forget their names in five minutes...my mind can't hold much right now cause there's so much running through it. They all arrive, except one, she's supposedly still in England. I have papers to hand out, forms to fill out, and most importantly names to learn. This one is the easy class. I don't really have to set down the rules with them. Homeroom is only ten minutes everyday, and I don't have to TEACH them, just get their day started.

I took my homeroom to the gym for a middle school assembly (where as a taskmaster I was the only one who made my girls carry their stuff with them) and then led them to the library for a prayer service. After that, there was an hour scheduled for pictures... Okay math teacher, there are about 50 eighth graders and sixty minutes for pictures. To me that equals some many minutes of down time with these students who I don't even know. What do I do? It's decided that I go back to my room with my girls, and we'll go down later to have our pictures. So we go back, finish up some homeroom business and then they chat. They are perfectly happy with that, somehow they never run out of things to say.

After everyone has changed their shirts and is readied for the pictures, we head back downstairs to get in line for pictures...once again making them carry their stuff with them. And here I have to leave them, for now, the show is about to begin. I am about to have my first core (class) with the seventh graders.

As they come in, some seem sure of themselves, others seem timid. I can tell some are new and some are old pros. I tell them they can sit where they choose, and inform them that I will be changing the desks around to make more room, so they don't have to worry about that. They'll be allowed to sit where they want, so long as there aren't any problems. If so, I'll just have to assign seats.

I need to learn names, so I have them make little nameplates out of index cards. Try to make it fun by giving them markers. Seems they enjoy it. Then I dive into my plans for the day. Pretty light, first day kind of stuff, yet it's amazing how nerve wracking it can be. I handed out math books and information cards for them to fill out. I handed out my course *outline and we reviewed it, now they'll know what I expect of them and what to expect from this course. We go over the rules of course, I'm trying to assert my authority. Then I explain the game for tomorrow. They are to think of two facts and a fiction about themselves to share with the class, I'm new and I want to get to know something about them. We talk about the website I've made and they seem excited. And before I know it my 45 minutes with them is up. They've got their homework, cover their books and get the course overview signed...I'll be checking it tomorrow.*

Then frantically, the girls rush to change their shirts because now it's time for seventh grade pictures. I'm so not used to this...We go down for pictures and then I have some down time before the eighth grade core begins. That's the one I'm really scared of. I've never really worked too much with eighth graders and there is a big difference between eighth grade and seventh grade.

They trickle in one by one, probably as confused by the schedule as I am. No bells to tell them when to go, where they go next, and today's schedule is out of the ordinary too since it's the first day. I introduce myself and start to run through a similar routine as I did with the seventh graders. I'm more intimidated by the eighth-graders though, I've heard they've got more of an edge. I start off with a brief introduction to let them know who I am, and then I ask them to make name tags, so I can begin to learn names. I pass out books, and information cards. I hand out the course outline, and go over it with them. Lay out the rules and the expectations, establish myself. I've been told over and over that the first day is the most important, so I'm not going to let anyone walk all over me. Though I don't hold true to the old adage, "Don't let them see you smile until December," I think I do a good job of letting them know I'm in charge. Not too many questions today, so I can feel at ease. Again I assign the homework, cover books and think of two facts and a fiction, and then the students are off. My responsibilities for the day are over, and I made it through.

Before I know it, I'm ready to go home after my first day of school. At the end of the day, I go home, thinking I made it through. No major disasters, no big mistakes on my part, and no one asked me my age! I left pretty early, with things in line for tomorrow. I had done it. I had made it through the first day, and I was still standing.

When I got home was when it set in. I don't feel like I can do this. Sure I made it through the first day, but what did I have to teach them? No knowledge was exchanged, what am I going to do tomorrow when I actually start to instruct them? How will I do it, how will they receive it? Tomorrow still isn't any major instruction, but I start feeling really anxious.

I don't sleep well at night, so many anxious thoughts running through my head, and I'm not hungry for breakfast in the morning. This has been the usual pattern for the past week. I'm not used to this and it doesn't feel healthy to me. Is this the way it is supposed to be? I don't know. I'll push on, I've got to get to school.

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"Where's the science?" she asks. What has she done all day? Was she prepared for this?

So much to do, so little time. As she continued to write, Stephanie decided that what might be best is reflecting on what "went wrong." It is here that the issues of content knowledge, planning, and the conflict within her personal theory are exposed.

"Do I know the content?"

> *I felt pretty comfortable when I was up in front of the class. I liked the interactions with the girls. But then there was some uneasiness with being up there too. Because I felt like because of my position up there I had to know everything. There were days when the girls hit me with a firing squad of questions, and I wasn't ready for that. The perfectionist in me told me that I had to have all the answers to their questions, no matter how much the other supportive teachers tried to convince me it was okay. I just had a lot of trouble getting past that compulsion. So that was a heavy weight on my shoulders, it took a lot out of me to be so afraid and excited at the same time. I wanted so badly to know the answers to all of their questions, somehow I felt that was what I was supposed to be like.*

"Can I plan the lessons?"

> *Planning was another big thing. I was used to working together with people with similar work habits. I was used to working with groups of like four or five people who all typically had the same drive as me. In this situation I was working with two different people (males at that, when I was used to working with only females. I'm not sure that that made much of a difference, but I just realized that point and am wondering if that was a factor at all) who had different work habits than me. In the past, I had liked to plan pretty well in advance and have things in line ahead of time. John, being new to the teaching profession, was kind of like me in that. In fact in the beginning, he was even more so. Over the summer we were to put together the first trimester worth of material. We worked hard those summer days, and almost accomplished that goal. I put together the first half and John put together the second half. We established the projects together and created some preliminary rubrics and grading tools, so we would be able to explain what was expected to the girls. While it was good that we got it all laid out, it was also bad in my mind for various reasons. The way we went about it, I wasn't familiar with the parts that John put together, and that lack of familiarity made me, of course, uncomfortable.*

<u>And the walls come tumbling down. Her own Jericho.</u>

> *Content was a big issue. My college GPA spoke well of my academic abilities, but my own personal interpretation of my knowledge base was far from the level of my GPA. In the required education courses we focused* [on] *a lot of different learning styles, the history of education, educational theories. In other words, our learning centered more around the "how" to teach as opposed to the "what" we were going to teach. So I felt underprepared in that aspect as well. While part of that anxiety is owed to my own perfectionism and the drive that I had that made me feel like I needed to know everything about something before I started teaching others about it, the other portion of that emotion can be contributed to the fact that I didn't have what I considered a sufficient training in content from my college studies. But then*

I could see how if we were required to take all of our methods courses on top of a large number of specific content courses that we would be in school forever. It just made it very hard for me when I first got out there, because since I didn't have a specialty in one particular subject I felt like I had so much more to put together. I didn't feel like I had mastered any subject area, just that I had a basic knowledge of a few. The saying is that hindsight is always 20/20 and I think that now looking back on things I realize that I did know enough, I just didn't have enough confidence in myself. I didn't give myself enough credit for my capacity to learn, or enough time to get more familiar with the material. Instead, I wanted to know everything from the beginning. Now I realize that's never going to happen. I'll never know everything, I just always have to keep my desire and drive to learn, so that what I don't know I can find out. Somehow in the stress and shuffle of those few weeks, I lost sight of that desire and I kind of shut down. I don't think that helped with my feelings of inadequacy.

<u>After her First Experience. Stephanie's Rebuilding and Constructing a Professional Stance.</u>

One of the biggest challenges was the conflict between many of the ideals I held and the actual instruction I was delivering. I didn't expect that it would be so hard for me to make learning fun my first year out there. I naïvely thought that my desire to be fresh and exciting would be enough of a drive to make me able to do it. Then I realized all the other tasks and challenges that were ahead of me in my first year of teaching and I realized that I had a lot on my plate. I had to prioritize what I was going to get to, and sometimes fun, or the exploration, or the hands on, wasn't always going to be first on the list. So I felt like I wasn't being a good teacher because I couldn't enact the wonderful ideals that I had developed throughout my studies in Education. We constantly talked about the struggle of putting theory into practice, but I never really realized how difficult it would be until I got my own classroom.

Ultimately, it didn't fit the mold I had imagined. With the science, things were too wide open and left up to me, whereas with the math, things were too structured and by the book. ***What I needed was a happy medium between the two*** (emphasis added). *I was used to working with a curriculum, at least having a guideline to go from. Not necessarily something that had a suggested lesson for each objective, but something that at least indicated what objectives I should be focusing on. As a first year teacher, I was overwhelmed by the lack of curriculum and the intense responsibility that* [was] *laid on me. I didn't have the experience to build something as extended as a year long curriculum for seventh grade, let alone repeat it for the eighth grade as well. It was quite an accomplishment when I put together my own Ecology unit for my seventh grade student teaching class, but I can't forget the struggle that accompanied that achievement.* ***Building my first year entirely from the ground up was not what I was ready for*** *(emphasis added). I realize now that what I needed was some more structure and support to start off my teaching career instead of the wide open freedom I received.*

<u>Substitute Teaching: Back on the bike.</u>

Each day I woke up facing the incredible challenge of a new day at Holy Child. I was afraid of the questions they would ask, afraid that I wouldn't know enough, afraid that somehow I would fail them. My expectations were entirely too high and ultimately, the only one I was letting down was myself. But I couldn't see that then. All I could see were the things that went wrong. Now I wake up each day with a different struggle. Though I am using this time to explore different venues of education, I really miss being in the classroom. It is so hard because I am so eager to get back into the classroom and try to establish my own classroom again, but after my experience, I am so scared at the same time. I would rather do anything else than have a repeat episode of what happened at the beginning of the school year. So I'm slowly preparing myself for reentry, rebuilding my confidence and trying to readjust my expectations.

Through teaching at the Huntington Learning Center, I have been exposed to students of all ages. This is helping me to determine the grade level I would like to pursue, which hasn't really changed as I am still interested in the 4-8 grade level, though I believe that fifth or sixth grade would be optimum. Teaching at Huntington has also exposed me to students of varying ability levels, with a variety of needs, and a variance of learning styles. Being responsible for four or five students with special needs is a challenge comparable to classroom teaching, just with a smaller ratio. It's helped me to become better at multi-tasking and I'm getting better at dealing with four different students needing me at the same time. Before, I wasn't really good at things like that, I used to get stressed out and think that I needed to help each one of them right when they needed to be helped. But now I'm starting to realize that while I do need to help each one of them, I can't do it all at once.

Through my Hands On Science classes, I am keeping my foot in the classroom. Though it's an after school program, these students come together once a week for an informal science class. These opportunities allow me to do what it is I set out to do, to teach science and make it fun. Through fun hands on activities the children learn about different scientific concepts. Though the children are not formally assessed on their acquisition of knowledge or their performance on the activities, it has been my informal observation that the nature of the activities makes the information meaningful and memorable to the students. This is the kind of science I hope to be able to teach in the future, though I realize that the format will be on a much larger scale in the public schools and the students and I will both be accountable for the information. This experience is also helping to ease me back into things, as I feel I was pretty broken down by my experience at the beginning of this fall. These smaller and more informal classes are helping to rebuild my confidence, restructure my thinking (I am actually able to focus on the positive aspects of the lessons when I leave the classroom, rather than beating myself up for every little mistake or negative aspect). This readjustment was something I should have focused on a long time ago, but I just got so caught up in everything I had to do, all the details, that my needs were put aside.

So where am I now? Right now, I am so eager to get back into the classroom, with my eyes set on either a *departmentalized fifth grade position or a sixth grade science position. Seventh grade would also work, but I think I would prefer fifth or sixth grade. Underneath this eagerness still lingers some anxiety, but I think that is a part of my fear of repeating past mistakes and falling into old traps. I realize now that when I pursue future teaching positions I need to measure one key aspect: support. How will I be supported in my position. At Holy Child, I had friendly emotional support, but not much when it came to content and teaching. Though we used to discuss in class how we didn't want to be restricted by curriculum, I now see it not as a restricting factor, but rather as a support and a guide to help lead me along. In addition to this curriculum support I also know that I need a supportive staff behind me, and it is with these insights that I'm looking towards the future.*

<u>Rethinking Year One. Stephanie Reflects on Her Ability to Teach (4/11/01).</u>

The following are some common themes that I noticed while reading over my lengthy pile of narratives. This won't really be in narrative form, but perhaps these notes will be helpful.

I often found places where I expressed frustration stemming from the problem that I just couldn't admit that I didn't know. I felt like as the teacher, the person in the position of authority, I HAD to know everything…that was my job. Again, reality has set in and some of those complications have diminished, but honestly I don't know if the compulsion will ever be completely gone. At least now I feel a little more confident in the fact that it's okay to not know everything. This lesson has been quickly learned through experience and watching other teachers.

The emotions I often found expressed throughout my narratives were usually combinations of worried and excited, or scared and excited. The feeling of confidence is expressed much less often. Was there something that I could have done or someone else could have done for me to help the confidence outweigh the uncertainty? But then I guess these are natural feelings for those just starting out. It's all new and you are feeling your way through it, so I guess you're not supposed to be totally sure of everything. A little more confidence in myself and my abilities and a little less worry wouldn't have done me any harm though. More situations like the one detailed on page 67 (highlighted in yellow…"I definitely think that one of the main reasons that I feel today was more successful than other days was that I went into this lesson so much more confident about content than I had been with previous lessons…This confidence and comfortability [sic], *I think, really showed through, and I was able to be more fun and personable with the students rather than so uptight and structured. For the first time, today I felt loosed* [sic] *enough to be me…")*

I also found that I often exhibited a struggle with my compulsion to try and make every lesson active. However this has been discussed in other writings… I've realized that "sometimes, not always", should be my motto there.

Assessment was also an issue that popped up more than once in my reading of my writing. On page 69 while discussing the introduction of the final assessment for my ecology unit I *highlighted my struggle with how to format assessment. "I'm at a loss as to what to do. I tried to make the assessment an alternative to the traditional test so that they may be more interested in it, and it worked for some of them, but for others I just don't know. They aren't motivated by the project, and they really aren't motivated by the grades." "I think many of them are just unmotivated and not willing to put forth the effort it takes to complete the assignment. What do I do about them?" " I look at them and think that I haven't been all that successful." Page 70 deals with my feelings about assessment throughout the unit. While I was implementing my unit at Hampton, I was constricted by the way the class had already been set up. I could have implemented exit slips, but the kids were unfamiliar with this concept and practice and to throw them into it for two weeks I thought was unfair. So although I would have liked to have implemented more intermittent assessment I felt as though "I had not done enough assessment to be able to know if the students were really understanding what I was trying to teach."*

Flexibility was another important skill that I realized was necessary through my student teaching experience. Pg 70-71

[I] *Could definitely use more help in CONTENT!*

Jennifer: The Reality of Teaching

Jennifer's narratives demonstrate a variety of emotions and expectations as she struggled from pre-student teaching, into student teaching, and on to her first year as a teacher. In the beginning she exhibits unending excitement and interest in teaching and learning and wanting to engage her kids in investigating the world. However, her full-time teaching experiences changed her views on teaching. Her professional stance moves away from the teaching of science and focuses on classroom management and behavior control. In her own words, she becomes *"hardened"* and struggles daily to *"get through"* the year. It is here where we can ask quite plainly, "What has happened to her exuberance, her excitement, her joy for teaching, and is there anything that we, as teacher educators, can do to help?"

Jennifer's early conception of teaching science. Responding to Science is . . ., Teaching is . . . , and Teaching science is . . . . (Spring 1999).

Science is a subject that encompasses many of the aspects that deal with the world around us. It deals with how things are made, what they are made of and how they work. Teaching is an opportunity to mold students into [a] *valuable and independent part of society. Therefore, I feel that science teaching is giving children the chance to explore the world around them by testing things and failing. It should allow students to learn things through hands-on, minds-on, applicable learning. Throughout this semester I have been given numerous opportunities to expand my knowledge base about chemistry, biology, ecology, MSPAP, curriculum and lesson plan construction, as well as the principles of benchmarks.*

From the start of the semester, inquiry learning was stressed not only by lecture but by example. By experiencing this on a daily basis, I was able to see the benefits and the drawbacks to this type of instruction. I have come to a realization about what my science classroom will look like. By utilizing these techniques in *our field placement, I was able to see that you could take a very structured lesson and make it a very child-centered, hands-on lesson. However, I also became aware that structuring your classroom in this manner all the time can be very detrimental to your students. There are times when other key teaching techniques must be utilized in order for the student to get a full understanding of major concepts. Therefore, many styles and strategies must be used in the classroom setting to accomplish the main goal of teachers, to teach children how to think and be independent learners.*

Pre-student teaching. Jennifer's Response to a Writing Prompt.

During the semester before student teaching (fall 1999), Jennifer and her peers were enrolled in an environmental science class, the capstone science course of the MCTP program. In this class the students not only spent a considerable amount of time investigating the integrated topics of the environment, but they also spent time discussing and reflecting on how to teach science in the classroom. Each student was asked to respond to a writing prompt that challenged her ideas of teaching science. As we can see in Jennifer's comments, her beliefs balance between a traditional and progressive framework of teaching science (Blake, in press) and she begins to construct her own definition of what it means to "facilitate" learning.

The Prompt: (From Fradd, S.H. and Okhee, L. (1999).* Teachers' Role in Promoting Science Inquiry with Students from Diverse Language Backgrounds. *1999,* Educational Researcher, *28(6).14-20.) At the beginning of the year, I had all the students work in small groups to do activities because in my science methods class, I had been taught to set up groups like that to promote inquiry. When students worked in little groups, neither they nor I really knew what they were doing. As they* [sic] *year progressed, I could see the students learned better when we did things together as a whole group. I know how to help them focus and learn when we are all together. I realize that some people would frown on how I've moved from small to whole group instruction, but I can see a big difference in the way students pay attention and learn. These experiences have helped me rethink the inquiry process. I'm not convinced that the way it's presented in the methods courses is really the best way for students to learn science, at least not my kids (fourth grade Haitian classroom teacher in an inner-city school) [p. 14]. Definitions: (From Fradd, S.H. and Okhee, L. (1999). p. 15). Explicit Instruction: Teachers leading students through predetermined lessons and activities. Exploratory Instruction: Teachers guiding children to consider their own questions and interests

Jennifer's Response.

I disagree with the author of the statement because I feel that he is not looking at the whole picture. There are times when students need to be taught directly and there are others when students need to learn by exploring. However, it sounds like he was not facilitating their small group work. He just let them do it on their own. Therefore, his students did not know what they were doing and neither did he. You must facilitate the students learning by walking around the room asking questions and prodding your students to think.

I have been apart of a class in which this *exact thing was going on. My physical science class was run like this: here is your lab, do it with your group, and the teacher left the room. There was no time to ask any question, there was no teacher to get feedback from. Basically the class consisted of a bunch of frustrated students trying to make heads or tails of a lab and the result was exactly the same. We did not know what we were doing and our teacher did not either. That, in my opinion, is a prime example of how inquiry learning can be misused. However, if it is used the right way it is one of the best ways of learning in the world. You learn through experience. You get your hands dirty and you sit back and watch as the world unfolds in front of your eyes. (Jennifer, Narrative Response, September 17, 1999)*

<u>Linking her Learning Experiences to her theory of teaching. "Why can't I do this?" (Fall 1999).</u>

During the environmental science class Jennifer admits that she re-visited what it meant to be a student and it is during these experiences that she continued to build a personal theory of teaching science that incorporates inquiry, hands-on, fun learning for her students. She emphasizes how important it is for her to not only be the teacher but to also be the learner and to attempt to instill this excitement in her classroom.

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Environmental science was a wonderful course for preservice teachers, as well as for any other science major. It was a wonderful content area class but was well-adapted to teachers and our specific needs. As teachers, we walk a fine line between our individual instruction and the instruction that we give our students. This class has provided us with a wonderful example of a project in which the teacher and the student can learn together to accomplish one goal: learn about our environment through a hands-one [sic] *model. Not only did this class display a hands-on approach, but it gave me many ideas of how to apply this within my own classroom. In all honesty, I was not all that excited about the course content at the start of the year. Environmental science is not one of my favorite science topics but, in reflection, I can see how this course has changed that. I found myself very interested and engaged throughout the course of the semester.*

This class has not only taught me many topics in environmental science but it allowed me to revisit myself as a scientist and as a learner. As I have progressed in the classes here at Towson, I have seen a switch in my focus. I have become more focused on the teaching aspect of my career as opposed to the learning aspect. I feel that I lost sight of what it really means to learn. Not that I haven't learned anything but I mean learning in the sense of how children learn. They come at a new topic with such gusto and excitement that it is almost breath taking. I have once again been able to experience this. I left the library last week with so much excitement that I could not contain myself. I was proud of what I had learned and what I had written. I even went so far as to call my parents to tell them how excited I was about our project. I am sure that it sounds completely crazy but why can't teachers be like this. Teachers need to be just as excited about, if not more, learning. They need to get down on their hands and knees with their students and learn with them. I now see how important it is for teachers to get out of the *classroom and go on trips where they can start to learn again. They need to do programs like Meredith Creek and Sod Run (field trips that we took as a class) to give them back the excitement and drive that first made them go into the teaching profession.*

The second thing that I have taken away from this experience is how to be a true scientist. During most of my course work, I have been in many science classes and done many projects that relate to course objectives. However, this project was far and above that. I was put in a situation in which, I had to design, alter and test a real-life scientific study. Talk about hands-on, well I got it. Myself, along with three other people decided that we would do our project on the Winters Run watershed in Harford County. During this time we got to apply all the environmental concepts that are stated in the course objective and see them working right before our own eyes.

For the last three months, I felt as if I have gained more insight into the field of science than I have gotten my whole four years at this University. I have learned that science is not predictable and is very dependent on many variables. Through our project, I have seen many hours turn into anger, frustration, tears, laughter and even pure joy. We have experienced true success and true failure but all in all, we have experienced science. Down and dirty, as it may be, I have learned many things while still having fun.

A teacher's main goal should be exactly that: fun. You should allow your students to have fun while they learn. To me there is no other way to go about this process. Therefore, this project [class research project] *has not really altered my beliefs in teaching science. It has solidified and reiterated what I have already learned. I feel that science should be hands-on, minds-on application of major principles of scientific theory. I have been in so many science classes that are full of drill and practice. That has a place in the science classroom but I do not feel that it should be the staple of science instruction.*

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It is very clear what Jennifer's personal theory of science teaching was at this stage in her career. In student teaching her theory meets reality, the reality of everyday classroom practice. This concern of reality is expressed in the next set of writings.

<u>Jennifer's Pre-Student Teaching Narrative. Expectations and Concerns (January 2000).</u>

In all honesty, I never thought that this day would arrive. I am about to become a student teacher. I will be spending my next three months engrossed in the lives of adolescents. Scared is the only word that I can use to describe how I feel right now. When I first started the education program at Towson my perception as a teacher was totally different. I looked at teaching as an easy job that anyone could do with a little effort. I remember thinking about myself and imagining that I was that fifth grade teacher whom I loved all those years ago. However, as the semesters passed, I learned that teaching was an acquired art that had to be refined and practices [sic] *just like any other field. I also learned that teaching was not for everyone. Teaching was for people who wanted to help others: children.*

Teachers feel that children are the future and that it is our job to get them ready for what lies ahead of them. We must give *them knowledge, morals, social behaviors and many other things. Therefore, I have learned that a teacher's job is all encompassing. You are not only a teacher; you are a mom, a dad, a friend and even a best friend when circumstances call for it. And to me, that is one of the best parts of the job. I don't know about you but what other job requires and challenges you to be all that you can be (except the Army) to benefit someone else. The thought inspires and excited* [sic] *me for the challenge ahead. By reflecting on my past experiences and noticing things that I have overcome, I realize what my expectations and fears are about my future.*

However, my fears are another issue. I have so many I can't even name them all. I have lied [sic] *in bed at night thinking about what could go wring* [sic]. *Let me tell you, the options are endless. However, all of my fears go back tone* [sic] *thing: classroom management. Over the last three semesters, I have seen myself plan and instruct lessons, give assessments, plan bulletin boards, talk to parents and even be flexible on command. However, I have always had trouble with classroom management. My classes have not been awful but they are not the way that I would prefer them. Is it me or is it my techniques? When asking my fellow student teachers and my cooperating teachers, I seem to be getting the same feedback.*

My classmates are having the same difficulties and my cooperating teachers always say that management will come with your "own" classroom. So, while my confidence has been hurt a little, I feel that I am exactly where I should be in my professional career. However, that is still my greatest concern and fear. I have not quite figured out how to enter into someone else's class and take control. Sometimes I wonder if it is truly attainable in seven weeks.

<u>All that Really Matters is the Kids: Student Teaching Response Log: 2/16/00.</u>

Yesterday was parent-teacher conferences. What an eye opening experience for me. I had so many preconceived ideas about what these conferences are suppose [sic] *to be and boy was I wrong. I expected no problems, no complaints but I got an ear full.*

The first conference was from a young girl in one of my middle groups. She lives with her grandmother, grandfather and her brother. I really don't know the actual age of the grandmother but I will guess about 70 years old. This sweet lady came into the conference because Cathy's grades had dropped a significant amount from first and second quarter. I expected the grandmother ready to come in saying that she can't believe that Cathy got such a bad grade and that the teacher needed to spend more time with her but the complete opposite happened. The grandmother came in half in tears looking to Keith (SS teacher on my team) for answers. She said that Cathy is going to therapy for emotional problems yet she is a well behaved pleasant child. She just doesn't communicate. The whole situation just broke my heart in half. This elderly women was asking a 23 year old first year teacher and a 22 year old student teacher how to raise this child. Amazing!! My heart just broke for her and Cathy.

What do you do as a teacher? I learned this, you MUST know the background of each and every child that you teacher

[sic] *if it is* [at] *all possible. It sheds such a light on why the child acts the way that he or she does in you* [sic] *class and if you are clueless your effectiveness is gone. You need to learn about every child's circumstances and accommodate to the best of your ability with that child.*

During the conference, we came to the conclusion that Cathy was feeling neglected. Her brother had been getting a lot of attention at home and she felt like she didn't matter or wasn't important to her family. Therefore, today in class, I decided to take a pro-active approach. Of course, I had the luxury of team teaching with Mark but I took Cathy one on one and worked with her out in the hallway. What a smile that child had for the rest of the day. She felt warm and loved but more importantly, she felt special and I think every child needs that opportunity. I guess I just felt like I mad [sic] *more of a difference in that child than I have ever had before in my life and it felt wonderful. It just reiterated to me that real true reason that I want to be a teacher: to help children. WOW!! What a profession to be apart* [sic] *of.*

I guess sometimes, I feel like we moan and grown [sic] *and pick and torture our lessons but in actuality all that really matters is those kids. Are you making a difference in their lives? In many cases, you are there* [sic] *lives. It may seem sad but it makes your job so much more serious and wonderful.*

During this week I have seen many of my original ideas come into play. From the start of this experience, I have seen my job as many different roles. I see myself as a teacher, a mother, a counselor, a friend and a confidant. And this week I have had the wonderful experience of seeing that play out in my life. A teacher's job is so encompassing that we have a tendency to lose focus of what is important. It doesn't matter how many mutilators [sic] *you have or how much variety that you have in your lesson plan, if you don't focus on what the kids need and want. If you focus on what they need, then everything else will take care of itself.*

I seemed to have forgotten that in the last two weeks. I started this experience out saying that I have to prove to all of these people that I respect that I am capable of doing what they expect me to do. I put so much pressure on myself in order to please them that I totally lost focus of the job at hand. I realized that a teachers job is stressful yes but don't ever let the stresses interfere with the joy that you have with your students. They must always know that you care about them, support them and are behind them one hundred percent. Without that trust, your student teaching experience will be a complete waste.

<u>But What if the Kids are Lazy? Theory and Reality Meet (2/22/00).</u>

Today was a boring day in my classroom. I gave a test; however, it wasn't any old test, it was a free response. Let me tell you, these kids are not used to that. All I heard was 'how do you write this, I am going to fail and I give up.' I would have really felt sorry for them but Mark and I had taught and re-taught this to them about 7 or 8 times. Also, Mark gave them the questions ahead of time so they could go home and prepare what they were going to write (He is more lenient than I would be but I see a method to his madness.) In any case, they still didn't get it. I haven't graded the tests yet but *and* [sic] *I hope that I will be pleasantly surprised but from what I heard today, that is not going to be the* case.

This leads me to my biggest problem with my kids: THE [sic] *ARE LAZY. How do you deal with lazy kids? I know the usual answer and that is if the kids are lazy then motivate them. The textbooks tell you to give them fun activities, real-life problems but what if you are already doing that and they still complain. When asked, "Do you like lab or lecture better?" Most of my students answer, "We like lecture because we can sit and not do anything." That answer completely astonished me. It was contrary to all the research that has ever been done on children. Therefore, I know that my students are just out of the ordinary. So, what do I do with them? What do you do with a group of students who are filled with lab activities and fun things that still don't want to participate?*

And, "how do I not become so consumed with the job?" (2/25/00).

Teaching…what a job. That is all I can say. The more days that I go to Hampton the more that I see what an incredibly draining job this is. I worry about my lessons, my clerical work, my sick students, my needy students. I worry about it all. I leave there everyday [so] *totally drained that it is amazing. However, I feel like I have accomplished what I am there to day* [sic] *and so much more. Some days it doesn't go as smooth* [sic] *as other days but it still goes. I pick up my boot straps at the end of a hard day and try it again. Sometimes with success and other times with failure.*

However, I fight with the emotional battle that goes along with the job. How do you become a teacher that cares but whose heart is not broken day after day by the students you have. Sometimes I just want to adopt them all and give them the life that they all truly deserve. I want to provide them all with two parents who love them to no end but I can't do that. I see some kids straggle in having no money or no food in their lunch boxes. I see some that are so tired because they have been taking care of their other siblings because their parents are out working trying to make ends meet. What can you do as a teacher. I guess I wonder whether I will ever get to the point where I can handle this with ease but them [sic] *I think, do I ever want to become so stone faced to their lives that I cut myself off totally. I guess that is a battle that I will have to fight in the years to come.*

Analysis of Middle School Student Teaching and the Construction of a Personal Theory. It's a Balance (3/3/2000).

Over the last few weeks, I have been spending a lot of time focusing on many extra aspects of teaching: what the students need personally, how I should give it to them etc. However, I have not focused much on the idea of teaching in its unique nature. Today I want to share my thoughts on what I have learned as a science teacher. I have learned one main idea: balance.

While taking classes at Towson, it was very engrained in my head that I must always teach hands-on activities because they would get students motivated to learn. Well, that is a great and wonderful idea in an ideal world; however, we do not live in a world such as that. We live in a world where there isn't the time, the money or the motivation to do this everyday. Therefore, I have come to see *education in a slightly different life* [sic]. *You need to provide both teacher-directed instruction as well as discovery learning.*

While I sit on my high horse and preach this idea to you, I am still struggling with it myself. I hate to teach at the overhead and dispense knowledge; however, I have found it necessary at times. Not a great amount but sometimes. Therefore, as a teacher, I need to work on my attitude as well. Last week my kids loved coming to science. They were busy making their earthquake-resistant buildings and they loved it, I loved it and we were all happy in out [sic] *little educational world; however, I have been snapped back into reality. I looked at my lesson plan book and I noticed that the students would need to be taking their performance assessments this coming week. I still have not taught two lessons that they will need. I have two days to teach two important pieces of information. I guess some would look at it as bad planning but I seem to look at it, as I am a prisoner to my schedule. Anyway, you know that I can't teach a good discovery lesson on two subjects in two days. Therefore, I have to have two days of direct instruction for my students. I am not looking forward to it and neither are they.*

Don't get me wrong, I am not just lecturing to them, I have some activities for them, some videos etc. but it is not true discovery learning. I am not giving them the opportunity to learn the way that I know they could achieve the best results. However, I live in the REAL world and I have to deal with that reality. Due to time constraints and other things, a teacher must have some lessons that are more teacher-directed. I guess I am just trying to say that I am having a personal dilemma with myself. I see the value of varied instruction but I just don't like doing it. In general this week, I have been given a large dose of reality and I am trying to make terms with it in the best way that I can.

Analysis of Middle School Student Teaching and the construction of a personal theory. It's a Balance (3/10/2000).

Another dilemma that I had during my experience was the tussle about Discovery versus Teacher-Centered. Since, you used my quotation, I guess I will use it again here. I have learned that I live in the REAL world and I have to deal with that reality. Due to time constraints and other things, a teacher must have some lessons that are more teacher-directed.

I have learned that because of many variables that teachers do not have control over, we must use teacher-directed lessons. I hate it, the kids hate it but sometimes we just have to dispense knowledge to students in order to get it done. However, more often than not we should provide our students with a chance to discover on their own. That is the most prevalent type of lesson in my repertoire. I try to find a way with every topic to make it discovery-oriented.

What is your role as the teacher in the classroom? This question relates directly to the above paragraph. Your role changes daily. On a day when I am using discovery learning, I am the facilitator of knowledge. I am there to give guidance, direct thinking and provide answers when necessary.

Other days, I try to make the activity *student-centered but not true discovery learning. During this type of lesson, I am used as a resource that is there to provide answers to many hard questions that they* [sic] *students may ask. I want to provide a balance on these days. I want to ask them questions, as well as answer the questions that they might have. Lastly, I have to give teacher-directed lessons. These are on the days with field trips, special assemblies or test time. During these lessons, I am the "God" of learning. The students look at me, as if I have all the answers. I dispense knowledge to them, they absorb and when there are questions, I provide the answers. Not a fun way to learn for me or for them but sometimes it has to be that way. As you can see, a teacher wears many hats but the hard part lies in when to use which one and why.*

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The issue presented here, the tussle between a teacher-centered and child-centered learning environment, is one that recurs throughout all of the teachers' narratives. In general, all of them view a constructivist framework as "discovery learning" where the teacher does very little to guide or help the students along. This misconception becomes an important point because constructivism is one of the central tenets of MCTP.

<u>Where's the Science? Jennifer's "New Theory" of Science Teaching (2/23/01).</u>

A year later, Jennifer reflects on her student teaching experiences, her previous narratives, and her "new" view on how to teach science. Full-time classroom teaching has taken its toll on her and her set of beliefs. It is here we see the ramifications of being a teacher.

***

As I reflect back on my old journals and ideas that I had about teaching, I realize that my focus, fears, and weaknesses have changed dramatically in many ways. Over the past six months of my first year of teaching, I have grown more than I think I ever will in my whole career. The greatest change I have seen in myself is my attitude or my focus, as I alluded to in the first sentence.

When I first went into student teaching, I had this idea that I would change the world. I have so much enthusiasm and so much life to make the world a better place. I still have that drive but reality has given me a good kick in the butt. As you know, I teach in a low socio-economic area of Maryland. It is not the worse [sic] *place you could teach but it defiantly* [sic] *is not the best. We have about 43% of our student body on free and reduced lunch, parental involvement is very low and we have low moral* [sic] *as a faculty.*

I believe strongly that my location as a teacher has had a strong impact on why my focus has changed. My first 6 months of teaching has [sic] *hardened me as a teacher more than I ever thought it would. Before, I would see so many things that I was doing that was* [sic] *helping my students; however, now, I can barely see one student that I have helped. I know that is not the case but I want to reach that 75% and in my case I will be lucky if I only reach 5%. That is tough on a person, especially if you spend your whole life wanted* [sic] *to change the world. I have just realized that the phrase, Changing the World One Student at a Time, relates really well for me. If I help three students this year, and nine students next year, then I have done more good in their lives than they will ever see.*

The second thing that I mentioned in my opening paragraphs was how my fears *have changed a lot of* [sic] *the last year. When I first started teaching, my main fear was that of the kids themselves. When you are thinking of yourself in front of 30-13 year olds that is a scary thing. And believe me, they can eat you alive if they see fit. However, as I have progressed through my first year teaching, they just don't scare me anymore. I have learned more ways of dealing with them but mainly, just being with them everyday has eliminated that fear. I have seen those big, tough, city boys cry when they fall on the ground and scrape their knee. There is something very "de-fearing" about that.*

My greatest fear now is am I teaching these kids what they need to know. When I go to get progress reports together and I average grades and I see that over 50% of my kids failed, about three hundred things go through my brain. Am I not teaching them they [sic] *way I should? Did I differentiate instructions enough for them? Do I need to make more modifications? Are they lazy? Do they not understand because their ability is to* [sic] *low for the groups they are in? I just have a hard time trying to determine what I can do to help these students succeed and if I can even do that with no parents at home to help.*

This leads me to me [sic] *last topic: weaknesses. I feel that my two greatest weaknesses are grading and parents. During my student teaching, I was the best grader in the whole building. I graded papers the night that I got them and I returned them the next day. Now, I am lucky if the kids get them back in two weeks after they have turned them in. That is pretty pathetic but I have realized that I have this weakness and I am working on trying to fix it.*

My second weakness is parents. This has been especially hard in my school because the parent involvement is so weak. I feel that a parent should be informed how their child is doing periodically thought out [sic] *the 9-week quarter. In most schools this is not a problem because the parents call you about every two weeks to check up on their child. My school is a little different. A good example of that* [occurred] *during the first quarter of my first year, I failed more than 50% of my students and I did not have ONE parent's phone call about their child's grade. This absolutely disgusted me and I did not have any idea how to deal with this. I felt that every parent needs to know about their child's progress, but how am I going to inform all the parents (I have 150 students) all on my own "I'm not" is the answer that I have come to but my dilemma arrives with how do I get the parents to care about their child's success.*

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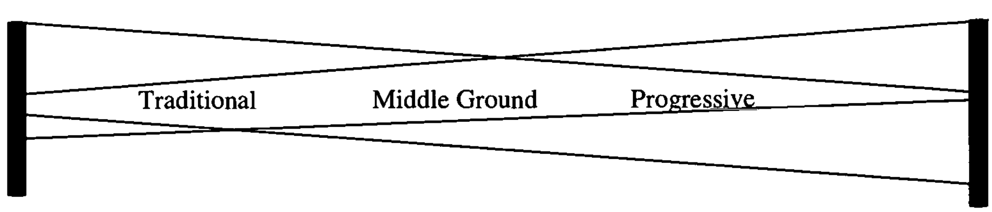
Upon reading this last entry I posed a number of follow-up questions to Jennifer. She was asked to consider each and respond in kind,

Figure 4. Three frameworks of teaching science. (Blake, in press).



or to write about something different. The questions focused on elaborations of her general statements. For example, what did she mean by "*reality has given me a good kick in the butt?*" Or, how has her location "*had a strong impact on why my focus has changed?*" Additionally, I asked her to consider any differences between "*what they need to know*" now and what her conceptions were on knowledge before she began teaching. It is this last question that Jennifer responded to.

Teaching and Learning from Student Teaching to Now!!! (Spring 2001).

> *During student teaching (spring 2000), my greatest fear and concern was how to deal with managing a classroom full of hormone-filled, entertainment-driven thirteen year olds. When you walk into a classroom full of kids about one hundred things cross your mind about how those students can kill you. I lost focus of the teaching and the learning that went on in my classroom during that time. I was more concerned about how my students were behaving than what they were learning. Just as long as they were quiet and sitting in there* [sic] *seat, that was all that I cared about.*
>
> *However, when I got my own classroom and my own group of students, I began finding myself trying to deal with what they were learning. I now began to not only focus on their behavior but I was concerned with many new questions. I was worried about teaching them various concepts of life science that every well-educated person should know. SO, not only was I focusing on whether or not David was quiet in class but I was focusing on did Ethan do his homework, was Takesha starring* [sic] *off into space or was she paying attention. It became very amazing to me how many things go through my head in one 45-minute class period. I actually would find it very amazing for someone to count the number of questions that pop in my head while I am actually talking. I guess that practice of walking, chewing gum and patting my head paid* [sic] *during my childhood really paid off in the end.*
>
> *The biggest struggle that faces me today is that of teacher-directed versus activity-oriented lessons. In all my training in college, professors would cram down your* [sic] *through constructivism. People have different meanings of that word but to me, it just means letting the students discover concepts on their own with a little guidance and a really, really, well-structured lesson planned by the teacher. When I was student teaching and in college, I thought to myself I am going to have a lesson like that everyday. Kids enjoy it, I enjoy it but reality hit me: time doesn't enjoy it.*
>
> *This dilemma comes up time and time again. Even this week I was trying to plan some of my lesson before Spring Vacation. I looked at my schedule and saw that I only have two days to get across the concept of natural selection. I have a really cool activity that I could use and the kids would love it; however, the activity would probably take about 3-day* [sic] *minimum to complete. That put me in a dither. Is it more important for the student to learn the basic principals of natural selection or is it more important for the students to have fun while learning those basic principals* [sic]*? This time around, TIME was not on my side. I chose to conduct a very teacher-centered activity in order to get the information to my students. And that is a choice that I have to make everyday on a regular basis.*

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Jennifer's last statement reveals a dilemma for her and her teaching. Can they learn the science and have fun all at the same time? How can she balance between discovery learning (which in her view is "fun") and teacher-centered lecturing? Is it either/or, or a balance?

General Themes and Implications

The general themes that emerge from these narratives may not be new to preservice and inservice teachers. Preservice interns often express anxiety and concern about classroom management and their inability to "pull from" a "bag of tricks." However, my thought here is not to apply the narratives towards filling a bag of tricks for novice teachers to use in the classroom, but to employ the narratives as a set of beliefs that will then guide how a teacher thinks and acts as she teaches. The themes expressed commonly by both Stephanie and Jennifer are listed below. The following discussion will focus on the first theme as it applies to teaching and teacher preparation.

1. A struggle between the pedagogy of "discovery learning" and teacher-centered instruction,
2. An understanding, or lack of understanding, of the science content,
3. Classroom management as it specifically relates to student behavior and attitudes, and
4. The role of parents in preparing their children for life inside the school.

The Pedagogy of Science, a Recurring Theme: A Struggle to find a Middle.

In *An Enactment of Science: A Dynamic Balance Among Curriculum, Context, and Teacher Beliefs*, Blake (in press) discusses three frameworks of teaching science, represented on a continuum with traditional science teaching at one end and progressive (defined as a strict child-centered approach) at the other (Figure 4).

Traditional science instruction, the dominant pedagogical paradigm in science education, is one in which content knowledge is emphasized and generally considered to be finite and existing "out there" for students to access from the ideas transferred to them by the teacher: a conduit metaphor (Shymansky & Kyle, 1992; Tobin, Briscoe, & Holman, 1990). Progressive science education represents a framework embracing a more humanistic approach, where students are more directly involved and have a greater responsibility for their learning than they do in a traditional approach. "Progressive" instructional experiences emphasize student interests and needs, and the teacher's role is to structure the learning and act as a "guide" or a "facilitator." A constructivist approach (see, among others, Lawson & Renner, 1975; O'Loughlin, 1992; Padilla, 1991; Shymansky & Kyle, 1992; Tobin & Tippins, 1993; Yager, 1991b) is often considered progressive.

In reading both sets of narratives it appears that both Stephanie and Jennifer believe that the two extremes (Traditional and Progressive) are irreducible in method. You teach science either through direct, teacher-centered instruction, or you employ a child-centered, discovery method. For both teachers, as evident through this set of narratives, something in the middle ground is less tangible. While both women (especially Jennifer) describe the need for a balance in her instruction, neither currently articulates a professional stance that resembles such a balance, one that is eclectic in method of teaching and learning. Of course, that is not to say that each does not employ a balance in her actual practice of teaching; the narratives, however, do not indicate this.

Constructivism in the Classroom. Is it Discovery Learning?

Through these writings it appears that a major obstacle in the teaching of science for both Stephanie and Jennifer is an understanding of the constructivist model and how to use it for teaching science. Both women express that they cannot always teach via a discovery method, and both women seem to equate constructivism with discovery learning. This distinction becomes critical in their teaching because an understanding of constructivism can be traced back to their college coursework in the MCTP program. If a strict child-centered view is their sense of constructivism then questions we may ask are: "Where did this understanding come from?," "How did their university professors understand a constructivist framework?," and "How did this representation of constructivism manifest itself in the university classroom practice?"

One answer, suggested by Korthagen and Kessels (1999), is that universities tend to focus on the "application-of-theory" model of professional practice, with little attention paid to the practical approaches often employed in school systems. Constructivism as a method of teaching science is often thought of, and taught, with the student "discovering" something, with the teacher acting as a "facilitator," with little defining roles of both the teacher and the student. Thus, the theory of constructivism can be interpreted in practice as discovery learning. This incongruency between theory and practice is often a criticism of higher education, especially in teacher preparation, and very well may be a reason for Stephanie's and Jennifer's apparent inability to link constructivism to their actual classroom teaching.

Implications for Teacher Preparation. A Case for More Practice Teaching.

Both Bryan and Abell (1994) and Trumbull (1999) suggest a disconnection between how preservice teachers are trained and the realities they face in the profession of teaching. As discussed earlier, employing "reflective approaches" for students may aid in their ability to make a link between the university and the middle school classroom. However, reflection on practice alone may not be enough; but linking these reflections to more classroom experience, earlier in the preservice teacher program may provide teacher interns with more relevant schooling in which to consider and to construct a personal theory of teaching.

For example, instituting a Professional Development School (PDS) model of teacher preparation provides preservice students with extended internships in the public school and thus gives them a greater number of classroom experiences to use as a basis for reflection and decision making. In addition, students are allowed opportunities to apply the theory learned in the university and to thus learn first-hand how they may alter these theories to fit where and what they teach. The PDS model, therefore, allows teachers to bridge, early in their careers, the apparent gap between theory and practice, and to learn how good theory may be used in the classroom.

What also may be useful is to make it clear to preservice and novice inservice teachers that an eclectic instructional framework is often what "works" in the classroom setting. Thus, in science, teachers may combine traditional and progressive models to construct a middle ground of teaching, one that fits their students and also forms the foundation of a professional stance of teaching.

In gaining insight into the processes and struggles involved as preservice teachers become teachers and construct personal theories and a professional stance of teaching science, we, as teacher educators, will be able to appropriately adjust our teacher education programs. What also appears useful is the process of allowing teachers to tell their stories of teaching, to describe the successes and failures each has, and to let these stories speak for themselves so that others can attach meaning and understanding to the everyday struggles of becoming a teacher. Narratives may also allow students and teachers to gain insight into these struggles. Through this process, they may become more cognizant of the challenges that they face in teaching science but also those challenges that children face in learning science.

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THE MARYLAND EDUCATORS' SUMMER RESEARCH PROGRAM:

THE RESEARCH EXPERIENCE IN TEACHER PREPARATION AND PROFESSIONAL DEVELOPMENT

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In the summer of 1998, the Maryland Educators' Summer Research Program (MESRP) was established to expand upon the foundation of two previous Maryland internship programs for teachers: The Maryland Collaborative for Teacher Preparation, and the University of Maryland Graduate Fellows (UMGF) program, a research internship program (1992-1998) for outstanding middle and secondary school mathematics and science teachers who had previously completed the Governor's Academy, a summer residence program for teachers that provides professional enhancement in the areas of reform- and standards-based science and mathematics education.

Recognizing that the audiences served by these programs could enrich the internship experiences for one another, the Center for Science and Mathematics Education at Towson University sought to pioneer a new model for summer research internships through the establishment of MESRP.

Introduction

Studies of the teaching of science and mathematics reveal a need for initiatives that equip teachers to foster students' conceptual understanding of science and mathematics. Simply increasing teacher content knowledge by requiring more course work has little positive effect on their students' learning; it does not foster the necessary radical shift in teaching emphasis from memorization to conceptualization. However, allowing teachers to participate in activities, contexts, and cultures in which science and mathematics are developed and practiced is a powerful intervention. Consider the following quotation from the e-mail journal of a preservice teacher intern in the MCTP program (Langford and Huntley, 1999):

> *I learned there must always be a nagging ignorance accompanied by accessible knowledge to achieve learning...I can use my experience as a learner to enhance my teaching. I need to use ignorance to feed curiosity. I want to model my mentor's ability to let me think for myself before assisting.*

Surveys indicate that retention rates within the national population of inservice teachers who participate in internship programs are higher than those among teachers who do not (Weisbaum and Huang, 2001). Teachers who have completed internships note that, as a result of the experience, their commitment to teaching intensifies. Studies of the effects of teacher internships in Maryland reveal that teachers who complete internships note that, as a result of the experience, their commitment to teaching intensifies (Langford and Huntley, 1999 and Abrams and Dierking, 1996).

These teachers' naïve ideas about scientists and mathematicians and about the processes in which they engage are challenged by their research experiences. They learn that content knowledge and understanding evolve within a process that involves dead ends, puzzling data, and unanswered questions. They learn that scientists and mathematicians are normal human beings who commit themselves to time-intensive, often physically taxing, work. They reflect on what they have learned and formulate clear intentions to be teachers who are risk-takers who, like their scientist mentors, question and pursue understanding alongside their students. They expect to encourage curiosity in their students. And they intend to nurture their students' courage and persistence so that they will continue to construct their own knowledge and understanding. In the words of another MCTP intern (Langford and Huntley, 1999):

> *I hold that we should teach students to be bold and take risks (not the life-threatening kind, but the kind where you risk failure or standing alone on your own ideas)...I want to be the type of teacher that not only encourages my students to take risks, but takes risks along with them. I want to create a place where my students can feel comfortable taking risks, and will openly share their thoughts, questions, and ideas.*

Program Summary

MESRP, headquartered in the Center for Science and Mathematics Education at Towson University, provides opportunities for motivated inservice and preservice teachers to experience cutting-edge science and technology through authentic research experiences. This hands-on approach promotes inquiry-based learning and gives teachers the credibility and experience needed to incorporate current content and authentic data into science and mathematics curriculum.

MESRP operates on a yearly cycle, beginning in early spring, when eligible inservice and preservice teachers are invited to apply for participation in the program. A selection committee, appointed by MESRP, reviews and ranks all applications and makes recommendations for placement according to each candidate's suitability for specific sites. Site Representatives interview candidates recommended for placement at their sites to determine final approval for intern placement.

During the summer, interns team with mentor scientists for a six- to twelve-week internship to participate in research at government, university, and private laboratories throughout Maryland. As both learner and contributor in the research environment, interns gain a wealth of knowledge that will impact how they view teaching and learning. Whenever possible, inservice and preservice teachers are paired at research sites, enabling experienced teachers to serve as mentors who can provide valuable insights on both classrooms and workplaces to preservice teachers. Likewise, preservice teachers are able to contribute fresh perspectives from their teacher preparation program.

The commitment to learning does not end with the research experience. During the school year following their internship experiences, interns participate in outreach and professional development activities designed to build bridges between laboratories and classrooms, while providing resources and further learning opportunities for themselves and other educators. These activities, which include a Classroom Implementation Project, a Speaking Event, and a Collaborative Activity, facilitate the transfer of attitudes and beliefs about science and mathematics education into classroom practices that engage students in active, investigative learning that will ultimately improve their attitudes, perceptions, and performance in science and mathematics.

...when it is time (for my students) to enter the public arena outside of the classroom, they will use the voice they have gained in my class to transform the world into a better place.
N. Davis '99

Program Goals and Expected Outcomes

Based on our conviction that teachers who participate in research are better able to foster their own students conceptual understanding and that these teachers have a greater commitment to teaching, MESRP has two primary goals:

1) to enhance teachers' ability to engage students in active, investigative learning that will ultimately improve their attitudes, perceptions, and performance in science and mathematics

2) to improve retention of teachers in Maryland schools while providing the opportunity for experienced teachers to serve as mentors offering preservice teachers valuable insights on classroom practices.

To achieve these goals, we have defined a set of Program Outcomes that are being assessed through surveys given before and after the summer program, as well as through follow-up contact with the interns:

* provide teachers with authentic research experiences in science and mathematics that can then be transformed into classroom experiences for their students

* foster changes in teachers' attitudes and beliefs concerning teaching and learning of science and mathematics

* facilitate the development, implementation, and dissemination of inquiry-based lessons that nurture students' curiosity and ability to construct knowledge

* construct networks of support among preservice and inservice teachers, and the research facilities to foster mentoring relationships

Performance Outcomes for Interns

I always describe my summer experience at the lab as "brain stretching."
A. Williams '99

Our program outcomes are supported by a detailed set of **Intern Performance Outcomes** that we deem essential to the accomplishment of the overall goals of MESRP. As with the Program Outcomes, successful achievement of these performance outcomes is assessed throughout the summer program, as well as through follow-up contact during the academic year. We have defined the following set of Expected Performance Outcomes:

* experience science and technology through the eyes of a scientists in an

authentic research project that will allow them to

- expand knowledge of science, mathematics, and technology content,

- learn about state-of-the-art equipment and techniques

- gain valuable resources.

* acquire knowledge, skills, and attitudes that will change the way they view and teach science and mathematics.

* facilitate the transfer of knowledge and enthusiasm of the research experience into classroom practices by completing a 3-part Outreach Project that extends into the school year following the internship, including a

✓ Classroom Implementation Project (CIP)

✓ Speaking Event

✓ Team or Collaborative Activity

The Research Internships

Selected government, university, and private research laboratories across the state serve as host institutions for the internships (see Table 1 on p. 134). To date, there have been 20 different participating sites, of which 82% have contributed to the cost of the interns' stipends and a portion of the related administrative and outreach expenses.

At each site, a representative is designated to collaborate with the MESRP coordinator regarding administrative issues. The site representative may be an administrative staff person, a scientist, or the mentor. At larger research facilities, a site representative may initially interview the Intern and work with the staff to identify an appropriate placement. Each intern/intern pair works with a mentor scientist while participating in the assigned research activity. The mentor scientist is the key to a successful summer experience. The mentor must take an **active** role by clearly defining an appropriate research project, providing guidance, training and support, and serving as a role model for the Intern. The mentor must be genuinely interested in science and mathematics education and be willing to assist in meeting the goals of the MESRP by

* enabling the Intern to complete a meaningful research assignment that is useful to the research site and consistent with the Intern's background and experience,

* enriching the Intern's content knowledge and skills in mathematics, science, and technology,

* motivating Interns to promote career opportunities in science and scientific literacy among students, and

* assisting the Intern in developing innovative ideas for the classroom based on the summer research experience.

MESRP expects that Interns will be contributing members of a scientific team, and that their exposure to scientists and "real world" science will impact their approach to teaching. We hope that their experiences in research will be well-planned in advance, with specific work goals, activities, and outcomes. Projects for teachers should be meaningful, active, and "hands-on" so that teachers can bring the skills, information, and insights they gain from the research experience - as well as a new enthusiasm for science - back to their students.

Table 1. MESRP Participating Research Sites

Site Name	City, State Zip	Contact Person	Years
Alliance, Inc.	Baltimore, MD 21222	Bryan Stoll	2000
American Red Cross Holland Lab	Rockville, MD 20855	Dr. Leon Hoyer	2000
Appalachian Laboratory UM-CES	Frostburg, MD 21532	Dr. Steven Seagle	2001*, 2000, 1999
Argonne National Laboratory	Argonne, IL 60439	Dr. Harold Myron	2001, 2000
Assateague Island National Seashore	Berlin, MD 21811	Liz Davis	2001, 2000*, 1999
Center of Marine Biotechnology / SciTEC	Baltimore, MD 21202	Mr. Adam Frederick	2001, 2000, 1999
Chesapeake Biological Laboratory UM-CES	Solomons, MD 20688	Dr. Eileen Hamilton	2001*, 2000, 1999
Event-Based Science	Rockville, MD	Russell G. Wright, Ed.D	1999
Horn Point Laboratory	Cambridge, MD 21613	Dr. Laura Murray	2001, 2000*, 1999
Johns Hopkins University APL	Laurel, MD 20723	Ms. Constance Finney	2001, 2000
Jug Bay Wetlands Sanctuary	Lothian, MD 20711	Karyn Molines	2001
MD Dept. of Natural Resources	Annapolis, MD 21532	Mr. Paul Kazyak	2001
NASA Goddard Space Flight Center	Greenbelt, MD 20771	Ron Erwin	2001, 2000, 1999
National Institute on Drug Abuse	Baltimore, MD 21224	Dr. Stephen Heishman	2001, 2000, 1999
NOAA/NESDIS	Camp Springs, MD 20233	Carmella Davis Watkins	2000
P. Sarbanes Cooperative Oxford Laboratory	Oxford, MD 21654	Dr. Stephen Jordan	2001*, 2000, 1999
Smithsonian Environmental Research Center	Edgewater, MD	Mark Haddon	1999
Towson University Biology / Baltimore Zoo	Baltimore, MD 21252	Dr. Don Forester Dr. Larry Wimmers	2001, 2000, 1999
Towson University Physics	Baltimore, MD 21252	Dr. David Schaefer	2001
US Army Research Laboratory	Adelphi, MD 20873	Susan Goldberg	2001, 2000, 1999
Washington College	Chestertown, MD 21620	Dr. Wayne Bell	2001*

Site willing to participate but no intern placed *

It is refreshing to be a part of the scientific process instead of a mere bystander.

D. Price '01

(Dr. Seagle) is great to work with. He trusts my decisions and has confidence in my work. That is the best part.

S. Winner '99

Interns are encouraged to think carefully about their role as a member of a scientific team and how it relates to their role as a teacher. They are asked to look for examples of how to link the research experience to science and mathematics teaching and outreach. Interns are also asked to keep a reflective record of their experiences in a journal.

Being placed in the role of a learner allowed me to truly understand the impact teachers can have on their students.

N. Davis '99

My eyes are opening to the "practical application" end of research. Just because you have the answer doesn't mean that people want to hear it (at least not everyone).

J. VanDeventer '00

Wow! To have my kids feel this way most of the time would be great!

S. Markowitz '01

Additional Program Elements

<u>*Orientation*</u>

All Interns are required to participate in an orientation program covering program procedures and expectations. This program is scheduled near the end of the school year and prior to the beginning of the internships.

<u>*Mid-Summer Meeting*</u>

This is a one-day meeting scheduled approximately four weeks after the beginning of the internships. It provides an opportunity for Interns to share common experiences, receive instruction and guidance in the preparation of outcomes-based learning activities, and coordinate their plans for outreach activities.

<u>*Presentation Day*</u>

All interns present a formal scientific talk summarizing their summer research experience, including implications and applications for transfer to the classroom.

<u>*Outreach*</u>

If a child is to keep alive his sense of wonder...he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement, and mystery of the world we live in.

Rachel Carson

A major theme of the Maryland Educators' Summer Research Program is *"Building Bridges Between Laboratories and Classrooms."* Throughout the summer internship, Interns look for ways to transfer the information they learn in the laboratory back into their classroom.

With the approval of their mentor, Interns are encouraged to spend 10% of their weekly internship (4 hours per week) developing outreach ideas and keeping a reflective journal of their experiences that they can use when they return to the classroom.

Following the internship, Interns work

individually and in teams to develop creative ways to teach problem solving, critical thinking skills, teamwork, career awareness, communication skills, and science and mathematics content. These "outreach activities" are designed to transfer experiences from laboratories to the classroom and benefit students as well as other teachers:

Classroom Implementation Project (CIP). The CIP brings some facet of the internship experience (content, technology, concept, procedure, etc.) back into the classroom for use as a teaching tool. The CIP's are developed into complete packages (i.e. units of instruction, performance tasks, etc.) that can be distributed to other Maryland educators for use in their own classrooms. All CIP's are created with reference to national and state standards and benchmarks (National Research Council, Project 2061, Maryland High School Core Learning Goals).

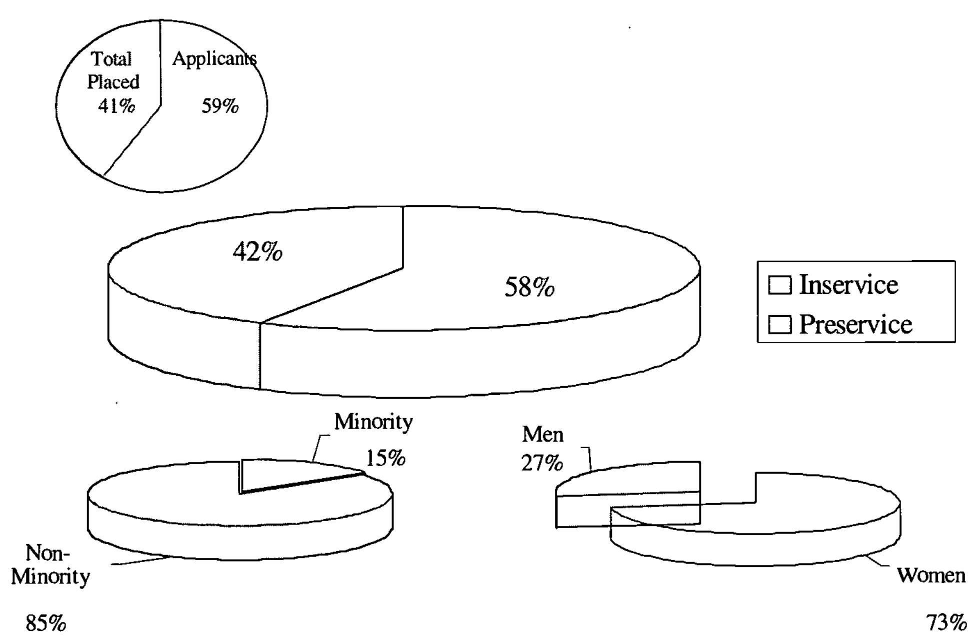
Speaking Event - Interns speak to teachers, administrators, parents, or community members about their summer experience and how it changed the way they view and teach science and mathematics.

Team or Collaborative Activity. The goal of this activity is to work with a small group of Interns, teachers, or other professionals in the scientific and/or academic community during the school year following the internship to design and implement a project that promotes positive changes in the way mathematics and science is viewed and taught.

This internship has provided much "raw material" for me to create meaningful, real-world, in-your-own-backyard sorts

Figure 1.

MESRP Overall Intern Demographics



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of lessons for my learners.
J. Brown '01

This internship gave me an up-close look at these people's lives, which I think will make me a more understanding teacher to the kids who come from this lifestyle... Now I can go back and teach my students about reality instead of what I have seen on TV or read in books.
J. Kraft '99

Program Evaluation and Impact

Demographics

Intern demographics are maintained in a database to determine the extent and nature of participation (see Figure 1 on previous page).

Over the course of three program years (1999-2001), MESRP has provided internship opportunities to 59 interns (34 inservice; 25 preservice) at 20 different research sites across the state of Maryland. Of the interns placed by MESRP, 15% were underrepresented minorities and 73% were female, distributed proportionally between preservice and inservice interns. Of the inservice interns, 21% serve a predominantly minority population through teaching in Baltimore City and Prince George's County Public Schools. Of the 59 internship placements, 68% were in pairs, of which 60% were preservice/inservice pairs. There have been a total of 85 applicants, of which 76 were offered placement. A total of 17 candidates withdrew from the program, yielding a placement rate of 69%, with the demographic profile representative of the applicants. All interns placed in a laboratory completed the terms and requirements of the internship.

Monitoring of Participation

During the course of the internship periods, the Program Coordinator has visited each intern/intern pair on-site to monitor progress, assist with program-related issues, and provide guidance in planning for the transfer of the research experience through outreach activities. Interns are required to communicate regularly (at least once each week) during the internship period via an email ListServ, which netted an overall average of 75% rate of use. A review of the ListServ entries and the reflective journals kept by each intern during the research experience has revealed increased understanding of the process and value of authentic research, renewed enthusiasm for using inquiry-based instructional strategies, and a depth of appreciation for the overall quality of the research experience.

It took a long time (to set up the equipment) and was tedious, but reminded me that science does not occur in a 60-minute class period.
R. Hermann '01

This experience has reinforced my desire to teach experientially, where students learn curriculum more through the outside environment than sitting down in a classroom.
S. Markowitz '01

Overall this was an incredible experience... one that I will never forget.
N. Friedland '00

In September following each summer internship period, a Presentation Day has been hosted at Towson University to allow interns an opportunity to present their summer experiences with family, peers, site representatives, mentor scientists, and others from the educational and scientific community. A total of 97% of the interns have participated in the Presentation Day, sharing not only the research activities in which they participated, but also implications and applications for transfer to their own classrooms. Titles and research sites are listed in Table 2. Complete text of Interns' Abstract Summaries are posted on the MESRP website www.towson.edu/~smross.

This summer has renewed my sense of

Table 2. **MESRP '01 Presentation Day**
Listing of Abstract Summaries

National Aeronautics & Space Administration ***So Yeon (Kelly) An***	**NASA Goddard Space Flight Center**
Teachers and Turtles ***AnnMarie Bassolino***	**Towson Biology w/ Baltimore Zoo**
Assessing the Biological Integrity of Maryland's Freshwater Streams ***Julie Brown***	**Maryland Department of Natural Resources**
Reconstruction of 1937 Land Use of the Maryland-Delaware Choptank River Basin Using Aerial Photographs ***Anthony Goodyear***	**Horn Point Laboratory**
A Very Special Place: Assateague Island ***Erin Greene***	**Assateague Island National Seashore**
The Effects of Phosphate and Nitrate on Biofilm Communities ***Ron Hermann and Lisa Muttillo***	**Center of Marine Biotechnology**
Is Blockade of Adenosine A1 Receptor Inducing Motor Activity? ***Jacqueline Johnson***	**National Institute on Drug Abuse**
Turtles, Technology, Students, and Science Research ***Stacy Markowitz***	**Towson Biology w/ Baltimore Zoo**
Space Missions and Education Public Outreach ***Michael Sivell & Autumn Moore***	**Johns Hopkins Applied Physics Laboratory**
The National Institute On Drug Abuse ***Pauline E Oji***	**National Institute on Drug Abuse**
Nanotechnology: Research in the 21st Century ***Donna Price***	**Towson Physics**
Critters, Creatures, & Kids at Jug Bay Wetlands Sanctuary ***Kimberly Smith***	**Jug Bay Wetlands Sanctuary**

wonder.

C. Harvey '99

I have learned more in the past 8 weeks about the environment than I have in all of my biology classes.

E. Greene '01

I am definitely a changed person from the beginning of the internship. I understand field research more, and (Dr. Forester) can see my improvements... I have really grown as a person and have learned so much science. (Dr. Forester) told me there is hope yet, but he will still never get me to be the outdoors type!

A. Bassolino '01

Follow-up

The Internship Coordinator has maintained on-going communication with all interns via written correspondence (email and post) and phone calls to monitor progress on outreach activities. The ListServ has remained active through the end of the academic year following each internship period to continue sharing of information relevant to the improvement of science and mathematics education.

Classroom Implementation Projects (Table 3) have been collected from each intern/intern pair, as well as documentation for the Speaking Events (Table 4) and Collaborative Activities (Table 5). In both 1999 and 2000 program years, two Interns withdrew from the MESRP following the internship period. Of the remaining Interns, 45% from 1999 and 67 % from 2000 completed all Outreach requirements, with the rates of completion for preservice and inservice Interns being equivalent. (Note: a larger portion of the 1999 Interns – 65% - completed the all but one piece of the Outreach.) For MESRP '01, 100% of the Interns have submitted drafts of their Classroom Implementation Projects, establishing a trend for increasing success in the completion of Outreach requirements.

Inservice interns who complete all outreach requirements are eligible to receive six Continuing Professional Development credits through the Maryland State Department of Education and receive documentation to be submitted by their Local Employing Agency. Preservice Interns who complete all Outreach requirements receive a Certificate of Completion to indicate their fulfillment of an internship experience (required for many MCTP students).

Implications for Additional Evaluation

Intern attitudes and practices toward teaching and learning of science and mathematics, as well as classroom practices were evaluated prior to the internship period by way of survey. These surveys will be compared to post-surveys administered within six weeks of the completion of the Outreach Requirements. The results of the analysis of data from the pre- and post-surveys, augmented by the study of the weekly e-mail journal entries, will examine changes in attitudes and perceptions about science and mathematics education, as well as changes in classroom activities, including teaching style, instructional strategies, and use of science, mathematics, and technology in the classroom.

Interns' professional activities will be monitored both during and beyond their commitment to MESRP by way of ongoing communication and survey to determine the extent of the outreach and dissemination of information and resources resulting from participation in MESRP. Retention rates will also be monitored for comparison to retention rates of teachers participating in

Table 3. **MESRP 2001 Outreach Classroom Implementation Projects Summary**

Intern Name	CIP Title	Content Area	Grade Level
AnnMarie Bassolino	Mini Unit on Turtles	Earth Science	7-8
Julie Brown	Assessing the Health of Our School Stream	Environmental Science	9
Ron Hermann	Implementing Biofilms to Observe Succession and Calculate Biodiversity of Aquatic Habitats	Biology, Marine Science, Ecology	9-12
Jacqueline Johnson	Effects of Stimulants on the Brain & Behavior	Biology	9
Anthony Goodyear	What's It Look Like? *Remote Sensing Lessons*	Earth Science, Astronomy, Geography	9-12
Erin Greene	Assateague Island National Seashore: A Very Special Place	Gen. Science, Lang. Arts, Soc. Studies, Mathematics	4-6
Stacy L. Markowitz	Michael Bird-Boy: The Effect of Pollution on Plants	General Science, Language Arts	3
Autumn Moore	Using Careers in Space as a Jumpstart to 6th Grade Astronomy	Astronomy	6
Lisa Mutillo	Biofilms and Biodiversity	Environmental Science, Biology, Ecology	4
Pauline Oji	DNA & Genetics	Life Science	8-12
Donna Price	Scanning Probe Microscopy Principles and Applications	Physics	11-12
Michael Sivell	Investigation of Crater Size Frequencies and Their Causes	Astronomy	11-12
Kimberly Smith	Interdependence & Interactions of Living Things	Biology	9-10

Table 4. MESRP 2000 Outreach Speaking Events Summary

Intern Name	Title of Speaking Event	Location/Audience	Date
Betsy Evans & Carole Ryan	Arthropod Analysis	Allegany College – Earth and Environmental Science teachers of Allegany County	August 21, 2000
Nina Hoffman	NSF Collaboratives for Excellence in Teacher Preparation Annual PI Meeting	NSF Headquarters – CETP PI's	April 3, 2001
Yovonda Ingram	NSF Collaboratives for Excellence in Teacher Preparation Annual PI Meeting	NSF Headquarters – CETP PI's	April 3, 2001
Yovonda Ingram	Implementation of Performance Tasks	Science Inservice Day Calvert County – Science teachers and supervisors (all grade levels)	October 20, 2000
Yovonda Ingram	My Summer Research at NOAA	NOAA Camp Springs – NOAA Outreach Scientists	August 15, 2000
Jennifer Jarosinski	Regulations of Gene Expression During T-Cell Development	American Red Cross – American Red Cross Immunology Scientists	July 28, 2000
Paul Marcantonio	NSF Collaboratives for Excellence in Teacher Preparation Annual PI Meeting	NSF Headquarters – CETP PI's	April 3, 2001
Teresita Metzbower & Diane Musick	NASA – Not Just Space Science, but Earth Science from Space	Maryland Instructional Computer Coordinators' Association – Science & Technology grade 3-8 teachers	March 22, 2001
Trisha Nyland	Research Under Controlled Conditions	Shiloh Middle School – 6^{th} grade Science students	April 27, 2001
Angeli Shah	Organic Slime! Developing Environmental Education Curriculum	University of Maryland – Gemstone Team	April 2, 2001
Teisha Taylor	My Summer Research at NOAA	NOAA Camp Springs – NOAA Outreach Scientists	August 15, 2000
Lois Tiffany	Using Math in Science	Ingenuity Science Teachers Meeting – Teachers of gifted children	May 15, 2001
Kevin Voritskul	Regulations of Gene Expression During T-Cell Development	American Red Cross – American Red Cross Immunology Scientists	July 28, 2000

Table 5. MESRP 1999 Outreach Collaborative Activities Summary

Intern Name	Collaborative Activity Title/Description	Location/Audience	Date
Taara Green ***Kim Sturdivant***	Women in the Workforce: Science, Math, and Technology	Harlem Park Middle School	January 19, 2000
Candace Harvey	Science Methods Class Peer Conversation – lesson demonstration followed by feedback and discussion	University of Maryland College Park – Preservice teachers	October 6, 1999
Pam Henry ***Jessica Kraft***	A New Twist on an Old Idea: Improved Drug Education – games, activities, posters, videos, booklets, etc. produced by 6th graders taken to share with 5th graders	Severna Park Middle School and feeder elementary schools – 5th and 6th graders	March 2000
Catherine Kern	The Role of the National Science Education Standards in Informal Education – a graduate thesis	University of Maryland – College Park & Science Center of Connecticut	1999-2000 school year
Mark Lichaa	Continued Research on the Dietary Habits of the *Panaque maccus* – collaborated with professors and additional researchers to continue project	Towson University	1999-2000 school year
Ben Spence	Calculating Confidence Intervals for Mean Growth Values in Orchid Protocorms	Annapolis Senior High – 40 AP high school students	March 27, 31, 2000
Ann Williams	PERIL in Maryland: an interactive computer game teaching about toxicology in everyday life	Northern Middle School – 175 8th grade physical science students	October 1999
Ann Williams	Scientist in the Classroom – Dr. Haasch (CBL) visits once per quarter to assist with labs and attends science club meetings	Northern Middle School – 200 middle school students	1999-2000 school year
Stephanie Winner	Life in the Biosphere: Arthropods, interactions, and energy flow – an interdisciplinary unit	Braddock Middle School – 130 7th grade students	Feb. – April 2000

other models of professional development.

All classroom implementation projects will be made available through the MESRP website www.towson.edu/~smross, which will be maintained by a Webmaster and monitored for quality of the information by the Project Director and the Coordinator. Criteria for evaluation will include scientific accuracy, age-appropriate content, and pedagogy.

Conclusion

As the program concludes its third year, it is evident from the existing evaluations that the design and implementation of MESRP has far-reaching potential to significantly impact the future of science and mathematics education. Having already been sought as a model for replication on a national scale for the Department of Energy Preservice Teacher Institute (http://www.scied.science.doe.gov/scied/PST/about.htm), MESRP sets the pace in providing a model for summer internships for the enhancement of both teacher preparation and professional development.

The continued support of the research laboratories through both financial and human resources, combined with fiscal support from the funding agencies, speaks to the validity of the program and a mutual interest in the enhancement of the teaching and learning of science and mathematics in the state of Maryland.

> *I can't believe that the internship is over... now I have completed something that I never in my life imagined I would do.*
>
> A. Bassolino '01

> *I feel like I learned something very valuable... things you can't learn while you're in school.*
>
> So Yeon An '01

> *I realized (the Internship Coordinator) was right. I learned a lot, loved it, and will never be the same.*
>
> *S. Markowitz '01*

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APPENDIX I

GUIDING PRINCIPLES: NEW THINKING IN MATHEMATICS AND SCIENCE TEACHING

Based on a Collaborative-Wide Effort to Define a Framework of Guiding Principles Led by Genevieve Knight and John Layman, MCTP I Co-Principal Investigators

Compiled by James Fey, MCTP I Project Director

Reprinted from *Journeys of Transformation*

If young people whose adult lives will be spent entirely in the 21st century are to be active and influential participants in the emerging social, political, economic, and scientific world, their education must provide broader and deeper knowledge of scientific concepts, principles, reasoning processes, and habits of mind than students typically acquire today. Unfortunately, there is convincing evidence that large numbers of students leave secondary and collegiate education with inadequate information and understanding about science and mathematics and little inclination to apply or even value the methods of those disciplines in the solution of problems or in reasoning about important personal and societal questions. A recent National Science Foundation review of undergraduate education concluded that

> *Too many students leave science, mathematics, engineering, and technology courses because they find them dull and unwelcoming. Too many teachers enter school systems under-prepared, without really understanding what science and mathematics are, and lacking the excitement of discovery and the confidence and ability to help children engage science, mathematics, engineering, and technology. Too many graduates go out into the workforce ill-prepared to solve real problems in a cooperative way, lacking the skills and motivation to continue learning.*
>
> (National Science Foundation, 1996, p.4)

Faculty who are drawn to *Journeys of Transformation* [our first monograph available on the Internet at http://www.towson.edu/csme/mctp/Journeys/Overview.html] are already sensitive to the problem of providing more sophisticated scientific and mathematical education to a broad and underachieving population. The central question is "If I want my students to develop a deeper understanding of science and mathematics, where do I turn for new ideas?" In grappling with the same question, leaders and participants in the Maryland Collaborative for Teacher Preparation (MCTP) found a number of credible sources of guidance.

Over the past decade, mathematics and science educators have engaged in spirited critical examination of current practice and have undertaken creative research and development activities. While the greatest energy has been focused on the elementary and secondary education, a significant number of college university faculty are now engaged in basic research and applied curriculum development projects aimed at improving undergraduate science and mathematics education. Their critical and creative work is producing remarkably consistent recommendations and intriguing resources.

For the Maryland Collaborative as a whole, the challenge was sorting through the recommendations and deciding which to adopt as a package that could be called "the MCTP approach." For the individual instructors, a greater challenge was deciding which innovations to try in their own classrooms. This section summarizes the underlying principles and recommendations that have guided their journeys of transformation. It describes (1) curriculum issues, including content coverage, connections among disciplines, and materials emphasizing scientific and mathematical investigation; (2) instructional issues, including constructivism, active learning, hands-on experiences, collaborative learning, and writing to enhance learning; (3) new approaches to assessment; and (4) technology as an impetus for changing course goals and classroom activities and for enhancing communication among faculty and students. (See APA, 1995)

Curriculum

For most scientists and mathematicians concerned with improving education, the first target of attention is usually the content and organization of topics in school and collegiate curricula. Quite naturally, they ask themselves and others whether current instruction focuses on the most important facts, concepts, principles, and methods of the disciplines and whether those topics are presented in the most effective sequences for students with different interests, aptitudes, and prior achievement (e.g. Leitzel, 1991).

Less is More. Given the explosive growth of scientific knowledge and the application of that new knowledge to a wide range of human activities, it is natural to expect that recommendations for reform would focus on the addition of topics to existing courses and an acceleration of the pace at which those topics are covered. In fact, there are strong arguments for quite different answers to questions about appropriate curriculum. For example, a report from the American Association for the Advancement of Science (AAAS) Project 2061 argues that

> *Present curricula in science and mathematics are overstuffed and undernourished....They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understanding in context, recitation over argument, reading in lieu of doing.*
> (AAAS, 1990, p. xvi)

The sentiments in that influential AAAS proposal are echoed in many other recent discussions of K-16 curriculum issues. Scientists and mathematicians have urged critical reexamination of their disciplines to identify the truly fundamental ideas and reasoning processes that most students must master and to cut away details that are important only for specialists. Lunn Steen (1988) has spoken eloquently about an evolving view of mathematics as the science of patterns, and he has proposed a framework of structures, actions, abstractions, attitudes, behaviors, and attributes that are useful in describing and reasoning about patterns of many different kinds. The Project 2061 recommendations include similar themes—

systems, models, constancy, patterns of change, evolution, and scale—that are useful in thinking about science, technology, and mathematics in the worlds that we experience and seek to understand.

While students undoubtedly will need some specific factual knowledge and skills as a basis for learning the proposed broader concepts and "habits of mind" (Cuoco, et al., 1996), a common thread in recent curriculum advice suggests that students would be better off if we would "organize curricula around profound exploration of a few basic ideas" (Stanley, as quoted in Millar & Alexander, 1996, p. 65). This point of view is often expressed with the catchy phrase, *less* is more.

Connections. The growth of scientific and mathematical knowledge has also been accompanied by increasing specialization in research fields. Science and mathematics curricula in secondary school and undergraduate education tend to be organized in ways that honor those specializations. On the other hand, recent developments have demonstrated that progress on major scientific problems usually requires integration of principles and methods from several traditional disciplines. For example, problems in environmental science often require concepts and strategies from the biological and physical sciences and mathematics as well as significant insights from economics, public policy, and law. The case for better-connected science and mathematics curricula rests on pedagogical grounds as well. For example, recent critiques of school and undergraduate mathematics have pointed out that typical syllabi and textbooks consist of hundreds of exercises "detached from the life experiences of students and seen by many students as irrelevant" (Mathematical Sciences Education Board, 1991, p. 17). A solid body of research in cognitive science demonstrates that learning with understanding requires learning how concepts, principles, and procedures are connected (Hiebert & Carpenter, 1992; Redish, 1994). These connections can relate within a subject area, across other subject areas, and to real-life situations in which the scientific or mathematical principles are at work.

Students can develop such interdisciplinary perspectives through theme-based curricular materials such as *Teaching Integrated Mathematics and Science (TIMS)* at the elementary level, *Event-Based Science* in the middle grades, and even the *Applications Reform in Secondary Education (ARISE)* and *Systemic Initiative for Montana Mathematics and Science (SIMMS)* projects at the high school level. (See references to follow for publisher information on curricular materials.) Not surprisingly, as one gets into advanced secondary school and undergraduate curricula, specialization by traditional discipline becomes more common. However, most of the recent developments in calculus and linear algebra curriculum materials give a prominent role to modeling of scientific and economic situations (Tucker & Leitzel, 1995; Carlson, et al., 1997). Moreover, at the college level, NSF has sponsored the development of curricular materials that honor the less-is-more philosophy and provide modules that exemplify current views of teaching and learning. One such project is *Powerful Ideas in Physical Science*, published by the American Association of Physics Teachers (College Park, MD). This project had a major influence on how MCTP structured its summer faculty development programs. Another example of theme-based materials at the college level is *Chemistry in Context* (Schwarz, et al., 1994), described by Dr. Thomas O' Haver in his contribution to this publication [the original monograph].

Scientific and Mathematical Thinking. While curriculum design has traditionally focused solely on the selection and sequencing of topics to be 'covered' in a course, there is growing support for the principle that *how* we teach is as important as *what* we teach. The National Council of Teachers of Mathematics (NCTM) articulates this notion in its Curriculum and Evaluations Standards:

> *Students' ability to reason, solve problems, and use mathematics to communicate their ideas will develop only if they actively and frequently engage in these processes. Whether students come to view mathematics as an integrated whole instead of a fragmented collection of arbitrary topics and whether they ultimately come to value mathematics will depend largely on how the subject is taught.*
> (National Council of Teachers of Mathematics, 1989, p. 244)

That NCTM position has been echoed in many recent comments on science curriculum and teaching as well. For example, at a 1994 conference on the preparation of science and mathematics teachers, Jaleh Daie suggested

> *Science is best learned as a way of knowing, not as a collection of facts...(C)ertain scientific facts are... needed before larger concepts can be understood and ideas can be constructed. (But) learning the process of science (logic, methods, quantitative skills, and cause and effect relationships) is more important than having a collection of facts. This approach emphasizes attainment of intellectual skills (rather than routine memorization) to reinforce student interest and increase motivation.*
> (Daie, 1996, p.70)

This point of view implies that curriculum materials should emphasize investigation and problem solving more than reading and imitation examples, and that students should have an opportunity to experience authentic scientific research environments.

Instruction

When content goals and curricular structures have been agreed upon, it is natural to turn to considerations of learning and instruction. How do students with various interests and aptitudes acquire the understanding we aim for? What kinds of instructional materials and activities stimulate that learning? Consistent themes have emerged from a substantial body of research on these questions, including much work directly related to undergraduate science and mathematics education.

Constructivism. The traditional pattern of K-16 mathematics and science teaching includes teacher explanation and demonstration of new ideas and skills followed by guided and then independent student work on routine exercises. Some students are able to learn from this pattern of interaction with their teachers and curriculum materials, but many are unsuccessful. Teacher-focused class meetings induce student inattention and, even when teacher explanations are clear and complete, students often report frustration when they face homework tasks away from the teacher's immediate guidance.

In response to the well-known difficulties that students have in learning science and mathematics, extensive research has attempted to clarify the mechanisms of learning in students of various ages and aptitudes. Over the years, this research, from a combination of content discipline and psychological perspectives, has led to a number of general theories about learning and those theories have then been used as bases for models of instruction. The theories that currently hold most promise for explaining and facilitating learning with understanding in science and mathematics are described the general label of *constructivism.*

With primary roots in the research and thought of John Dewey, Jean Piaget, and Lev Vygotsky, modern constructivism has several key tenets:

- Knowledge is actively created, not passively received.
- Students construct new understanding by reflecting on and modifying their prior knowledge structures.
- Knowledge is personal, an amalgam of individual interpretations of experiences and observations that are shaped by prior conceptions and social interactions.
- Learning is a social enterprise in which scientific ideas are established by members of a culture through shared observations and social discourse involving explanation, negotiation, and evaluation.

From a constructivist perspective, the goal of learning is the formation of internal representations of objects and relationships. Those representations can then be manipulated mentally to explain and make predictions about the structure of modeled situations. While there is little direct evidence of how representations are stored in the brain, there is general consensus that students will develop effective representations of mathematical and scientific concepts and principles only if they actively examine those ideas in varied forms, on a continuum from tactile to symbolic.

Active Learning. Constructivism is basically a theory of knowledge and how knowledge is acquired and used. However, it has been translated in various ways to give guidelines for mathematics and science instruction as well. The fundamental premise of constructivist learning theory is that knowledge is acquired only through direct involvement of the learner. Theories of teaching built on that principle have emphasized some of the following objectives:

- Instruction should engage students in experiences that challenge their prior conceptions and beliefs about mathematics and science.
- Instruction should encourage student autonomy and initiative. The instructor should be willing to let go of control over classroom discourse.
- The instructor should encourage the spirit of questioning by posing thoughtful, open-ended questions and encouraging discussion among students.
- Instruction should not separate knowing from the process of finding out.
- The instructor should allow student responses to drive lessons and seek elaboration of students' initial responses.

- The instructor should allow students some thinking time after posing questions.

[A comprehensive listing of "Learner-Centered Psychological Principles" developed by the American Psychological Association can be found in Appendix II of the original *Journeys of Transformation* monograph.]

Of course, it is one thing to set these admirable goals and quite another to create the desired classroom learning community. It seems fair to say that development has just begun on instructional materials (problems, laboratory investigations, etc.) and classroom strategies that will constitute a "wisdom of practice" comparable to the patterns of traditional instruction that have been passed from generation to generation of teachers. Further discussion of constructivist teaching and its foundation in theory and research on learning appears in a number of contemporary research and expository journals and books (for example, see Brooks & Brooks, 1993; NCTM, 1990; Simon, 1995; Driver, et al., 1994; Redish, 1994).

Hands-On Laboratory Experience. Interpretations of constructivist learning theory also generally infer that the most effective path to conceptual understanding is one that proceeds from active engagement with concrete embodiments to progressively more abstract and efficient representations. The implication for education is that science and mathematics instruction should make extensive use of interactive physical materials and "real-world" data from primary sources. While laboratory experiences have been standard features in secondary and collegiate science instruction for years, there have always been challenges to the authenticity of those experiences. They tend to be exercises in demonstrating or confirming principles learned from classroom lectures, rather than opportunities to discover answers to genuine scientific puzzles. Until very recently, mathematics classrooms have only rarely engaged students in genuine investigation of data or modeling results from experiments.

Over the past decade creative science educators have demonstrated ways to make laboratory investigations the central component of instruction in physics. The pervasive influence of computers and calculators on mathematics has transformed many school and college classrooms into laboratory environments as well. Furthermore, calculator- and computer-based laboratory equipment has facilitated a blending of science laboratory and mathematical modeling/analysis activity. Many innovative instructional materials and case reports of laboratory-style classes are now available, particularly for courses in physics, statistics, and calculus. Much of that work began at the Technical Education Research Center (TERC) under the leadership of Robert Tinker, and descriptions of the development are in reports from physics educators (see Thornton & Sokoloff, 1990; Laws, 1991; Krajcek & Layman, 1992). Moreover, evidence that these methods really work is building (see Redish, et al., 1997).

Collaborative Learning. The dominant public image of a scientist or mathematician is that of a solitary figure in a private world of laboratory experimentation or hypothetical reasoning. Indeed many stunning examples of scientific and mathematical discoveries have developed from one individual's sustained deep thought about complex problems. However, progress in science and mathematics is also cumulative—the work of any individual builds on the observations, conjectures, and reasoning of many others with similar interests. Furthermore, the power of teamwork in problem solving has been demonstrated not only in science and mathematics but also in our increasingly complex and technical environments in business and industry.

In addition to the payoff of collaborative work in professional science, mathematics, and engineering, recent research on learning and teaching has demonstrated the effectiveness of engaging students in structured cooperative learning activities. Consistent results suggest that student learning will be impressive if the classroom is organized to put students in small groups working on challenging problems. Common guidelines for teaching through cooperative problem solving include (from Johnson, Johnson & Smith, 1991, and Davidson, 1990)

- *Simultaneous Interaction.* Students should interact in team structures that work simultaneously to optimize their engagement during classroom time.

- *Positive Interdependence.* Activities should be structured to require contributions from all team members.

- *Individual Accountability.* While learning takes place in a team environment, students must demonstrate individual achievement.

- *Social Skill Development.* Since learning is socially negotiated from multiple perspectives, students must develop the social skills necessary for effective group interaction. Those skills must be taught and monitored along with academic objectives.

- *Reflecting.* At the conclusion of an activity, groups should be brought together to share their findings and reflect in their meaning.

Studies show that when these guidelines are effectively implemented, students have higher achievement, increased retention, increased motivation to learn, increased ability to consider multiple perspectives, more positive relationships with others, more positive attitudes toward learning, better self-esteem, and improved social skills.

If one is interested in acquiring skill in teaching that employs cooperative small-group problem solving in science and mathematics, advice is readily available (see, for example, Artzt & Newman, 1990; Davidson, 1990). Furthermore, new curriculum materials generally include a variety of group problem-solving activities that stimulate positive interdependence, allow multiple solution approaches, and pose reflection questions that help groups to articulate important scientific and mathematical principles represented in the problems.

Writing. When educators ask representatives of business and industry about skills they look for in future employees, they often mention the ability to work effectively as part of problem-solving teams. But representatives of technical fields also frequently mention the importance of the ability to communicate clearly in speaking and writing.

One of the truisms of education asserts that one never truly understands a subject until required to teach it to others. Thus it is not surprising that active participation in collaborative problem-solving activities facilitates learning. It also appears to enhance the development of student communication skills. Furthermore, one of the standard aspects of laboratory and small-group problem-solving instruction is the writing of reports that summarize and reflect on group work. Experimental K-16 science and mathematics curricula are now including substantial writing tasks, and they seem to help students to solidify and become more articulate about their knowledge (see, for example, Countryman, 1992).

Many science and mathematics teachers have begun using regular journal writing as a tool for communication with their students. On a daily or weekly basis, students are asked to write about their understanding of ideas in science or mathematics courses—what they are confident about and what they are still puzzled about—and their reflections on class activities. For many students this sort of opportunity to write about their learning is a powerful tool for developing understanding as well as a way to make personal contact with their teachers.

Assessment

Closely related to questions of learning and instruction are questions about techniques for assessing students' skills and conceptual understanding. In K-16 science and mathematics classrooms, the most common strategy for assessing student learning is through competitive, timed, written quizzes and tests that require individual students to answer a collection of specific short questions or to perform routine calculations to solve well-defined problems. Some students do very well in this sort of testing, but for many others, the conventional testing paradigms do not give accurate readings of their knowledge. Furthermore, even students who are "successful" on standard tests often have embarrassing gaps in their understanding of key scientific and mathematical ideas.

As curriculum developers have focused more on developing student skills and conceptual understanding and less on memorization and routine procedural skills, they have been compelled to devise assessment approaches that reflect the same shift in goals. For both mathematics and science, many prototypes for new assessment strategies are available (see Hestenes, Wells & Swackhammer, 1992; Mathematical Sciences Education Board, 1993; Schoenfeld, 1997).

To make student assessment more authentic, the tasks used in testing are increasingly set in realistic, open-ended contexts; may involve small groups of students; and allow multiple solutions or multiple paths to solutions. Responses to these assessment tasks are being scored using a range of new techniques, including looking at the work holistically, rather than by analyzing it as a collection of many discrete "right/wrong" responses. Assessment of portfolios of student work, which show the development of understanding over time, can also play a role in a more complete evaluation of each student's progress.

Advocates of group and portfolio assessment strategies often emphasize their interest in learning what students do know as much as what they do not know. They also stress the importance of making assessment an integral part of instruction, not simply a sorting tool to identify winners and losers in the game of science and mathematics learning.

As with other new ideas in mathematics and science teaching, the opportunities for innovative assessment are described in numerous publications. The NCTM has published a Standards volume focusing on assessment in mathematics (NCTM, 1995), the National Science Education Standards

(NRC, 1996) contain similar guidance to options in science assessment, and there are practical suggestions in dozens of books (e. g., Stenmark, 1991), journal articles, and Web sites.

Technology

Curriculum, learning, teaching, and assessment are long-standing concerns in mathematics and science education. But consideration of new approaches to those problems is influenced today by fundamental changes in the technology available for doing and learning about science and mathematics. From calculators and computers to video disks and the World Wide Web, science and mathematics educators can employ many new tools in their teaching practice. These tools influence the choice of content goals in mathematics and science courses, strategies for organizing classroom and laboratory instruction, and options for communication with students and colleagues about course materials and assignments.

Changing Course Goals. When calculators and computers are available as standard tools for mathematical problem-solving, it makes sense to rethink the goals for students learning mathematics. Curriculum development projects at every level are designing new mathematics courses that assume access to arithmetic and graphing computing software—reducing attention to training students in paper and pencil execution of routine procedures and increasing attention to strategies for intelligent use of electronic tools.

The explosion of information resources available on CD-ROM and World Wide Web networks raises similar questions about the balance between conceptual learning and acquisition of specific facts in science courses. When one can search the libraries of the world from a home computer terminal, what sort of broad understanding is needed to guide the retrieval of information from those resources, and what knowledge must still be retained "locally?" It is still too early to tell how science and mathematics education will use these information resources most effectively, but a great deal of activity is under way.

Changing Classroom Activities. Hand-held electronic technologies of various kinds are reshaping the possibilities for classroom instruction in science and mathematics in fundamental ways. The popular calculator- and computer-based laboratory instruments (CBL) are supporting exciting new kinds of investigations in which data are collected in real-time and then represented and modeled in numerical, graphic, and symbolic forms. These electronic tools for data collection and analysis are helping to integrate science and mathematics more deeply than ever before. Mathematical concepts are developed through modeling of real-life activities and scientific experiments are analyzed mathematically with a variety of convenient statistical and algebraic tools.

For example, motion detectors can be used to monitor the movement of people or objects and transform and record that information, usually in real time, directly into computers or calculators. The computers or calculators then display the data in tabular or graphic formats. Students can then analyze the data to study position, velocity and acceleration for these experiments. In addition, devices are being used with computers and calculators that measure force, temperature, pressure, voltage, current, and kinetic energy for a wide variety of "real-time" experiments. Laboratory material is available for these devices (see Thornton & Sokoloff, 1990).

When mathematics students have access to hand-held calculators with powerful numeric, graphic, and symbolic capabilities, they can investigate algebraic expressions, functions, and geometric shapes in search of interesting patterns. The mathematics classroom can become an experimental laboratory in which students construct their own understanding of key ideas and then share results with other students and the teacher as co-investigator. The use of multiple representations for mathematical ideas opens doors to the subject for students who are more adept at visual or numeric reasoning than the conventional symbol manipulation. These attractive options are being built into a range of new K-16 curricula.

Communication. Electronic communication via e-mail and the World Wide Web has made the world seem physically smaller but intellectually larger. Recent projects have also explored the power of electronic information technologies for creating scientific communities that join individuals from many schools and geographic areas—sharing experimental data and mathematical problems across state and national borders. Although work has only begun on projects to provide access to rich databases and on-demand assessments, the promise is great. Many school and university faculty are already using e-mail to communicate with their students and colleagues, as well as using the World Wide Web as an information resource and as a medium for publishing class materials and student projects.

The Challenge and the Opportunity

It is easy to identify the problems of teacher education in mathematics and science. But reaching agreement on ways to proceed toward solutions for those problems is a more imposing challenge. It took science, mathematics, and education faculty participating in the Maryland Collaborative for Teacher Preparation nearly two years to reach a comfortable consensus on the principles that would characterize MCTP courses. The key changes from traditional practice that we agreed would be required to reach our goals are summarized well by the following table, adapted from Johnson et al. (1991, p. 7) and Wright & Penn (1992, p. 35).

Science, mathematics, and education faculty from across Maryland accepted the challenge of creating courses that reflect these desired departures from traditional practice. Working together across disciplines and institutions, they have developed, tested, refined, and implemented dozens of new courses. Their case reports describe both successes and failures along the way. They also illustrate ways that such collaboration can facilitate faculty professional development by forming an *invisible college* of interacting students, mathematicians, and educators who stimulate and support each other in change.

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Traditional Courses	MCTP Courses
Science and Mathematics for Some	Science and Mathematics for All
Science and Mathematics as Separate and Distinct Subjects	Science and Mathematics as Part of an Interdisciplinary World
Many Topics Covered with Little Depth	Few Topics Covered in Greater Depth
Focus on Factual Knowledge	Focus on Conceptual Knowledge
Behavioral Learning Theory	Constructivist Learning Theory
Teacher Imparts Knowledge and Students Receive and Store It	Teacher is a Facilitator of Learning and a Learner, Too
Passive Students	Active Students
Text-Based Instruction	Hands-on/Minds-on Investigation
Confirmatory Investigations	Problem-Solving Investigation
Teacher Demonstration	Laboratory and Field Experiences
One-Way Communication	Networks of Communication in a Learning Community
Limited Use of Technology	Full Integration of Appropriate Technology
Competitive Learning	Cooperative Learning
Testing to Assign Grades	Multi-dimensional Assessment Integrated with Instruction

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APPENDIX II
MCTP PARTICIPANTS

Principal Investigators

MCTP I

James Fey, Project Director	University of Maryland College Park
Genevieve Knight	Coppin State College
John Layman	University of Maryland College Park
Tom O'Haver	University of Maryland College Park
Jack Taylor	Baltimore City Community College

MCTP II

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National Science Foundation

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James Lightbourne	Program Officer
Curtis Sears	Consultant
Terry Woodin	Program Officer

Faculty

Note:
Plain text—*MCTP I participants*
Italics—MCTP II participants
Bold—*MCTP I & II participants*

Anne Arundel Community College
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Donald Hoster (Chemistry)
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University of Northern Colorado
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Washington, D.C. Public Schools (Retired)

Glenda Lappan
Michigan State University
Martha McLaren
Gettysburg PA Public Schools
James Rutherford
American Association for the Advancement of Science

MESRP Research Sites

Alliance, Inc – Expanding Horizons
American Red Cross Holland Laboratory
Appalachian Laboratory UM-CES
Argonne National Laboratory
Assateague Island National Seashore
Center of Marine Biotechnology / SciTEC
Chesapeake Biological Laboratory UM-CES
Event-Based Science
Horn Point Laboratory
Johns Hopkins Applied Physics Laboratory
Jug Bay Wetlands Sanctuary
Maryland Department of Natural Resources
NASA Goddard Space Flight Center
National Institute on Drug Abuse Addiction Research Center
NOAA/NESDIS
Paul Sarbanes Cooperative Oxford Laboratory
Smithsonian Environmental Research Center
Towson University Biology & The Baltimore Zoo
Towson University Physics
US Army Research Laboratory
Washington College

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Jessica Thomas
Qing Tong
Marty Toronto
Kevin Voritskul

APPENDIX III
MCTP INSTITUTIONAL PROGRAMS

MCTP Program at Baltimore City Community College

TEACHER EDUCATION MATH/SCIENCE DEGREE OPTION (141)

This option is structured as preparation for those who expect to teach in the math and science areas. It is designed to address the transfer needs of students planning to attend University of Maryland College Park, Towson University, Frostburg State University, Salisbury State University, and/or any other four-year college within the Maryland Collaborative for Teacher Preparation.

Teacher Education Math/Science
Associate of Science Degree Option
Suggested Sequence of Courses

1st Semester			**Credits**
PRE	100	Preparation for Academic Achievement	1
ENG	101	English Writing	3
MAT	107	Modern Elementary Statistics	3
MUS	103	Music Appreciation	3
PSY	101	Introductory Psychology	3
SCI	110	Physical Science	4
		Total	17

2nd Semester			**Credits**
BIO	102	Principles of Biology	4
ENG	102	Introduction to the Term Paper and Research Methods	3
MAT	115	Dynamic Geometry	4
PSY	201	Educational Psychology	3
SP	101	Fundamentals of Speech Communication	3
		Total	17

3rd Semester			**Credits**
CHE	101	General Chemistry I	
		or	
PHSC	120	Contemporary Chemistry/Physical Science	4
ENG		Choose any ENG 200 course	3
H		Choose H 101, or H 110, or H 151	3
MAT	128	Precalculus I: College Algebra	4
SOC	101	Introduction to Sociology	3
		Total	17

4th Semester			**Credits**
ART	106	Art in the Culture	3
EDU	200	Introduction to Education	3
GEO	102	Elements of Cultural Geography Earth Science	3
H		Next course in student's history sequence	
		or	
HLF	201	Personal and Community Health	3
SCI	100	Elements of Earth Science	3
SED	220	Special Education: An Overview	3
		National Teacher Examination/Core Battery—PRAXIS I	0
		Total	18
		Program Total	69

MCTP Program at Towson University
Application Packet

MARYLAND COLLABORATIVE FOR TEACHER PREPARATION at TOWSON UNIVERSITY

PROGRAM DESCRIPTION

In this program the teaching and research institutions of the University of Maryland System, in collaboration with several community colleges and the Baltimore City, Baltimore County, and Prince George's County school systems designed, developed, and implemented an innovative interdisciplinary program to prepare teachers who can provide exemplary mathematics and science instruction in the elementary and middle schools in Maryland. The program was initiated in response to the widely recognized need for improved learning in these areas. The development and initial implementation of the program has been funded by the National Science Foundation. Teachers completing this program will be fully certified to teach throughout the elementary and middle school grades and will be exceptionally qualified for teaching mathematics and science.

The courses and field experiences at TU were developed cooperatively by faculty from the College of Science and Mathematics and the College of Education under the guidance of the following basic principles:

< Prospective teachers should learn science and mathematics themselves through instruction that models the best practice that they will be expected to employ in their own subsequent teaching careers.
< Courses and field experiences to develop skills and understanding in mathematics and science need to integrate the disciplines so that prospective teachers know and can take advantage of the important connections between the disciplines.
< The content and teaching methods preparation should include opportunities for prospective teachers to use modern technologies as standard tools for research, problem solving, and imaginative classroom instruction

The program at TU calls for a total of 15 credits in science, 15-16 credits in mathematics, and 6-8 credits in upper level interdisciplinary science/math. Field placements and student teaching assignments include experiences at both elementary school and middle school levels.

Students completing the MCTP program at TU will receive a certificate and letter of recommendation for their professional portfolio identifying them as having special preparation in mathematics and science. Local school officials have assured us that this endorsement will be important in making hiring and placement decisions.

TOWSON UNIVERSITY
CHECKLIST OF DEGREE REQUIREMENTS FOR ELEMENTARY EDUCATION STUDENTS (MCTP)
MATRICULATING ON OR AFTER SEPTEMBER 1, 1999

The major in elementary education, MCTP track in science and mathematics, requires a minimum of 135 semester hours of college credit. An average GPA of 3.00 or better is required for entering and remaining in the program, and a GPA of at least 3.0 in the major is required for entering student teaching. The following listing includes the requirements for General Education (GenEd), Elementary Education science and mathematics track, and Maryland State Certification. Requirements may change based on course availability; substitute courses may be allowed with approval of MCTP director.

ACADEMIC CONTENT

Courses taken before formal admission to the four semester professional education sequence.

I. ENGLISH (12 semester hrs)

(I.A)	ENGL 102 Writing for a Liberal Education	(3) ___
(II.C.3)	Choose an English course from II.C.3	(3) ___
	ENGL elective	(3) ___
(I.D)	Advanced Composition (ENGL.)***	(3) ___

II. SOCIAL STUDIES (12 semester hrs)

(II.D)	GEOG 102 World Regional Geography	(3) ___
	OR	
(II.D)	GEOG 105 Geog. Of International Affairs	(3) ___
	HIST elective	(3) ___
(II.B.1)	HIST 145 Hist of US to Mid-19th Century	(3) ___
	OR	
(II.B.1)	HIST 146 Hist of US since Mid-19th Cent.	(3) ___
(II.B.2)	POSC 103 American National Gov't	(3) ___
	OR	
(II.B.2)	SOCI 101 Intro to Sociology	(3) ___

III. SCIENCE (15 semester hrs)

(II.A.1)	BIOL 110 Contemporary General Biology & CHEM 100 Chemistry For Non-Scientists	(7) ___
(II.A.1)	PHSC 101 & GEOL 121 Physical Geology	(8) ___
	(ENVS 471 Environmental Science—See 3rd level internship)	

IV. MATHEMATICS (18-20 semester hrs)

(I.C)	MATH 205 Mathematical Concepts & Structures II	(4) ___
	MATH 251 Elements of Geometry	(4) ___
(I.C)	MATH 273 Calculus	(4) ___
	2 MATH electives (Suggested 231 & 263)	(6-8) ___

V. ART (3 semester hrs)

(I.E)	Choose an ART course from I.E.)	(3) ___

VI. MUSIC (3 semester hrs)

(II.C.1)	MUSC 101 Intro to Music Western Heritage	(3) ___

VII. KINESIOLOGY (2 semester hrs)

	KNES 281 Physical Ed. For ELED students I	(1) ___
	KNES 282 Physical Ed. For ELED students II	(1) ___

Academic Content (continued)

VIII. Add'l Required Courses (12 semester hrs)

(I.B)	ISTC 201 Using Info. Effectively in Educ.	(3) ___
	OR	
(II.B)	IDNM 101 Using Information Effectively in Science	(3) ___
(II.B.3)	Choose 1 course II.B.3	(3) ___
(II.C.2)	PSYC 101 Intro. To Psychology	(3) ___
	PSYC 201 Educational Psych.	(3) ___
	Summer Internship in Math/Science (or semester research project pre-approved by MCTP director)	___

Students must have taken Praxis Series tests, Speech and Hearing screening, and possess a GPA of 2.75 to enter the Four Semester Professional Education Sequence.

FOUR SEMESTER PROFESSIONAL EDUCATION SEQUENCE

FIRST LEVEL INTERNSHIP (15 semester hrs)

*ELED 321 Foundations Rdng. & Other Lang. Arts	(3) ___
*ELED 323 Prin. & Prac. Instr. Rdng. & Lang. Arts	(3) ___
*ELED 363 Field Studies in Elem. Teaching	(3) ___
*EDUC 417 Child Lit. & Other Mat. For Rdng. Lang. Art	(3) ___
**SPED 301 Intro. To Special Education	(3) ___

SECOND LEVEL INTERNSHIP (14 semester hrs)

*BIOL 303 Life Sciences	(3) ___
*MATH 323 Tchg. Math. Elem. School	(3) ___
*MATH 324 Obs. Part./Elem. Sch. Math	(2) ___
*PHSC 303 Earth-Space Science	(3) ___
*SCIE 376 Tchg. Science Elementary School	(3) ___

THIRD LEVEL INTERNSHIP (14/15 semester hrs)

*ELED 311 Child & Elem. School Curriculum	(3) ___
ENVS 471 Environmental Sciences	(3) ___
*ELED 429 Prin. & Prac. Of Assess. In Rdng. Lang. Arts	(3) ___
**ARED 371 Art and Child	(3) ___ OR
**KNES 324 Tchg. P.E. in Elem. School	(2) ___ OR
**MUED 305 Meth. Tchg. Music/El. Ed.	(2) ___
**EDUC 401 Foundations of Education	(3) ___

TEACHER CANDIDATE (15 semester hrs)

*ELED 468 Student Teaching	(12) ___
*ELED 469 Student Teaching Seminar	(3) ___

MCTP Minimum Total—135 Semester Hours

*Must be taken in prescribed sequence. **Prescribed sequence strongly recommended. All courses must be completed **prior to student teaching.** *** Gen. Ed. I.D. Advanced Composition course must be taken at Towson University.

Rev. Spring 2001

MCTP Program at University of Maryland College Park
Application Packet

Maryland Collaborative for Excellence in Teacher Preparation
(MCTP)
University of Maryland

Special Teachers
For
Mathematics and Science

MCTP AREA OF EMPHASIS

within

Elementary Education
Department of Curriculum and Instruction

Introduction

The preparation of teachers who have strong backgrounds in science and mathematics is an important long-term factor in implementation of current reforms in mathematics and science education. The elementary/middle school level is critical because students in those grades acquire the foundation of understanding, skills, and attitudes that will influence their future achievement and participation in science and mathematics. Unfortunately, it is too often the case that teachers in grades 4-8 do not have strong preparation in mathematics and science or in the best current practices for teaching those subjects.

The Maryland Collaborative for Teacher Preparation/University of Maryland program for the Preparation of Specialists in Mathematics and Science Teaching for Upper Elementary and Middle School is an innovative interdisciplinary program. Teachers will be eligible for certification to teach throughout the elementary and middle school grades, but will have taken special MCTP courses, an internship and a field experience that will make them exceptionally qualified for teaching science and mathematics. This program is an approved program within the Elementary Education program of the Department of Curriculum and Instruction at the University of Maryland College Park.

Students will student teach for a full semester. They will be placed in an elementary school for 7-8 weeks and then a middle school for the same length of time, whenever possible with Mentor Teachers who have been trained within the MCTP Mentor Teacher Preparation Program. Attempts will be made to assure that some of their EDCI 280 service semester and EDHD 300 observations are at the middle school level, perhaps with Mentor Teachers as well.

Student Record

36 semester hours of mathematics, science, and internships

MATHEMATICS

For the math/science area of emphasis the mathematics component of the program will include at least **18 semester hours** of coursework with labels MATH or STAT:

- At least one course emphasizing algebraic topics (ordinarily satisfied by MATH 110 (3), 113(3), 115 (3), or MATH 210 (4))

  Course ______ Semester ______ Grade ______ Cr. ______

- At least one course emphasizing topics in probability and statistics (ordinarily satisfied by MATH 111 (3) or STAT 100 (3) or STAT 400 (3))

  Course ______ Semester ______ Grade ______ Cr. ______

- At least one course emphasizing topics in geometry (ordinarily satisfied by MATH 211 (4) or MATH 430 (3))

  Course ______ Semester ______ Grade ______ Cr. ______

- At least one course emphasizing topics in calculus (ordinarily satisfied by MATH 220 (3) or MATH 140 (4))

  Course ______ Semester ______ Grade ______ Cr. ______

- Additional course(s)

  Course ______ Semester ______ Grade ______ Cr. ______

The collection of courses offered to satisfy the mathematics component of the interdisciplinary area of emphasis must include at least one intermediate level course, at the 200 level or above.

Because there are many ways to satisfy the spirit of these recommendations by selecting courses from the UM MATH offerings, approval of alternatives to listed courses will be given by mathematics education advisors. Attempts should always be made to take the courses or sections of courses designated MCTP, when offered.

SCIENCE

For the math/science area of emphasis the science component of the program will include at least **18 semester hours** of coursework:

- At least two courses emphasizing physical science (ordinarily satisfied by PHYS 117 (4) and CHEM 121 (3)/122 (1))

  Course ______ Semester ______ Grade ______ Cr. ______
  Course ______ Semester ______ Grade ______ Cr. ______

- At least one course emphasizing biological science (ordinarily satisfied by BIOL 101 (3)/ 102 (1), or BIOL 105 (4), P BIOL 100 (3)/101 (1) or MICB 100 (4))

  Course ______ Semester ______ Grade ______ Cr. ______

- At least one course emphasizing earth or space science (ordinarily GEOL 100 (3)/110 (1) or Astronomy 101 (4))

  Course ______ Semester ______ Grade ______ Cr. ______

- Intermediate science course

  Course ______ Semester ______ Grade ______ Cr. ______

The collection of courses offered to satisfy the science component of the interdisciplinary area of emphasis must include at least one intermediate level course, at the 200 level or above.

Because there are many ways to satisfy the spirit of these recommendations by selecting courses from the UM science offerings, approval of alternatives to listed courses will be given by science education advisors. Attempts should always be made to take the courses or sections of courses designated by MCTP.

SCIENCE AND MATHEMATICS COURSES

Students can have grades of C or below in at most two of ten courses offered to satisfy the area of concentration.

INTERNSHIP

It is expected that all students earning an MCTP area of emphasis with elementary certification will take part in at least one internship emphasizing science/mathematics research or informal science education. Internships may or may not be associated with course credit but at least one internship is required within the program. Student satisfaction of this requirement will be certified by a mathematics or science education faculty advisor.

Internship Location ______________________________ Date _______________

SEMINAR

Students who are pursuing the MCTP program are encouraged to regularly participate in the MCTP seminar in science and mathematics education. This 1-credit course meets on a biweekly basis each semester of the academic year to study issues in science and mathematics education through reading, discussion, field trips, and projects. The class is offered under the title, EDCI 288P.

Course EDCI 288P Semester _______ Grade _______ Cr. _______

MCTP Activities Record

DATE _______________ ACTIVITY ____
DATE _______________ ACTIVITY ____
DATE _______________ ACTIVITY ____
DATE _______________ ACTIVITY ____

Student Teaching (Note)

EDCI 460 (15 cr). This allows placement in both elementary and middle schools.

Course EDCI 460 Semester _______ Grade _______ Cr. 12
Course EDCI 464 Semester _______ Grade _______ Cr. 3

MARYLAND COLLABORATIVE FOR TEACHER EDUCATION
SPECIALISTS IN MATHEMATICS AND SCIENCE

CORE REQUIREMENTS

Course	Credit	Grade
I. CORE Fundamental Studies (3 courses)		
1. Introduction to Writing		
ENGL 102..................	3	___
2. Mathematics (1 course) (See Area of Emphasis)		
MATH 110/111.........................	3	___
ENGL 391/392/393/394/395...	3	___
II. CORE Distributive Studies (9 courses)		
1. Humanities and the Arts (3 courses)		
Literature—one course	3	___
Arts—one course........................	3	___
2. Mathematics and the Sciences (10 credits)		
Physical Science (See Area of Emphasis)	4	___
Life Science (See Area of Emphasis)	4	___
Mathematics/Formal Reasoning (See Area of Emphasis)	3	___
3. Social Sciences and History (3 courses)		
Social or Political History (1 course)		
HIST 156..................	3	___
Behavioral and Social Sciences (2 courses)		
SOCY 227...............	3	___
(May meet Major Requirement)		
ANTH, ECON, GVPT, GEOG, SOCY	3	___
III. Advanced Studies 2 courses (6 credits)		
(outside major after 56 credits)		
One upper level course outside your major	3	___
One Math/Science Capstone course (See Area of Emphasis)	3	___
IV. Diversity		
One course from approved list		
______________________	3	___

PRE-PROFESSIONAL REQUIREMENTS

To be completed with a "C" or better
*May also count as Core Requirement
Double count within Area of Emphasis

Course	Credit	Grade
EDCI 280 School Service Semester	3	___
EDCI 443 or 466, Children's Lit., Lit. for Adolescents	3	___
EDCI 301 Art Ed. Or ARTT 100 or 110		optional
MUSIC 155 Music Education		optional
*SOCY 227	3	___
*CORE Soc Sci in ANTH, ECON GVPT, GEOG, HIST, SOCY	3	___
*HIST 156	3	___
MATH 210 (See Area of Emphasis)	4	___
MATH 211 (See Area of Emphasis)	4	___
Physical Science (See Area of Emphasis)	4	___
Biological Science (See Area of Emphasis)	4	___

Area of Emphasis (Math & Science)

Course	Credit	Grade
Science		
A. Physical Science (2 courses) *PHYS 115 & *CHEM 121/122.....	8	___
B. Life Science (1 course)................. *BSCI 103, or *BSCI 124/125, or *BSCI 105,106	4	___
C. Earth Science or Astronomy (1 course) *GEOL 100/110 or *ASTR 101	4	___
D. Intermediate Science (200 level or above)	3 or 4	___
Mathematics		
E. Algebra Topics (1 course) *MATH 110, 113, 115, or 210	3 or 4	___
F. Probability & Statistics (1 course) MATH *111, or *STAT 100 or *400	3	___
G. Geometry (1 course)		___
MATH 211 or *430	3 or 4	___
H. Topics in Calculus MATH *220 or *140	3 or 4	___
Mathematics and Science		
I. MCTP Seminar (EDCI 288P)	1	___
J. Science/Math Internship (Credit optional) Internship required		___
After completion of 56 credits:		
EDMS 410 Classroom Assessment	3	___
EDPL 301 Foundations of Education	3	___
EDHD 425 Lang. Dev. & Reading Acq.	3	___
EDHD 411 Child Growth & Dev.	3	___

PROFESSIONAL REQUIREMENTS

All professional coursework must be taken in sequence and completed with a "C" or better prior to student teaching. All students must be admitted to the College of Education to register for Professional Level courses. Students must maintain a 2.5 GPA while completing Professional Requirements to continue in teacher education.

PROFESSIONAL SUPPORT COURSES

Course	Credit	Grade
EDCI 397 Prin. & Methods of Teaching	3	___
EDCI 461 Materials for Readers	3	___
EDCI 385 Computers for Teachers	optional	

BLOCKED METHODS SEMESTER

Course	Credit	Grade
EDCI 322 Social Studies Methods	3	___
EDCI 342 Language Arts Methods	3	___
EDCI 352 Mathematics Methods	3	___
EDCI 362 Reading Methods	3	___
EDCI 372 Science Methods	3	___
STUDENT TEACHING SEMESTER		
EDCI 460 Stud. Teaching: Elem./Middle	3	___
EDCI 464 Reading Diagnosis & Inst.	3	___

4/17/2001

APPENDIX IV:

MCTP SURVEY INSTRUMENTS

Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science

Section One: Background Information

1. Sex:
   a. Male   b. Female

2. Ethnicity:
   a. African-American   b. Asian/Pacific Islander   c. Caucasian
   d. Hispanic   e. Other

3. Number of completed college credits:
   a. 0- 30   b. 31-60   c. 61-90   d. 91+   e. post-baccalaureate

4. Major or area of concentration:
   a. Education/Mathematics   b. Education/Science
   c. Education/Mathematics & Science   d. Education/Other Subject(s)
   e. Not in teacher certification program

Section Two: Attitudes and Beliefs

Below, there is a series of sentences. Indicate on your bubble sheet the degree to which you agree or disagree with each sentence.

Your choices are:

A	B	C	D	E
strongly agree	sort of agree	not sure	sort of disagree	strongly disagree

There are no right or wrong answers. The correct responses are those that reflect your attitudes and beliefs. *Do not spend too much time with any statement.*

5. I am looking forward to taking more mathematics courses.

6. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in mathematics classrooms.

7. I like mathematics.

8. Calculators should always be available for students in mathematics classes.

9. In grades K-9, truly understanding mathematics in schools requires special abilities that only some people possess.

10. The use of technologies (e. g., calculators, computers, etc.) in mathematics is an aid primarily for slow learners.

11. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry).

12. To understand mathematics, students must solve many problems following examples provided.

13. Students should have opportunities to experience manipulating materials in the mathematics classroom before teachers introduce mathematics vocabulary.

14. Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.

15. Students should be given regular opportunities to think about what they have learned in the mathematics classroom.

16. Using technologies (e.g., calculators, computers, etc.) in mathematics lessons will improve students' understanding of mathematics.

17. The primary reason for learning mathematics is to learn skills for doing science.

18. Small group activity should be a regular part of the mathematics classroom.

19. I am looking forward to taking more science courses.

20. Using technologies (e.g., calculators, computers, etc.) in science lessons will improve students' understanding of science.

21. Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.

22. In grades K-9, truly understanding science in the science classroom requires special abilities that only some people possess.

23. Students should be given regular opportunities to think about what they have learned in the science classroom.

24. Science is a constantly expanding field.

25. Theories in science are rarely replaced by other theories.

26. To understand science, students must solve many problems following examples provided.

27. I like science.

28. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in science.

29. The use of technologies (e. g., calculators, computers, etc.) in science is an aid primarily for slow learners.

30. Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary.

31. Science consists of unrelated topics like biology, chemistry, geology, and physics.

32. Calculators should always be available for students in science classes.

33. The primary reason for learning science is to provide real life examples for learning mathematics.

34. Small group activity should be a regular part of the science classroom.

ITEMS 35--45 ARE FOR ONLY THOSE INTENDING TO TEACH

A	B	C	D	E
strongly agree	sort of agree	not sure	sort of disagree	strongly disagree

35. I expect that the college mathematics courses I take will be helpful to me in teaching mathematics in elementary or middle school.

36. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach mathematics.

37. The idea of teaching science scares me.

38. I expect that the college science courses I take will be helpful to me in teaching science in elementary or middle school.

39. I prefer to teach mathematics and science emphasizing connections between the two disciplines.

40. The idea of teaching mathematics scares me.

41. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach science.

42. I feel prepared to teach mathematics and science emphasizing connections between the two disciplines.

43. Area of teaching certification

a. elementary (grades 1-8) b. secondary mathematics (5-12)

c. secondary science (5-12) d. other

44. I intend to teach grades

a. K - 3 b. 4-8 c. 9-12 d. post-secondary e. undecided

45. I am a student in the Maryland Collaborative for Teacher Preparation.

a. yes b. no

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MCTP Teacher's Actions and Beliefs of Mathematics and Science

SECTION I.
To what extent do you agree or disagree with each of the following statements?

Choices:

(A)	(B)	(C)	(D)
Strongly disagree	Disagree	Agree	Strongly agree

<u>Mathematics</u>

1. is primarily an abstract subject.
2. is primarily a formal way of representing the real world.
3. is primarily a practical and structured guide for addressing real situations.
4. should be learned as sets of algorithms or rules that cover all possibilities.
5. A liking for and understanding of students are essential for teaching math.
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.
7. More than one representation should be used in teaching a math concept.
8. Some students have a natural talent for math and others do not.
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.

<u>Science</u>

10. is primarily an abstract subject.
11. is primarily a formal way of representing the real world.
12. is primarily a practical and structured guide for addressing real situations.
13. Some students have a natural talent for science and others do not.
14. A liking for and understanding of students are essential for teaching science.
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.
18. Students see a science task as the same task when it is represented in two different ways.

SECTION II.

To be good at mathematics [science] at school, how important do you think it is for students to [fill in the blank with each of the items below] ?

Choices:

(A)	(B)	(C)
Not important	Somewhat important	Very Important

<u>In Mathematics</u>

19. remember formulas and procedures?
20. think in sequential manner?
21. understand concepts?
22. think creatively?
23. understand math use in real world?
24. support solutions?

<u>In Science</u>

25. remember formulas and procedures?
26. think in sequential manner?
27. understand concepts?
28. think creatively?
29. understand science use in real world?
30. support solutions?

SECTION III.

What is your familiarity with the reform documents?

Choices:

(A)	(B)	(C)	(D)	(E)
Not at all	Small extent	Fairly	Moderate extent	Great extent

31. Mathematics standards document (*Curriculum and Evaluation Standards for School Mathematics*).
32. Science standards document *Benchmarks for Science Literacy.*
33. Science standards document *National Science Education Standards.*

SECTION IV.

Please indicate if you use (or would use if you taught mathematics and science) the instructional strategies listed below.

Choices:
(A) No (B) Yes

In Mathematics

34. Assisting all students to achieve high standards.
35. Providing examples of high-standard work.
36. Using authentic assessments.
37. Using standards-aligned curricula.
38. Using standards-aligned textbooks and materials.
39. Using telecommunication-supported instruction.
40. Making connections with science.

In Science

41. Assisting all students to achieve high standards.
42. Providing examples of high-standard work.
43. Using authentic assessments.
44. Using standards aligned curricula.
45. Using standards-aligned textbooks and materials.
46. Using telecommunication-supported instruction.
47. Making connections with mathematics.

SECTION V

48. If you have taught since graduation, for what duration?
    a. in beginning year b. 1 to 2 years c. 3 to 4 years d. > 4 years
49. If applicable, what grade level are you teaching this year?
    a. 1 or 2 b. 3 or 4 c. 5 or 6 d. 7 or 8 e. other
50. If applicable, are you a specialized teacher (by content)?
    a. yes b. no
51. If you are a specialized teacher, what is your content area?
    a. mathematics b. science c. both mathematics and science d. other

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APPENDIX V:

TEACHER-WRITTEN CASES

1. "Science Fair Projects" by Kristina Clark

I started my MCTP teaching career in a fourth grade classroom toward the end of the school year. The school that I teach at is in the inner city of Jacksonville, Florida. This past school year I had twenty-two students in my classroom. I was very excited to have my first teaching assignment and I had so many good ideas saved up from my MCTP courses at the University of Maryland.

When it grew closer to the end of the year, the buzz of the Science Fair rang through the hallways. In a lot of the classrooms there were challenges with behavior. With these problems in mind some of the other teachers decided not to do Science Fair projects with their students. Actually most of the teachers decided not to participate in the Science Fair. I heard many excuses why the other teachers were not going to participate. Some teachers said, "It is too much work. The students will not do the work. The class will not behave long enough to do the projects." At times my students' behavior problems made me question whether I should try to do Science Fair projects with my class. I knew that it would be a lot of work, but I also knew that it would be very meaningful for my students and they would learn a lot from it.

The students were very unknowledgeable about how to do Science Fair projects so I knew that it would be very time consuming. This really did not bother me, because I knew it was going to be a very educational experience and some teachers were not teaching their students science at all or very little.

First, we had to establish rules to follow during our lab work for the science fair projects. The whole class was a part of the rule making, as well as, the consequence making. Next, we had to discuss that when the students are working with a group everyone has responsibilities so the task can be accomplished. We discussed all the jobs that are involved with group work. We also discussed ways of dealing with differences of opinions and working out problems.

I started off with a class project so I could model to the class the steps to follow throughout the project and the way to present the project. I was prepared to do the project with the class because I did the same project in my MCTP science methods class, taught by Dr. McGinnis. That is also one of the reasons I decided to do the Science projects with the students because I was prepared. I have determined that the most important aspect and time consuming part of teaching is the actual preparation for the lessons. Usually the more meaningful the lesson, the more preparation and work required. Luckily, I did a lot of preparing for my class in the MCTP program.

The class project involved testing the quality of different brands of paper towels. The class discussed how they would need to test the paper towels to determine if the quality would meet their needs. We decided that the paper towels would need to be absorbent because we need to soak up spills. The towels would need to be durable so many windows can be washed and the paper towels will be long lasting. The students also decided the paper towels should be strong so the towels will not tear apart easily.

After discussing the qualities the paper towels need to have, the students decided on a question to investigate. The students voted and came up with the question, "Which paper towel has the greatest quality?" Then, students brought in paper towels and we had four different brands to test. The students observed the texture, thickness, and differences of the paper towels. The students recorded their individual or group hypothesis and we recorded the class majority hypothesis.

The students continued by designing ways to test the variables they had identified earlier. After designing the experiments, we set up stations around the room so everyone could get a chance to test the paper towels. Then, we compiled the results and plotted the data on our class charts.

After all the experimenting, cleaning up, and recording we discussed what we discovered. The students wrote their conclusions and we also wrote a conclusion for our class display board. At the end of our class project we had all of our information up on our display board. We reviewed the steps to follow for a Science Fair project and the important elements of the display board. I left the class project display board up so the students could use it as a reference for their own boards. I also gave the students some handouts that outlined everything that we discussed throughout the class project to use as references.

I gathered up a bunch of books with ideas for science fair projects. The students spent a few days in their groups looking at the books and trying to decide what they wanted to investigate. The students worked cooperatively in their groups to complete their projects. Of course there were a few students that were not able to stay on task and work in the group so they had to do an alternative assignment.

There were five groups of three or four students each. Throughout the whole process the students were graded by their group members, the class, and their teacher. The students graded each other's participation in the groups, the class graded the group presentations, and I graded the final project.

The students made connections between math and science throughout their hard work on their projects. The students measured, calculated, recorded, charted, investigated, observed, questioned, guessed, discovered and so much more. Most of the knowledge the students learned was from their experiments, investigations, researching, probing, and combined ideas of their group and class.

The students infused the use of technology with their projects because we were able to use computers to make our charts, record data, and type reports. The use of the computers allowed the students to make more professional looking projects and it also made the students take more pride in their work.

The projects were definitely an example of teaching for understanding in mathematics and science. The students would have to have an understanding of mathematics and science to be able to investigate their questions for their projects. When a student lacked the knowledge, I observed the other students in the group explaining and helping the unknowledgeable student to understand. So the students used the combined knowledge of their group to get the job done.

The students took great pride of their work and we shared the projects on the morning-televised announcements. I think the key that made everything go so well is that every student had a big responsibility. They took pride in what they were responsible for and did not want to let their group down. It was a lot of work in the fact that I had to get all the materials that were needed for the experiments. Some of the students were able to supply their own materials but I helped the other students who needed it. I had to be very organized so all materials were available when needed and the reference sources were abundant.

The most important step of the whole process was the initial introduction explaining how we will work together and what will happen if we can not do that. So no matter how time consuming it may be jobs need to be defined, rules need to be established along with consequences & rewards, and methods need to be discussed to solve problems. Rules not only need to be established, but followed, and enforced.

I didn't become a MCTP teacher because I thought it was an easy job or to become a millionaire. I became a teacher because I wanted to make a difference in students' lives. I wanted to make learning interesting, exciting, and valuable to the students. When the students understand the meaning behind the work, they are more motivated to do the work. It is so wonderful to be a witness to a child's creativity, self-determination, and improved self-esteem.

I really enjoyed the whole science fair experience—hard work and all! I sometimes think its because I am a new teacher full of reform-based ideas and energy. I sure hope that some day I'm not the teacher saying I'm not going to do that in my class because its too much work and my students can't do it. Your students will only do what you think they can do. Students live up to high expectations.

2. Me? A Middle School Math Teacher? by Josephine To

My first year of teaching as a graduate of the MCTP program was more than I could ever [have] imagined. All my life I wanted to be a teacher, but I never thought I'd be a math teacher. Although I enjoyed math in elementary school, I developed a negative attitude toward this subject in middle school because I did not understand it and did not see why it was important for me to learn. As a result, I did poorly in math all the way through high school. The summer before I entered college, I decided to major in elementary education and concentrate in anything but math and science.

During freshman orientation, I attended an informational session on the MCTP program. At first, I had no desire to participate in such a program because it focused on preparing students to be middle school math and science teachers. In my mind, there was no way that I would ever teach middle school, let alone middle school math, because I had such bad memories of those experiences. But as I listened to the presentation, I realized that without a strong math and science background, I would have a difficult time finding a job. The presenters talked about the opportunity to take math and science classes that were taught from a constructivist approach, whatever that was. Either way, it sounded like fun because we could "play" with things, which was something I did not expect to find in college courses. I figured if I joined the program, I didn't necessarily have to teach middle school math or science. I could just try it out and see how it goes. Little did I know what I was getting myself into.

Participating in the MCTP program was one of the best decisions I have ever made. It transformed my attitudes toward learning and gave me a memorable experience that I now share with my students. I had the opportunity to re-learn math, the very same concepts that I struggled with in middle school and high school, yet this time I was successful. Through my MCTP professors, I experienced and witnessed their passion for math and science. They led me to draw connections between what I learned and the real world. MCTP provided me with opportunities to observe outstanding middle school math teachers, who modeled what I learned in a real classroom. Through these experiences, I fell in love with math and teaching from a constructivist approach. Although I joined the program with a different purpose, I graduated with a whole new vision. I now desired to be a middle school math teacher.

When I graduated, I felt well-prepared for teaching math. I was privileged to receive several offers from a variety of middle schools, primarily because of the experiences I gained through MCTP. Each offer boasted a different quality. I had the option of becoming a math, science, and/or computer teacher for sixth, seventh, and eighth grade students. Some offers included teaching other subjects as well. The schools ranged from needy ones to very affluent ones. The decision was very difficult but in the end, I chose to teach seventh grade math at a lower to middle class school, even though I would have three preps, which included a seventh grade English class.

Looking back, although I felt prepared to teach math, I'm not sure how prepared I was to address the challenges that I would face from my students and colleagues as a constructivist teacher. Having spent four years in the MCTP program, I was so used to having teachers who always asked "why?" or answered my question with another question. Likewise, I assumed that I would use hands-on, inquiry-based activities all the time in my classroom.

I was so excited about teaching and applying what I learned in school in my own classroom. My vision as a math teacher was to guide my students in learning and applying math in the real world. I started my first year of teaching before I even met my students. I spent several days transforming an ordinary room into my classroom. I loved my room. It was bright and reflected who I was as a teacher. I chose to have trapezoid tables instead of the normal chair-desks, which would facilitate cooperative learning. I put my desk in the back of the room to encourage me to spend more time interacting with my students. I put up posters of problem solving strategies, higher order thinking key words, and math application illustrations. I created a bulletin board titled "Math in our World," where I posted real-life examples of math concepts that my students would encounter. I wanted my students to sense my passion for math.

Preparing for the first week of school was exhausting. I had to learn the procedures and policies of the school, familiarize myself with curriculum I would [be] teaching, and meet the teachers that I would be working with. In addition to all of this, I had to prepare materials for my classes. I wanted to start the year off with a fun math activity. Most teachers started with the usual "expectations speech," but I wanted to convey to my students that math was really important to me.

Before I started teaching, I had a mental picture of what I wanted to be like. I wanted to challenge my students to think, incorporate hands-on activities in my lessons, and spend time drawing connections between what we learned to the real world. I was very ambitious. I intended to use every minute meaningfully. Within my first month of teaching, I faced the cold reality. How do I accomplish all of these goals in the time that I'm given? It was so disheartening when I realized the constraints of my situation. At my school, students have seven periods, 45 minutes each. By the time I finished going over the day's warm-up exercise and homework, I was left with about 25 minutes to teach a lesson. Twenty-five minutes was not enough time to guide my students to discover the concept of the day. I wanted to do so much, especially with my "leisurely learner" classes. They were the ones who needed the hands-on, real world application approach the most. It was so hard when I compromised and found myself "telling" them the answer rather than helping them discover it.

Another reality that I encountered was not from my students but from my colleagues. When I chose a school, there was no way to guarantee that the teachers I would work with shared the same vision of teaching that I did. I am blessed to work with two great seventh grade math teachers, who looked out for me and helped make my transition successful. We got along very well. We wanted to plan together and keep the same pace each day. Yet, our teaching styles were very different. They would teach a concept through direct instruction, then have students practice it by doing worksheets for the rest of the period. I felt caught between their practical approach to my discovery, yet time-consuming, lessons. I did not want to betray the training I received through MCTP, but it was so difficult to implement in my classroom. Eventually, I compromised and integrated the two approaches together. I reduced the number of lengthy investigations, but continued to promote higher order thinking by asking "why" a lot, challenging students to work together to solve problems, and used demonstrations to stimulate my students' thinking.

As my first year of teaching progressed, my passion for teaching grew. I enjoyed teaching. I enjoyed working with my kids. I enjoyed watching and waiting for the "light bulb" moments. At first, my students disliked being challenged. They hated to think. They would rather have the boring worksheets and the busy work, than to have a hands-on activity that made them think. This was the strangest discovery for me. I would have traded to be in this type of classroom than the kind I grew up in. I would ask them a "why" question, and they would respond with a shrug and "I don't know." After a while, I formed a new policy that this response was no longer acceptable [in] my classroom. Everyone had to try. I had no idea how frustrating this would be for me to uphold. Every time I asked a thinking question, I felt like I was pulling teeth. My students were so reluctant to cooperate. After much persistence and patience, my students realized that I was not giving up, and eventually they participated in these class discussions.

My experiences in MCTP gave me many ideas that I tried to implement in my class. One assignment that I gave my students was called "Wanted: Math in the Real World." I presented my students with a challenge to find a real world example of a concept that they learned in this unit. I used this assignment as a culminating project to help my students reflect and apply what they had learned. I had high expectations for this project and got a mixed response from my students. I was pleased that some of my students took this assignment seriously and brought back some excellent examples of how we use graphs, fractions, percents, probability and more. One of my students brought in McDonald's Monopoly game board to illustrate how we need an understanding of odds to realize our chances in playing this game. I was also surprised that some of my students had no idea how they used math in their daily lives. After showing them several examples from magazines and newspapers, my students were a little more convinced that they need to know math to survive in this world. Through this assignment, my students came to realize how important and prevalent math was in their lives.

My experiences with learning math in middle school shaped how I approached to teach it. When school started, I tried to be honest with my students by telling them about how I disliked math in middle school and it wasn't until I reached college, that I developed a real appreciation for this subject. I shared my vision with them and encouraged them to keep an open mind about math. I realized that seventh grade was a critical time in their mathematics education. I knew that if they developed negative attitudes about math now, it would affect their future outlook of it. So, I created an assignment that helped them reflect on their past math experiences. I asked them to write a "mathography." A mathography is a mathematics autobiography. I provided them with a pre-write guide to help them focus their writing. I asked them to include information about their favorite and least favorite math topics, their most memorable math learning experience, whether they liked math or not, how they learned math best, and how they used math in their daily lives. This assignment gave me a better understanding of my students and how I could better meet their needs.

One thing that I had the opportunity to share with my students and my colleagues was my experience with technology. Before I joined MCTP, I had little interest in technology. I approached it the same way I approached learning math. Through MCTP, I interned at NASA Goddard Space Flight Center and helped develop an interactive educational website for children. This experience gave me exposure in using different platforms and software packages. I became more confident in using technology, and as a result, felt at ease in experimenting with it. Soon, technology became an important part of my teaching preparation. When I started teaching, I used the computer for many things. I used an electronic grade book program which saved me so much time. It allowed me to keep my students updated on their grades. I created many activities on my computer, such as Integer Bingo boards and concentration games. I even made an interactive Jeopardy game using MS PowerPoint. My students responded to this technology that they were so familiar with and it motivated them to learn math even more. I am looking forward to next year when our school will receive three computer labs and equip each classroom with a computer and a television monitor.

Looking back, I experienced several emotions my first year of teaching. Excitement, as I met my young students. Anxious, as I learned to juggle the many responsibilities of a new teacher. Frustrated, when my students struggled to grasp the concepts that I taught them. And most of all, satisfied, when my students responded to lessons that I taught them. So far, my second year of teaching has proved to be even more enjoyable and rewarding than the first. I now have only two preps. I have mastered the skill of doing many things at one time. I learned how to interact with parents more efficiently. My day feels smoother because I know how to manage my classroom better. And, I'm learning to integrate my visions and experiences from MCTP more successfully in my classroom. I am looking forward to challenging my students to bridge the gap between their knowledge and their world so that they will be more successful in math.

3. "Mathematics and Science Teaching as a Voyage of Discovery"
by Jessica Ort

I accepted a third grade teaching position at a school that I felt would help and support me in carrying out the constructivist ideals that I had experienced in the MCTP teacher preparation program. The principal was excited as I shared my portfolio of experience with technology, classes, and internships. I was excited when she showed me a relatively new computer lab, computers in each classroom, and shared the emphasis on teamwork in the school. I spent most of the summer creating items for my classroom and trying to get some kind of grip on what I would be teaching. At the end of the summer, I spent a solid week (and really the whole year) preparing my classroom, trying to create an inspiring, motivating environment that would turn my students on to discovery. I decided that I would call my class the Discovery Team, which emulates my belief that learning is letting students discover concepts versus my simply transmitting information to them, I want students to discover as I guide them to that discovery. In addition, I want students to discover their goals, interest, and talents throughout the year and develop early on the sense of our class as a team of people learning together.

The year started off with an open house, the Friday prior to school starting. It was during the open house that I realized challenges beyond the huge challenges of meeting student needs and teaching aspects. I met the parents. Parents were very wary of having the new teacher, especially having a new teacher in a portable classroom. I was relieved to have graduated from a fabulous teaching preparation program (the MCTP), but still felt tremendous pressure to prove myself worthy of this huge responsibility. I arrived at school very early that first day. Excited about the unbelievable possibilities that awaited my students and I, sick to my stomach at the enormous responsibility, confident that I had been trained well, and overwhelmed at the awesome feeling at finally being able to say, "hello, I am your teacher." Little did I know as I walked out that portable door to pick up those 27 wonderful children that I was embarking on the most challenging and overwhelming 10 months of my life.

For most of the year, I felt like a sailor drowning in a boat with a large hole. I was constantly trying to shovel the water out to keep up and keep from drowning in phone calls, papers and projects to grade, administrative paperwork, motivating my students, creating a positive, motivating environment, meeting the needs of my diverse students, school functions, bulletin boards, newsletters, meetings, training classes, planning, creating lessons, and understanding and implementing the curriculum effectively to name a few. I worked long hours often arriving at 8:15 AM and staying till 7:30 PM, 8:00 PM or later. I took a load of work home and spent time through the weekend grading papers, creating and planning lessons, and writing newsletters trying desperately to keep the water out of the boat to continue my sail through my first year of teaching.

I learned early on that teamwork at my school meant meeting once a week to talk about logistics and once a quarter for a day to talk generally about what we needed to accomplish academically in the next quarter. This is not exactly what I had envisioned. I really thought that we would be planning and developing materials together on a weekly basis. In addition, I also discovered that the curriculum in general left much to be desired. While my principal loved my new ways of thinking, there were no materials to support my ideas. In fact, there really were not many materials to support any type of teaching, except in science. I found myself looking frantically everywhere for materials to support the objectives I was supposed to meet in my subject areas. I was not looking for cookbook lessons, but looking for a place to learn more about these specific subject areas and ideas to use a springboard for the way I wanted to teach. Fortunately, I did some student teaching in third grade of the same county and had those materials from my cooperating teacher to spring from and materials I had created, but curriculum guides were few and far between.

I began to feel in those first few weeks, which continued, like I was in this huge pitch-black maze with only a flashlight to guide me. I could not get a sense of the big picture. I could not see where I was trying to go. I knew I had to make it through this maze of subject objectives by the end of the year, but I could not see how to get there. I found myself as the light shown on each new objective trying to remember where I had been and find clues on how to make it to the next section or objective by successfully feeling my way through the section I was in. It was so frustrating to know that I needed to somehow get the big light on, but I did not know how to go about it. I just kept plugging away and trying to anticipate the next section while I moved little by little with my flashlight straining to see what was up ahead. Math was especially challenging for me. In my county we currently have to meet a certain number of objectives each quarter. The problem is that this greatly limited my ability to allow students to discover on their own due to the time pressure of meeting objectives. In addition, the objective assessments were mainly fact-based, not open-ended or life-based, and sometimes even multiple-choice. I did not feel that these assessments accurately measured student's understanding at all. I was very frustrated at having to keep up with a pace that required me to move quickly through the curriculum without much time for student discovery and reflection, and having to assess students with material where understanding is based on fact recall or circling the right answer. I kept thinking how could the county not want to know how students arrived at the answer, if they understand the computation or if they can apply the objective to a real-life situation?

Other challenges in math included very old teacher materials that did not make sense to me and were missing elements or so faded that they were hard to read. In addition, our textbooks for math did not even match the curriculum set-up. I ended up looking for my own materials, delving through teammates' materials, buying materials, and creating materials as I could. I tried to make a compromise to meet the county standards and my own.

For each objective I would find out what the student's already new [*sic*]and wanted to know by setting up a math journal. My goal was to introduce new objectives using manipulatives—and providing an opportunity for students to make as many discoveries on their own as possible considering time constraints. In addition, I had students share ways they used concepts in their own lives, create word problems, and make connections with other subjects and life often to enhance their understanding and motivation. We started each class with some type of open-ended problem that required students to use a variety of math concepts we had learned thus far. Depending on where we were in the curriculum, we would act out various math concepts, be working on a project related to a concept, use manipulatives, create and solve word problems, read a piece of literature that connects to a math concept, or share prompt responses where students explained their understanding of a math concept.

In the best of all worlds I would have had more time to develop the concepts with the children. This was very hard for me to deal with since one of my main goals for teaching math is that I would not teach the way I had learned math in elementary school. I learned through my teacher preparation program (the MCTP) how much I really did not understand about math. Sure I could multiply and divide with the best of them, but I really did not understand the underlying concepts. I did not want my students to go through life wondering how and why math concepts work and how they will ever use these concepts in life. I struggled through teaching math every day trying to meet the county standards in math and trying to teach the way in my heart of hearts was best.

Science was an entirely different story. In my county teachers receive science kits to support teaching. These are relatively new and closely reflect my beliefs about teaching and learning. While this was a fabulous tool for me, it was difficult for my teammates to see the importance of letting students discover the concepts for themselves. The most thrilling thing for me in teaching is to set up a situation where students can figure something out on their own. I live for that, "Wow!" "Aha!" "Teacher look what I found!" "Oh, I get it!" moment where students have grabbed a hold [*sic*]of learning and created a moment they won't soon forget. When students have made a connection to open the door for creating understanding. I found many of these precious moments teaching science. However, I noticed in discussing this with my colleagues that they were not excited about teaching science and did not see these connections and discoveries happening in their classrooms. Using some of the peer coaching strategies I learned through MCTP, I was able to have a big effect in the way science was taught through my third grade team. My teammates started seeing science differently, not as cookbook subject on the back shelf to get to when there was time. Over time teachers came to me to ask how to approach a lesson or experiment to get those discoveries and I have seen a marked difference in not only science teaching, but it has begun to transcend into other subjects as well!

Science gave me an incredible opportunity that I did not have in math. I was limited in math due not only to quarterly time constraints, but in having to be done in an hour no matter what great discovery or connection was being made since we regrouped for math. In addition, the whole focus of the science curriculum was to teach students the underlying fundamentals in science of careful observation, use of the scientific method for discovery, and recording discoveries and observations effectively while studying different science concepts. I felt so free and able to teach science the way I wanted to teach it, it was such a relief and treat for me. We started out planting our own Wisconsin Fast Plants, learning about the entire development of a plant by experiencing it. We graphed the growth of our plant, recorded changes and observations throughout our study. After the discovery of our flowers, we dissected flowers I had donated from Giant [supermarket] and talked about the parts of a flower. After finding out about what students thought and knew about bees we examined dried bees and discovered various parts. We created bee sticks to discover how flowers are pollinated and what happens to plants after they are pollinated. We did a play where actors were bees in a beehive. We read several fiction and non-fiction books and articles to enhance our understanding after a discovery. In addition to keeping a journal about our plants, we wrote articles to tell about how the Wisconsin Fast Plant Seed was created, and did a sequence picture chain of the life cycle with a detailed paragraph about the stages of our plants development. Iwas amazed at what the students remembered to the littlest detail about their plant's development and this was not because we drilled facts or I told them, it was because they had lived it!

Throughout the entire year in science we worked cooperatively and most everything was hands-on discovery backed up with reading and writing while incorporating math to record data as possible. When we studied sound, we even used an interactive CD-ROM called sound court where students did experiments to solve a case proposed on the CD-ROM. I felt very successful meeting my goals in teaching science.

I am now in my second year of teaching and I have patched up some of the hole in my boat. My voyage this year is not as hard since I discovered ways to avoid as much water coming in and ways to get water out more efficiently. I have a little experience as a sailor now and it has made my voyage easier. This year I have already made great improvements in my voyage, especially in math. I have obtained quarterly assessments that are performance-based to use in assessing students more effectively. I have shared my beliefs in educating students with my captains and have been given support to focus on teaching for understanding and not simply as teaching for covering a certain number of objectives. Through the aid of a parent volunteer, my class now has a web page where I can communicate to parents all the fabulous things we are doing in school and give students a way to share their work with the world (www.geocities.com/potomacschool).

I now know that no matter how long you have been sailing you'll still have voyages with storms and troubled waters no matter how good of a sailor you are or how hard you try. However, the longer you sail, the more you work on your technique, talk to other veteran sailors, learn to make adaptations to the equipment you have and reflect on what has worked and hasn't worked in the past-making improvements the more effective you are in dealing with those stormy times and making your voyage smooth sailing. I am looking forward to the amazing discoveries and adventures I will have through my teaching voyages.

4. "My Education as a Private School Mathematics and Science Teacher" by Stephanie Colby

Finally, after four years of my innovative teacher education program (the MCTP), it was time for me to enter "the real world." Strangely frightening and exciting at the same time, this was what I had been waiting for ever since my field experiences had begun. I was learning all these fascinating and innovative methods in my college courses, and was repeatedly frustrated when I didn't get to see them used in the classroom. "Think WIGMOC" (When I Get My Own Classroom) they would tell us when we'd struggle with these conflicts. And finally that day had come! It was my turn to be the one making the decisions, doing the planning, and finally be able to put to practice all the new methods I had learned. My mind was full of idealistic thoughts and excitement for all that lay ahead of me. Unfortunately, it didn't turn out as well as I had planned.

I had always pictured myself working in a public school system. It was all I had really known. I went all the way through school at public institutions, and had even completed all of my field experiences and student teaching in public school systems (Baltimore and Harford Counties). When it came time to make my decision about where I would begin my first year of teaching, I had more to consider than just my previous experience. Family considerations dominated my geographic work preferences. Though I really enjoyed my teaching experiences in Baltimore County and Harford County, and was offered positions in both counties (and Howard and Charles in addition) I knew I wanted to be near my family in Montgomery County. So that limited my choices to schools in Montgomery County.

While the county school system offered me an open contract, I was looking for more certainty about exactly where I would be teaching. So, with all these things in mind, I made the decision that seemed to fit all my requirements. It was close to home, I knew exactly where the school I would be teaching in was, and I would be teaching math and science to middle school age students. It was a private school, something I hadn't really figured in my future. However, it seemed to be the best fit for my life at the current time. All summer long I was filled with anticipation at the opportunities that lay ahead of me. Soon, through my instruction, I would have the opportunity to impact the lives of my future students, to have the chance to make math and science fun for them. Especially exciting was the idea that my position would give me the chance to serve as a positive role model for these young women. I convinced myself I had made the best choice and that this was a good place to start off. At least that's what I thought.

I knew from the very start that this job would be quite different from my field experiences in the public schools. I could definitely deal with the smaller (15-17 students), single-sex classes (only females) which greatly decreased the management efforts in the classroom. The unique schedule format was also something to which I could adapt. The school used a block schedule, where I would have each of the two classes for an hour and a half to two hours. In that period I would divide my teaching between math and science. Since I would have both classes in the morning, the afternoon was left for planning. On Tuesdays I would [be] done teaching by 11:30 a.m. What an ideal situation this sounds like: small classes, plenty of planning time, minimal discipline problems, who could ask for more?

Things were definitely very different at the private school. For example: no textbooks for the science classes, but a highly structured mathematics program with a new lesson each day, 30 homework problems each night, a quiz every day, and a test after every four or five lessons. Probably the most interesting difference was the fireplace I had in my classroom! (The part of the school where my room was located was part of an old ranch house.)

Unfortunately, there was one thing on which I just couldn't seem to get a handle. That one aspect was the source of great difficulty and frustration for me. This factor was probably the biggest difference I would face from my public school experiences. They told me at the very first interview that the school operated instruction on a thematic basis. This meant that each trimester, there was a different theme for each grade, and that was the only restriction or guideline that the teacher was given in regards to what they were responsible for teaching. While I must admit there were times before when I felt stifled by curriculum, in public school settings I had never imagined the reality [of] teaching completely curriculum free. The thought was frightening and liberating at the same time. It was because of my fear of having no curriculum that I hesitated on accepting the position, but I was repeatedly reassured by other staff members that it was hardly as bad as I was imagining. So after a couple weeks of stewing, I decided to override the doubtful voice in my mind and accepted the position teaching seventh and eighth grade math and science.

With no curriculum with which to familiarize myself, I spent most of my summer working with John, the other new seventh grade math/ science teacher, to build our own curriculum. Both being new to the school and apprehensive about starting the school year, we went in with the attitude, "Better to be over prepared than under prepared." We spent many weeks trying to figure out exactly how we were going to incorporate the theme "Conflict" through our classes. Ultimately, we decided to start with a unit on Ecology. We would study different environmental factors and focus on the conflict between humans and the environment. We had a basis to build on since I had created a two-week ecology unit for my seventh grade student teaching class, but we would definitely need to add more, in order to expand two weeks into two and a half months. We spent many busy summer hours discussing, researching, and deciding how we were going to familiarize the students with this information, what kinds of projects, assignments, activities, and lessons we were going to present to them. As I recognized the great deal of time it was taking us to construct this first unit, I began to get worried about the two remaining units. If it took us many summer weeks, when we didn't have daily classes to prepare for and assignments to grade, how would we ever be able to repeat the same planning performance for the following units?

Now remember, though I have just described my planning experience for the first trimester for the seventh grade, that was only half of my challenge. The summer days that I wasn't spending working with John, I was working with Brian, the other eighth grade math/ science teacher, to put together the first unit for the eighth grade. My planning sessions with Brian presented me with a different struggle. Brian was familiar with the way things ran at the school since he had been teaching there for four years. While this was definitely a positive aspect, it also had its drawbacks. With the experience Brian had over me, and because of the difference in our personalities, he was much more comfortable and laid back about things. He had taught drugs and the human body for the eighth grade "Choices" theme before and though he didn't have any written remains from this previous experience, he had the memory of what he had done before and could operate off of that. I on the other hand, had a very limited knowledge basis of this subject matter, and minimal experience teaching those subjects, and both of those factors combined made me very uncomfortable. I didn't have a curriculum that I could refer to help me identify the objectives, or the important points to get across, and the topic just seemed so massive I was unsure where to even begin.

Despite all my worries and anxieties the school year began, and my first year of teaching started. And with the start, I was thrown into a whirlwind of teaching that was nothing like I had ever expected it to be. I met my homeroom and two classes, and found my students to be wonderful, though certainly not without difficulties or complications. But I was lucky, because for the most part, I didn't have to deal with one of the biggest issues for beginning teachers: classroom management. With only about 16 students and a small classroom, my voice didn't have to carry far to reach all of the students, and the girls were so well-behaved that the only slight behavior problem that I encountered was too much talking. This was to be expected though considering my audience of teenage girls. I did however, have to pay the price in other areas.

Once the school year started and I didn't have all day to put together all four of my lessons for each day, things got much more difficult. I was trying desperately to keep up with Brian and John's classes, but somehow they seemed to be able to get through more than me all the time. Math was so hard for me to teach because it was too structured. The lessons were dry and direct and I found myself standing up at the overhead lecturing for each lesson. That was exactly the opposite of what I wanted to be doing. I couldn't find a way to change it though because it was so controlled and limiting and I had to get through the lessons to get to the tests. I would look out at the girls as I was delivering what I found to be very boring lessons, and could see that they felt the same way. Even though they were not at all inspired by these lessons, they continually copied down the notes I put up. I was glad that they could stay on task through these lessons, but felt awful because I wasn't able to teach the way I wanted to. I wanted to be able to use manipulatives, let students discover concepts, and provide them with discussions and projects. However, the program didn't often allow for these kinds of activities, and thus I struggled yet again.

My difficulties with science once the school year started were at the opposite end of the spectrum from mathematics. Where I felt restricted with math, I felt I had too much freedom with science. It was the ideal situation we had all dreamed of in our methods classes, not being restricted by a curriculum, having the freedom to plan as many hands-on lessons as we could handle, providing time for exploration and discovery, and basically having the opportunity to do things anyway in which you wanted. For a first year teacher however, this dream turned out to be a nightmare. I found I didn't have the resources or the knowledge base to go out and create these spectacular lessons on my own. It was too much to ask for me to start from the bottom and be able to build everything up from there. I had great ambition to go out there and make learning fun, but my ambitions were quickly squelched by a lack of guidance and an overwhelming amount of work. In our summer efforts, we planned many interesting science lessons, but the planning was much easier than the implementation. My room was about the farthest thing from a science classroom and both space and equipment were limited. If we wanted to do an experiment in the lab, Brian and I had to stagger the lessons because his room was the only science lab for the middle school. We had designed projects that required both seventh and eighth grade classes to use the computer lab (seventh graders were doing research, eighth graders were going to construct their own web pages), so again lessons had to be staggered in order to allow all the classes an opportunity to use the lab.

It was all so much more complicated than I had expected, and being the perfectionist that I am, I tried so hard to do everything I could to overcome these complications and make things the way I had planned them to be. I was almost always the first one there and the last one to leave, and yet somehow I still felt as if I wasn't doing enough. "If I am working so hard", I often thought to myself, "why can't things turn out the way I want them to? Why can't I teach the way MCTP inspired me to teach?" After many hours of reflection and self analysis I realized that I had to cut myself some slack. It wasn't my fault that things weren't turning out the way I had imagined they would. The situation I was in was much to [*sic*] difficult for someone who was still learning how to put everything together, trying to learn from experience through the first year of teaching. Instead, thrown ahead of the learning curve allowed for first year teachers, I was expected to build on years of experience I didn't have.

Please do not misinterpret me. Though the private school wasn't the ideal place for me, the school wasn't a horrible place. Though the other teachers couldn't give me the structural and content support that I was longing for, they were always there to provide me with the emotional support that was also in great need. Sadly, the situation only got worse, my hours at school continued to increase, as my appetite and hours of sleep decreased. I found myself in a conflicted state where I knew I wasn't in the right place, but I didn't know how to get out. It wasn't a simple situation and involved more factors than enumerated above. Until one day after school, I finally brought it up in one of my many discussions with the Dean of the Middle School and together we decided, that the best move for everyone would be to remove myself from the situation. So within the first month of my first year of teaching I left. We all parted on amiable [*sic*] terms, though I do still regret I never had the opportunity to say good-bye to my first set of students.

The first days after I left were the hardest. Now instead of struggling with the fact that I couldn't implement the MCTP ideals in my classes, I was dealing with the fact that I didn't think I could cut it as a teacher. I felt like I had failed and didn't know if I would ever be ready to go back again. Time has passed now, and I've spent the last month reflecting on what happened, dissecting the situation and trying to figure out where things went wrong. I replay my lessons in my head and now I can see that the lessons I delivered were quite successful, they just didn't meet up to my expectations. I look over the lessons that I worked so hard on planning this past summer, and see how organized and well thought out they are, and realize that they too were a success, but similarly somehow they did not match up to my expectations. Through all of this I have come to realize that I set myself up for failure with such high expectations and by putting myself into a position that was not made for first year teachers. I had such ambition and drive to go out and be the best teacher, to make learning fun, and to make a difference. But I got so caught up in having to plan my whole curriculum, something most first year teachers don't have to struggle with, that I didn't have much left when it came to the actual teaching. I accepted a job that I thought was the ideal place to start, and now I realize that it would have been more ideal had I had years of experience to bring with me.

We've always been taught that one of the best ways for our students to learn is through experience. Though this experience isn't one I'd ever like to repeat, I can honestly say, it's taught me a great deal about myself and has helped me to realize what I need to look for in a teaching position. I am using my time to explore different venues of education, again trying to learn from experience where I fit best. Soon, I know I will be back out there filled with the same ambition and drive. This go around, however, I will know what I need to get started, and I will go in with more reasonable expectations.

[Editor's Note: For more of Stephanie's story, see the article by Robert Blake in this volume]

5. "Bringing the MCTP into my Teaching World"
by Holly A. Nevy

I think back now, to when I first began my MCTP student teaching experience. How scary it was to be actually teaching a class full-time! I was in charge of their personal and educational growth for the next couple months! It seemed so frightening. As I got into it, I faced some challenges, smoothed over some bumps, and really started to find who I was and what I wanted to be as a teacher. Finally, by the last few weeks, I could hardly stand having to be under the watch of my cooperating teacher. I wanted to do it on my own, my own way.

Well, I got my wish. I started my first year of teaching at a middle school, in Maryland. This was a brand new school, bursting with technology. Not only was that an attractive feature, but the school also revolved around teamwork. We were set up into interdisciplinary teams and encouraged to work together with both these teachers and with the other math/science teachers. Most of the school's teachers came from an elementary school background, including the principal. These helped to incorporate the interdisciplinary, hands-on, active learning environment the principal encouraged. Cooperative group work was not just encouraged, but required.

As you can see, this school seemed to be based on the MCTP philosophy. How could I refuse such a school? It fit me perfectly. My only concern was that I knew this would be [a] challenging job since the children from this area are extremely needy. We have a lot of city children and mostly children from broken homes. Yet, this challenge only inspired me more, since I knew that many of the wealthier and better off communities had good teachers, using strategies to help kids bring learning outside the textbook. These students didn't have that.

Well, as I started my job, I thought I had everything set. My students were not going to be rushed through the curriculum. They were going to learn through hands-on, minds-on activities, discovery learning, technology-enhanced lessons, and real-life, science-connected examples, that math can be fun and understandable. No student would be left out; girl, boy, they would all accomplish the feat of pre-algebra.

Well, I had high goals set for myself and truly wanted to accomplish them. I had the tools, now I just had to apply them. Unfortunately, the road was not as smooth as I had planned. My philosophy is constantly being challenged and my method tested. Yet, I still continue on, struggling, but learning the way, and building my beliefs.

One area of teaching that has constantly challenged my beliefs is the curriculum. I believe strongly that we should teach for understanding. This is the way for students to learn since when a student understands certain material, he/she not only retains it better, but is able to extend and apply the information. This is what these students need to be able to survive and succeed in the real world. The only problem I have come across with teaching for understanding is that it is time consuming. A lesson is not going to be completed in one class period. Information must be explored, discovered, and internalized by the student. It cannot just be spat out by the teacher in hopes that one student will memorize.

Well, here is the problem. The curriculum, which must be strictly adhered to since my school district gives block tests after every marking period, does not allow this time needed. Often topics are given a day or two and then new topics must be started. I firmly believe this is why we are still teaching fractions in the eighth grade. The students do not have time to truly understand the material so it is memorized, tested, and then left for the next year.

I started out the year teaching for understanding, ignoring the rigorous schedule of the curriculum. Fortunately, I think the students really began to understand the math for the first time; unfortunately, we did not cover half of what we were supposed to and did not achieve good scores on the block assessments. Personally, I was proud of what my students had accomplished; yet, I knew technically, we were far behind of the curriculum, and would be looked badly upon by the administration.

This struggle for me continues as I head into the second marking period. I continually go back and forth on what is right for my students. I am always questioning myself: "What if I don't teach half of the curriculum the students need for next year? Or should I let them fall back into the memorizing trend?" I know in my heart I have to teach for understanding and deal with the grief later. My conclusion has been to stick by my guns and continue this way.

Another area of teaching which has been a struggle is the infusion of technology. I was so excited when I found out my school was going to have state of the art equipment. We are supposed to have four computers in each room for the students, one in every room for the teacher, a TV in every room that can be hooked up to the computers, and a huge lab that has more educational programs that [*sic*] you can count. Plus, as a math teacher, each class receives a set of both graphing calculators and scientific calculators. I was amazed at the technology and so excited that I would have the ability to infuse technology into my lessons. Since I have had a lot of experience and training using technology thanks to MCTP, I was ready and prepared.

Unfortunately, some things stood in my way. First of all, due to some technical problems, I only have one computer up and my TV and computer have not been hooked up. My room needs to be rewired in order to have things as they should be. Because of these little technical issues, I have not been able to completely use technology as I would have liked to.

Secondly, I have had problems with behavior and using the equipment. My students come from a lower income level and do not have this kind of technology at home. They do not understand how much it costs and how lucky we are to have it. One graphing calculator has been stolen and one has been deliberately broken. The one computer that is up for the children had its mouse and keyboard stolen. The math department head's solution to this was that until these things were returned and treated with more respect, I should not use them. This certainly brought up a problem since these items have not been returned yet and I doubt they will be. So I am to not use technology at all with my students? I feel like I am in a no-win situation.

I still use my calculators and computers when I can and try my best to closely monitor the students. I feel that depriving the kids is not the solution and that we must stress over and over that these are "the students' things." When one is stolen, then it is stolen from the students. I hope that as we continue to learn how to use these pieces of technology, the students will begin to have more respect for them and enjoy using them; thus, leading to less [*sic*] damaged and stolen pieces. I cannot, as a teacher, deprive the students of a needed area of education, no matter what.

Finally, one of the last areas of teaching where I thought I would have some difficulties is helping my students make connections between math [and] science. This actually to my surprise has been very easy and exciting for me. I believe strongly that students need to make these important connections in order for them to see the relevance and importance of mathematics in the real world. Plus, the students need to realize that all the material they learn in school is all inter-related and not really separate like schools tend to portray them. And, of course, connecting mathematics to science and vice versa really creates interest, motivation, and excitement for the students. One reason I thought this would be difficult to achieve was that it takes the team work of both the math and science teachers. I knew that I was all for it and willing to put in the extra work to connect what the children were learning in math and science, but would the science teacher? What if he/she was not willing to work together or even let me use his/her equipment and resources? Luckily, I did not have to ask these questions for too long because luckily for me, the science teacher on my team is extremely cooperative and wants to also make that connection. She has allowed me to not only plan with her, but also allows me to take my math kids into her lab and use her equipment and resources! The students love it and are very enthusiastic. The first time we did an experiment they asked why we were doing science in a math class. This led to a beautiful discussion of how the two are related. It was wonderful! An example of a lesson that I did that connected math and science was when we compared two substances' cooling rates using the addition of negative integers. We got to talk about science-related terms like density and cooling rate, practice the scientific method, and do an experiment, all while practicing our math skills. The students heated up two different liquids to 90 degrees Fahrenheit and then let them cool, recording the change in temperature every minute using negative numbers. After ten minutes, the students had to add up the negative numbers to find the total change in temperature of each liquid. Afterwards, they dove into the scientific part of it, trying to explain why one liquid cooled faster than the other. It was a great way to introduce how closely math and science are related.

Even though I am only halfway through my first year of teaching, I know it is a success for me. I have overcome many obstacles and have strengthened my beliefs. Truly, I feel this is due fully to the role of the MCTP in my teacher preparation. Without my specific background and training in both mathematics and science, I would not have the courage (and know how) to do the many different activities I do involving math and science. I am not afraid to take risks and try new and exciting things because I feel confident in my content knowledge.

Furthermore, this strong content preparation in both math and science has helped to make it easy for me to help the students make connections between the two. Unlike most other middle school teachers, I have a strong background in both and easily can see and create connections across the two fields. I do not have to hunt out other teachers to help me find connections.

In addition, I feel that the elementary education background has also been a benefit for me teaching in the middle schools. First and foremost, I have a more diverse background of training, having taken many reading courses that help support the interdisciplinary approach that many middle schools want and need to have. Also, the elementary education background has given me a more creative and exciting background than a secondary education would. Its focus on cooperative, hands-on, and fun learning have definitely helped me to teach in middle school. The students are not adults yet, and they still need this kind of stimulation to learn.

Speaking of hands-on and cooperative learning, MCTP's focus on the active learning has also greatly enhanced my teaching. My principal has commented many times on how she likes my use [of] active learning. Both her [*sic*]and the mathematics resource teacher are happily surprised at how I am so familiar and comfortable with using active teaching. It is not something that I have to really struggle with since it comes so naturally after being taught it during my college training. Because of this training, I am thoroughly convinced that active, hands-on, minds-on learning is how students truly learn and it is used in my classroom frequently.

I also attribute my frequent use of technology in my classroom to my education in the MCTP. Because technology was always integrated into our training, it has also been integrated into my classroom. I feel confident and comfortable using all types of technology and try to integrate into as many lessons as I can instead of having specific lessons on technology. Students can then realize how technology enhances mathematics and science and isn't simply another distinctive chunk.

In closing, my distinctive, enhanced education background provided by the MCTP has given me the ability, knowledge, and confidence to teach middle school mathematics. It has given me the tools to become a great facilitator of learning and the power to be one. Without it, I would definitely not be the strong, courageous teacher I am today.

6. "Differentiation of Instruction" by Autumn Moore

As a second year MCTP teacher, many things are revealed to you, such as: the relevancy of your methods courses, strategies that can actually be used in the classroom, and the fact that you can't change everything at once and remain effective. The county I work for has a major push for differentiation. Sometimes that small word strikes fear or irritation; basically it means being aware of the make-up of your classroom when planning to teach to the strengths of your students. (Which is not an easy task when you have thirty individuals.) During my first year, differentiation was something that you did with tests. Every test had three levels or less, and were [*sic*] given to students on their performance for the unit or given out based on "GT" classes that they were taking. Every time I gave out something that looked different, the students would point out that I was treating them different [*sic*] or that I was not being fair. This was not good, before they even started the test their attention was focused on something else. My frustration was growing as much as the students'. I could not figure out a fair way to do it and then I began wondering if I was doing "it" right. I also wondered if I was actually challenging some students by giving them an extra essay question. Were they really showing me that they could discuss advanced levels of a topic? Or, could they simply memorize and write more than the average students?

One day, as I was team planning, another teacher pointed out that my thinking was wrong. When used correctly, differentiation would give me the freedom of assessing my students on their strengths and developing my lessons to support different weaknesses. It would also help me help my students to focus on their personal needs and how to take responsibility and pride in their own work. It took a while for her message to digest. I was looking at differentiation as the new buzzword—something else to worry about. I should have looked at it as an organization tool; something that would help me put all of the curriculum, the techniques, and the team objectives in order.

It was just my luck that my team leader was the EII coordinator and had some examples to help me see immediate results of a multi-approached lesson. After looking at her examples, I realized that even though I didn't feel it, I was implementing some different strategies. Our first half day training was on differentiation where each section of teachers got together to develop one task. I was glad to know that I was not the only one having trouble. I was also not the only one who did not fully understand the different looks of a differentiated classroom. In school we are taught how to write a plan, strategies to manage a classroom, and how to be clear on objectives. During my time with MCTP, I learned about questioning techniques; student-based inquiry methods, and how to increase the learning of students through participation in activities. However, when you are thrown into the real world first as a student teacher that basically follows the lead teacher and then a first year teacher with responsibilities that are overwhelming, the techniques come second to survival. Therefore, when it came to this workshop and planning time, I was glad for some direction. Basically, the first thing we learned was that you had to pick an area of need within your classroom and start there. If you don't pick one thing to start you will not see results or benefits to changing your style. Second, I learned that a differentiation classroom did not mean 30 different lesson plans, nor did it mean that there were three levels: low, middle, and high.

Our group chose to focus on vocabulary. This was an area of team concern. Our upcoming unit was Thrill Ride, an EBS unit on Physics and roller coasters. Starting up was easy—figure out a basic plan. After deciding on a list of vocabulary terms, we had to also look at not only a plan, but also a way [to] train the kids to use it. This was the key that was missing. Differentiation also meant changing the atmosphere of the classroom and giving students the chance for more input by increasing their responsibility and shifting the focus off of strictly teacher direction. We decided to go with a plan that optimized student responsibility. The basic idea was to give students the list and date for the test. Then we talked about how to prepare and brought in the use of assignment books and reminder calendars. The students complained but filled out their books with more than the word physics. I decided to leave it up to them, as an experiment, what and how much they would write in their books. We then explained that the test would be a matching and short answer. The students were responsible for coming up with a way to study and explain the use of the vocabulary using strategies from reading. This brought laughter and that horrible question: "but Why, this is science class? I hate that question—which I think my students understand—so we talked about how scientists explain their data and share information with others. One student then called out how I go crazy with the metric system and using the correct measurement. He laughed and said that we all need to speak the same language. This made us all laugh and made me happy because at least one was catching on that communication was the key to spreading information and you needed other skills to help you be effective.

Everyday after the words were given, I started class by asking how the studying was going, did anyone have a strategy, and by giving examples and definition to two words. A couple of things happened. One, the students separated themselves into the organized, the 'I don't care's', and the ones who just didn't catch on yet. Second, not all students got the idea that it was their job to remember to study. I kept this in mind as the two weeks passed and as we reviewed so that when the test was over and they either got assignment A or B, we could discuss their preparation. The test was given and the results were different. There was a wide range of grades and student comments. This time they could not claim that some had it easier, because the test was all the same. The difference came with the follow up. Those students who passed their quiz were assigned a project where they chose some words from "coaster" vocabulary and designed a model, diagram, or wall word about the words and how they were related to roller coasters. Those that had trouble with the quiz, four or more wrong, were given an assignment where they filled in a chart for how they studied, why they had trouble, and ideas for next time—very short fill-in. After the chart, those students were able to create wall words of their vocabulary, or word webs similar to what they used in English. Through these two branches, the students were able to investigate their own study habits, and those that were ready to move on could investigate other terms associated with the topic and broaden their own personal vocabulary. I was also given a heads up as to who was still confused and needed some reinforcement. One of our team objectives was to improve the organization of our students. It was new for these sixth graders to be responsible for their own studying without direct instruction from me. Three sixth grade teachers, including myself, used this small-differentiated activity with success. Students were re-tested on a surprise quiz at the end of the unit and almost all of the scores were raised.

All teachers use some form of differentiation in the classroom. I have come to realize that it has a broad definition. I already change my seating for different activities, have different strategies for grouping, and allow students to have a choice in projects. These are all components of a good lesson. However, I was now ready to give up some of the direct control I felt was needed in my instruction. It is not easy to find a comfort level and train the kids. I quickly learned that you cannot give a five-minute explanation, tell the students to start, and then sit back and relax. To have a differentiated classroom takes planning and knowledge of objectives that need to be met. It also requires follow-up. I wish that all of my lessons could remain open ended with room for exploration and the ability to complete unique projects. However, county and state assessments are not like that, so I need to teach my kids to develop their strengths but make sure they have the basics. I feel that I accomplished a beginning to that theory by giving a standard quiz and then the opportunity for clarification. I have come to realize that my students do not always have to be 'doing' and that it is okay to take notes. I have also learned that by starting small on one focused area, I can learn about my own comfort levels and develop a training and management plan for my classroom. Maybe this is just a right [*sic*] of passage as I begin to dive into the different methods behind teaching that I can directly compare to my own personal experiences. I have begun to see teaching as a balancing act and change if need be; things will work out.

I think that MCTP has taught me to use the questions of students and their comments to explore topics. Meaning, that it is okay to meander off the path and use the students' interest to help them learn. The training and some of my personal observations from MCTP-related classes helps me to use alternative means of assessment. It is very easy to fall into the pen/paper multiple choice tests or text-created test because it is already there. However, then I recall how I had to use portfolios and actually complete labs during my MCTP classes while gaining a foundation in constructivism. Therefore, I really try to use conferences and questioning techniques during activities to assess students' knowledge. Also, my internship experience really plays a part in my teaching (especially now that I have experience). Observing science in [the] real world reminds me that science is not a single subject. It incorporates everything else including reading and math. This means that with all of the activities, there needs to also be instruction that includes verbal and non-verbal presentation skills, quality of work, and connections to the real world! I plan to work on grouping and advanced clusters in my classes. Also, I would like to implement more guest speakers into the daily flow so students can see the importance of discovery [and] positive role models.

7. "My First Year of Teaching as a Graduate of the MCTP" by Jessica Phelan

When I first heard about the opportunity by the MCTP to write this account of my first year teaching, I knew that I had more to say than would ever fit onto three pages. I went into my first year with all sorts of ideas about how I wanted my classroom to look, and how I wanted to teach. I learned a great deal in college, and felt that I was well-prepared to jump right in. I was excited, and eager for the first day of school to come.

I learned right away that things do not always go as you intend them too [*sic*]. Let me first talk a little about my teaching assignment. I was hired to work at a beautiful, newly renovated middle school in a very affluent Maryland neighborhood. After my interview I was given a tour of the school, and could not imagine working in a more wonderful building. Of course when the principal asked me into her office after the tour, and offered me a job at the school, I jumped at the opportunity. This was in spite of the fact that I would have three preps (Earth Science, Math 8+, and Math 6).

When I went into my first day of work (a week before the students arrived), I was informed that I had a new assignment. My new schedule required me to teach Earth Science, Math 8+, and Life Science, each in a different classroom. Life Science is not a subject that I felt at all comfortable teaching, but I was assured by the science team leader that she would provide me with all the lessons and copies that I would need. I was also apprehensive about sharing a classroom with three other teachers. I would be in each classroom no more than two periods a day, so it really felt more like I was "borrowing" the rooms than sharing them. My visions of the ideal classroom setting would have to be put off, at least for a year.

The first day of school is really a blur to me now. Mostly I can remember having to weave through the hallways to get to my next classes (which of course were on opposite sides of the building, and on different floors).

The most difficult thing for me was remembering where I was supposed to be at what time. I went with a positive attitude, knowing that things could only get easier. I couldn't have been more wrong.

My first two months of teaching really killed me. I wanted so badly to incorporate all of the strategies that I had learned through MCTP. I really wanted all of my lessons to be hands-on and meaningful. I tried to incorporate math into science lessons, and science into math lessons, so much that my students would often say, "This isn't science class, this is math class," or vice versa. I also wanted to incorporate technology into my lessons, but dragging six computers into a classroom where you will only teach one period just didn't seem like an efficient use of time. Taking a class to the library to use the computers was virtually impossible, because teachers sign up for the lab six months in advance and then stay there for two or more weeks at a time. I would get to school at 7 am and often stay until 7 pm planning lessons, gathering materials, writing e-mails to parents, and grading. All the while, seeing other teachers leaving the building as soon as the afternoon bell rang.

It didn't take long before all of this began to seem very unfair. Here I was, the newest teacher at the school, with the hardest schedule, and no one wanted to help me. I will be honest in saying that Life Science was not my priority. I usually made my plans for Life Science after I had already planned for everything else and by that time worksheets and book reading seamed [*sic*] like a pretty good idea. I did feel bad for the kids in the class, because I knew that I wasn't a very good Life Science teacher. I know that I will have many of them again this coming year in Earth Science, and I will make it up to them.

I found early on that the only way I would ever survive the year was to be very organized, to have a set schedule, and to work quickly. I made Friday my planning day. I would not leave work on Friday until I had planned the coming week for all three classes. I would get all of my copies and overheads together. Everything had a folder. Friday was also the day that I collected warm-ups and journals. I would stay late to grade them, make comments, and enter them into the computer grading system. Only rarely would I take any work home with me. I felt that after an exhausting week, I deserved a break.

I can say that I was fortunate to teach Earth Science with two great teachers. The three of us had to plan lessons together because we shared classrooms. Luckily we had very similar ideas about teaching. We developed a lot of lab experiences, and performance assessments. The students probably hated us because we made them write so much. We stressed the scientific method, and required the students to do formal lab write-ups of many of the labs that they did in class. Weekly journal assignments were mandatory in my class. Sometimes I would assign the students a topic to write about, and other times I would let them write about an Earth Science topic of there [*sic*] choice. I found that journals were really a great way to differentiate learning. Some students would write a paragraph about the weather that week, and others would do research on the Internet and turn in three pages, in great detail, about what they had learned. This really helped me to understand the individual students and their abilities, and I learned a lot from reading the journals. I never graded the journals; I only gave credit for completeness, and wrote comments to the students.

Each quarter the students had a major project in Earth Science. The first quarter they worked in pairs to build solar ovens. For the second quarter, each student completed an individual project on a self-selected gem or mineral. Students chose a mineral after a field trip to the Smithsonian's gem and mineral exhibit. They had the choice of creating a poster or brochure, writing a report, or developing a PowerPoint presentation. The third quarter project was to "invent" a fossil from a particular time period in the Earth's history, and write an article explaining the time period and the fossil for a scientific magazine. A parent verbally attacked me at a conference, in front of the principal, for assigning this project. The parent thought that it was a ridiculous waste of time, and suggested that I make the students memorize the time periods and their dates. The fourth quarter project was to design a weather board game that incorporated weather vocabulary. The students brought their games to class and played them together. The final exam in the class was a scavenger hunt. The students were given a list of 50 items either to collect or create, each item related to something we had studied during the year. On the day of the final exam they presented their collections museum style. I am happy to say that everyone passed the final exam with a C or better!

When it came to teaching Math 8+, I was entirely on my own. The other Math 8+ teachers had been teaching for many years, and were very set in their ways. They did not assign projects, or group work, and they relied heavily on the textbook and worksheets. While inventing lessons for math was a lot of work, I really enjoyed the independence. Math was the one class that I really felt was mine.

In my county, students have to take ISM's. These are short quizzes that must be passed after each new concept is taught. They are never ending. At the beginning of the year I received reports on each of my students showing their progress on the ISM's. Not surprisingly, about 90% of my students were below grade level. In many cases, because their seventh grade teachers never gave the required ISM's. As an eighth grade teacher, it was my responsibility to get them on grade level before they went off to high school. The ISM's became a major focus in my classroom. The ISM objectives became my classroom objectives, and the ISM's became my quizzes.

The ISM's were a daunting task, but I tried not to let them dictate everything that I did in math class. One learning strategy that I thought worked really well was the use of round-the-clock learning buddies. The students got a worksheet with a picture of a clock, and they had to make appointments with a different person for each hour. They kept this sheet in their notebook for the entire year. I would say, "Meet with your 4 o'clock buddy," and the students would move and work with that person. This gave them some choice in selecting partners, but it also assured that they learned to work with lots of different people, and the shy kids always had someone to work with.

I assigned projects each quarter in math class, and I tried to do a lot of hands-on work that incorporated science. Sometimes we would do experiments to generate and analyze data for relationships between variables. We went outside to measure shadows and related this to the height of tall objects during a unit on similar triangles and indirect measure. Students created tessellation artwork, and studied M.C. Escher in our geometry unit. During the probability unit, we played a lot of games, and students worked in groups on a probability scavenger hunt for which they had to find items from school, home, and the community that related to probability. Sometimes I did resort to worksheets, but in all I was very happy with what we accomplished in Math 8+.

Life Science is not a subject that I want to spend much time writing about. Worksheets were common, as were textbooks. We did complete quite a few prepared lab packets, and the students created hyper studio presentations on endangered species. The trip to the National Zoo was probably the high point of the year in Life Science.

I can honestly say that my first year teaching has changed me in ways that I never thought it would. I came into teaching with so many ideas, but no idea of how things really work. I have learned to be organized, and I have learned to work quickly. Most importantly though, I have learned that one person alone can't do everything. I am not the perfect teacher, no one is. Teaching is an ongoing learning experience. Each year I will learn new things and grow as a teacher. I will continue to set goals for myself, but I will not make myself crazy trying to attain them.

Next year I will be teaching both Earth Science and Math 8+, no more Life Science (at least that's what they say now). I will already have lots of great lessons from last year, and I will add more (and use fewer worksheets). I still will not have my own classroom, but I know that one day I will, and it will be wonderful.

8. "Becoming a Good Teacher by Being Open to Learning"

by Kate Walder

So much can be said about being a first year MCTP teacher. I experienced more emotions on my first day of teaching than I have ever experienced before in my life. I was filled with excitement, apprehension, concern, eagerness, and an overwhelming sense of wonder that I was now in charge of the education of middle school minds.

Three months before this very emotional day, I had been torn between several job opportunities at many wonderful schools. However, when I had the opportunity to interview for a seventh grade math position at the middle school where I was a former student, I jumped at the chance. I interviewed and was offered a position in a middle school in Maryland. I had fallen love with the school and with its approach to learning. Each grade consisted of two teams of teachers. Each team had a science, social studies, language arts, and math teacher, who worked together to provide a consistent learning experience for the 150 students on their team. The individuals with whom I would be working were fabulous and above all supportive. When I accepted the position, I was already imagining how my classroom would be arranged and how I would begin my first year of teaching. I was eager to begin looking through and planning some lessons for the beginning of the year, since I would have three preps. I was hired to teach Math 7, Pre-Algebra, and Algebra I, however, my school district had chosen to rewrite the curriculum guides for two of the classes I would be teaching. Needless to say, I was unable to begin planning until the first week of school. While this provided for a relaxing summer, my first week as a teacher was very hectic.

Two weeks before students returned, my school district held a one-week workshop to prepare new teachers for the upcoming school year. Through this inservice workshop, I was able to make connections with many local educators, meet the school superintendent, and familiarize myself with the philosophy of my school district.

During this time, I visited my middle school several times in order to get a head start on setting up my classroom. I could have waited until the week before students returned, but I was so excited to arrange the desks, decorate the walls, and organize my materials for the beginning of the year, that I could not wait. This also gave me the chance to meet many of my dedicated colleagues, as they were setting up their classrooms ahead of time as well. Therefore, on my first day of work without students, I had met many of the individuals with whom I would be working. This made the first faculty meeting where I had to stand up and introduce myself, much easier since the people who I was speaking to were familiar faces.

The faculty was wonderful! They offered me any assistance that I needed and the principal even asked what she could do to make my first year a little easier. As I continued to prepare for my first day with students, I felt an overwhelming sense of support and commitment from the entire staff, especially the math department. As a department, we were faced with two new curriculum guides that we had to use in order to teach our seventh and eighth graders. Instead of each teacher tackling this overwhelming task on her own, the consensus was to sit down as a department and plan together. I cannot tell you how much of [*sic*] help it was to me to have this collaboration process. It has been my experience through the MCTP program that more and better ideas are produced as a result of this collaboration than could ever be developed on your own. The ability to share ideas as a new teacher and learn from mentor teachers is the most effective planning strategy I have ever seen. When you think about it, it just makes sense. As a teacher with three preps, I would have had to write and make copies for 15 different lessons per week. Instead, when we sat down to plan together, we divided up the lessons between 5 teachers. Each teacher was responsible for planning and making copies for the whole group of teachers teaching that particular class. With this collaboration the math department was able to develop consistency and fluency in the math program as well as excellent hands-on lessons that appealed to the students.

The lessons that we planned connected mathematics to the other classes the students were taking as well as to the real-world. This allowed students to see that they use math on a daily basis. A sense of importance in learning and appreciating mathematics was established from day one. In addition, the use of technology was incorporated in many of the lessons. While I did not have a great deal of knowledge (although I was introduced to a broad range of technology in my MCTP teacher preparation program) of the graphing calculator and Computer Based Labs (CBL's), several teachers in the department were very well-versed at the use of these devices. Therefore, they were of great assistance to me in teaching students how to use the graphing calculator and CBL. Students enjoy these activities and learning experiences, and without the collaboration with my colleagues, my students may not have experienced these wonderful opportunities. However, because we were planning together I learned how to better incorporate technology in my classroom. Now I feel like an expert when it comes to using the graphing calculator and CBL. From this and many other experiences, I have learned that each one of us has different strengths as teachers. By planning together, we were able to pull on those strengths as a team in order to formulate the best possible experience for all of our math students.

In attending inservice workshops for new teachers throughout the year, I had conversations with many individuals who said they were overwhelmed with the amount of planning they had to do. When I shared with them the method we use at Hereford, they were able to see how collaboration assists and makes stronger the education that is provided. Always remember that collaboration is the key!

With planning under control, I than [*sic*] began to focus on how I would begin the school year with students. On the first day with students, I did a fun icebreaker activity called "Snowball" where the students wrote a question that they would like to ask me on a piece of paper. They then crumpled the paper and were given their one and only chance to throw paper at a teacher. I then picked up each "snowball" and read the question and the students' name who asked the question. After giving an answer, I was allowed to ask them the same question in response. This allowed me to get to know my students, and the students were able to learn something new about their classmates and myself. After completing the icebreaker, I wanted them to know the rules of the classroom in addition to the requirements for class work, homework, and tests. My goal was to set up an environment that was positive, rewarding, and enthusiastic for both the students and myself. During this first week back in school, the students became familiar with their new routines and acquainted with the ideals of the classroom. They were very accepting and excited about the upcoming year.

As a result, the first month seemed to fly by. In this time, I was establishing a sense of routine for myself and for the students. I collected almost everything that the students completed because I wanted them to know precisely what I expected of them. By collecting all of their assignments (including nightly homework) I was able to see where their abilities lay and the areas in which they needed some assistance. While this created a lot of work for me in the beginning of the year, the students were able to see that I expected them to put every effort into completing assignments. It also allowed me the opportunity to make comments that were beneficial to the students. As the school year progressed, I slowly reduced the number of assignments that I collected. For instance, instead of collecting every homework assignment for all of my classes, I now collect one randomly selected homework per week. The students don't know which homework I am collecting, so they are sure to complete all assignments. Due to the fact that I collected everything at the beginning of the year, students know that whether they are turning the assignment in for a grade or not, they still need to give 100%.

As the days of teaching continued to fly by into the second month, I continued to prepare for lessons, collect and grade assignments, and settle into my routine. I knew I would have to be observed four times during the year as a new, untenured teacher. Therefore, my first observation was scheduled for Friday, October 13th. I took a great deal of time to prepare for this formal observation. While the principal, assistant principals, and department chairman had visited my classroom on numerous occasions to observe for a few minutes, this formal observation was to last for an entire class period. While I was very prepared, organized, and excited about the observation, I was also feeling quite apprehensive. I had been observed in student teaching by math supervisors, principals, and my supervisor of student teaching, but that was all part of my education experience in college. Now, I was being observed as a professional who was responsible for the education of others. The day of the observation, I was unbelievably nervous. Luckily, my observation was scheduled for first period, which allowed me to complete this stressful event without having to worry about it all day. I felt a need to prove myself to the department chair, principal, and assistant principal who were observing me. After all, they were the ones who had selected me for this job, out of many candidates, as being the best to fill the position. The observation was very successful and all those involved were pleased with my teaching and the students' learning. After this observation and their comments in the post-observation conference, I felt more secure with my teaching abilities and presence in the classroom. This knowledge will make my other upcoming observations that much easier.

After surviving the first day of school, two months of strenuous teaching, back-to-school night, and my first observation, I now had the daunting task of interims and report cards to look forward to! My school had provided me with an excellent grading program for the computer. I was able to enter all of the grades into the program and have my grades calculated for me. While I am a math teacher and I love doing math, the task of calculating grades for 150 students by hand was not very appealing. The program was easy to use and allowed me to keep track of student progress throughout the quarter. Because of this, I was aware of students who had low grades and I was able to assist them in improving their grades through lunch and after school help. While many middle school students are given the stereotype of being uncommitted to schoolwork, I have found the opposite to be true. As a teacher, if you take the time to show that you care about what they are doing and how they are doing academically and personally, they will put every effort into achieving success. While this effort and success may come in varying extremes, if tapped, greater success is almost a given. As a result of the students' dedication to their math work, all of them earned a C or higher on their report card! The grades made not only the students feel successful, but myself as well. I was seeing an enthusiasm for math in my classroom that I had not seen before. Those students who entered the room at the beginning of the year without any interest in math what-so-ever, were now coming to my room at lunch to practice problems on the board or use the graphing calculators. This is more the success story of my year than the grades ever will be. For if the students enjoy math and see its usefulness than [*sic*] they will be successful and continue to pursue math in the future, even when not required to.

My first year of teaching has been unbelievably rewarding. While I have run the gamut of emotions, more often than not those emotions have been extremely positive. However, there are those days when you leave the school building feeling as if you have accomplished nothing at all. Those are the days when you have to focus on the hundreds of other times when you have had such a wonderful day that you want to share the success with everyone around you. These successes may not be major, but they are significant. For instance, the student who has not brought his homework all year who rushes up in the morning before homeroom with a big smile on his face to say "Miss Walder, I have my homework today!" or the student who simply says "Goodbye Miss Walder, I'll see you tomorrow" which shows that even though you may have had a rough day, they expect you to be there tomorrow and the next day and the day after that.

Next year, I plan to continue teaching seventh grade mathematics at Hereford Middle School with many new ideas and an appreciation for the dedication that must be shown as a teacher. With teaching you learn something new everyday. I have learned a great deal in my first year of teaching, which I hope to put into use in the future. Some say that anyone can be a teacher. Maybe that is true, but to be a good teacher, you must take what you learn and use it to improve your teaching. If you can do this than [*sic*] you not only improve your teaching but the learning of the students who sit in your classroom day in and day out, expecting the best. Every year I will make the commitment to become a better teacher by setting goals for myself and than [*sic*] striving to achieve them. While the second year may be easier because I am familiar with the school, have a lot of resources, and great lessons, it will be a new year with new learning experiences and challenges to face.

APPENDIX VI:

MCTP MENTOR TEACHER CASES

1. "Mentoring in an 'Up and Down' Component of Teacher Education, Student Teaching"

by Cynthia Sadula

No matter how much you read or how much you study and find out about the "ups and downs" of student teaching, the roller coaster ride of emotions still happens - like finishing an ice cream cone; you know its coming, but you are still surprised when it happens.

I have been teaching science and math at the secondary level for over twenty years. During this time I have had the opportunity to mentor five teaching interns from four different institutions. All of these individuals have struggled through the same highs of confidence and lows of professional doubt.

"Chris", like "Pat," is truly a name in our society that has no set gender, and so it is the perfect name for my MCTP teaching intern. The details of this experience are as true for men as for women.

My current teaching assignment is at a Washington, D.C., suburban middle school. As department chairperson and academic team leader I teach four life science classes. Three of the classes are designated "average" or "regular" and one class is composed of twenty-nine TAG or G/T students (i.e., identified as "gifted"), and five students identified as educable mentally retarded.

Chris came to my school following a very successful academic career, in possession of a superior understanding of scientific concepts. Having already completed the elementary school experience, Chris started her middle school experience at the end of October.

On the first day of the internship I introduced her to the students. For two days she observed what I did in the classroom. Every free moment, between classes or during planning periods or at lunch, we would review the characteristics of the individual classes and why I used specific techniques of presentation and classroom control. Behavior management was a major concern to Chris, realizing that students who are not paying attention are not able to learn.

Chris and I had worked together to develop exactly what we would present to the class. Our expectations were clear and the mode of presentation was fairly well established. In other words, we both know [*sic*] what was going to happen. I taught first period class and, as the students were leaving I turned to Chris. "You're on!" I said. "This next class is yours."

Without hesitation Chris jumped right in. Students listened attentively as she explained the general characteristics of an environment. She talked confidently about the differences between biotic (living) things and abiotic (non-living) things right up to the dismissal bell. From then on, until she completed her internship in December, the second period class (the gifted students) were hers. We discussed enrichment activities and modifications which were appropriate for "her class."

By the end of the second week she was teaching two classes, second and seventh periods, while I did the planning for the classes. Chris now had the experience of guiding the classes, differentiating presentation to maximize the students' understanding and trying an assortment of behavior management techniques so [*sic*] "ensure" maximum learning. We were already one quarter of the way through the intern experience, and it was time for Chris to start to develop lessons.

During lunch and a planning period we talked through the unit to be presented at the end of her internship, the lesson she would develop and present to all of the students. Chris added this to her homework and began to develop lessons to present. As I said to her, my task, at this point, was to provide guidance and assistance. There is nothing that a teaching intern can do in the classroom that is permanent. As the master teacher, I should be able to correct any errors and clear up any problems that might occur.

By the end of the fourth week, half way through the internship, Chris was teaching all of the classes and developing the lessons to present in two weeks. As frequently happens, students gobbled up the material we gave them and moved more quickly than we expected. Chris' lessons would be presented at the end of the sixth week, just two days earlier than we had planned. This provided just a little additional pressure for Chris, but she seemed to welcome it.

The big day of beginning her unit came, and Chris began to present the information on Wednesday, at the end of each class period Chris introduced the next unit. Thursday the students successfully completed the first part of the activities, with analysis to begin on Friday. During Thursday students had collected data relating the permeability of pebbles, sand and a sand/pebble combination. The activities had seemed very successful and students were able to demonstrate fairly accurate data, but collecting data and analyzing data are two very different skills.

Friday turned out to be a day of reviewing data. Students filled in some of the information that they had not accurately collected. In reviewing the lesson with Chris we realized that the pace was too quick. Students needed some time to review their data and also needed some guidance in understanding what they had done and what they had found out.

The weekend seemed to be a low point. I was very busy and did not call Chris at home. (Even though I had only called one weekend, I think now that I should have called that weekend.) Chris returned to school on Monday clearly frustrated. At first I thought that something had happened with the "significant other" or with the family in Pennsylvania or, perhaps I had inadvertently done something to offend. But I knew that she had not gone home, and there was no boyfriend that I was aware of and we had a relationship that allowed for open communication. By the end of second period I had decided to ask her, straight out, what was wrong. Considering her expertise and clear ability in the classroom I was truly surprised at her response, "I think I'm not meant to be a teacher," she said.

The surprise that I felt must have shown on my face and Chris misinterpreted it. "Oh," she said, before I had a chance to say anything. "You must have known this all the time. I guess I just needed to find it out."

I thought that all along during the experience I had supported her and given her positive feedback. At this point in her experience she thought that my comments had been designed to placate her. Had I been too effusive in my positive comments? Was there a lack of balance in what I said? Was there some signal from her that I failed to be aware of?

The open communication that we had (and still have) helped me to understand the depth of the questioning that even the very best teaching intern goes through during their internship. As I work with more and more teaching interns I am repeatedly reminded of this low point in the internship. I now watch for it and try to stem it off before it gets to [the] point that Chris suffered.

2. "Teaching for Understanding in Math and Science"
by Janet Leonard-Walker

As a "product" of several NSF-funded projects for teachers (Project IMPACT (Increasing Mathematical Power of All Students and Teachers) and the MCTP) I have made it my aim to use what I learned from those professional development experiences in as many curriculum areas as possible, especially in mathematics. Because I have seen such wonderful results of the teaching style/philosophy presented in these reform-aligned programs (no matter what the student's ability level) in student learning, it has become a firm foundation for my thinking and planning of lessons.
Basically, this is the goal of the NSF projects I have had experienced: To encourage students to construct and talk/write about their own solutions to problems, so that in the end they are not merely memorizing algorithms and facts (and perhaps forgetting them due to lack of understanding). On the contrary, the students are given time to slowly process ideas in order that the technique they use to arrive at an answer makes sense to them. Several strategies in which the teacher achieves this goal include providing the following: "wait time;" a relaxed classroom atmosphere for children to explore, take risks, and share their reasoning; and meaningful student activities. One strategy, in particular, has proven to be quite successful in fostering children's understanding of concepts.

That strategy is teacher questioning. Some examples of the kinds of questions used are as follows:

- Explain how you solved this problem
- How did you begin to think about it?
- Who has the same answer, but solved it in a different way?
- What if . . . ?

These types of higher-level questions are designed to draw out the child's thinking (metacognition) without a hint of approval or disapproval in the teacher's voice, face, or posture. Instead, it is an honest desire on the part of the teacher to learn *how* the child solved a problem, whether the answer is correct or incorrect (If the answer is incorrect, the teacher asks questions for the purpose of helping the child reflect and think through what he/she did in order to learn from his/her mistake and make necessary adjustments for the future).

Here are just a few of the fantastic results of teacher questioning:

- Many interesting, on-the- topic classroom discussions
- New, child-derived strategies (shared orally and written, which other children may understand and choose to use)

- Student self-correction (Because of the questions asked, the child is challenged to think more, "revise" his/her answer if necessary, explain why the answer was changed or not changed, and, thus, "save face," if the solution was incorrect
- Since the teacher didn't just say that the answer was" wrong" and go on with the lesson, the student was able to learn from his/her strategy, thereby increasing his/ her confidence. "Unexpected" children display of creativity!

Consequently, when a "mentee" (teacher intern/candidate) enters my fourth grade classroom, this is one of the main teaching styles that is emphasized.

I first worked with Stacy (a teacher candidate in the MCTP) when she came to my classroom biweekly in the fall semester as a teacher intern. During this time she became acquainted with the students, how the class was run, and how lessons were presented. In addition, she "got her feet wet" as a prospective teacher. We hit it off right away, and communication between the two of us flowed freely. It was, therefore, a delight to have had her return as a teacher candidate for eight weeks the following spring. After observing various lessons that I modeled on a regular basis, it seemed to me that Stacy began to value my aforementioned teaching/learning philosophy. Soon she incorporated the same strategies I used (that promoted student thinking and increased academic learning time) in her lessons, such as "KWL, Think-Pair-Share, Every Pupil Response, differentiated activities, and cooperative learning groups."

For instance, while giving mathematics instruction Stacy continued to provide the same level of comfort (that had been previously established) for the students to share their thinking. By utilizing many of the types of questions I had given her (I listed 25 for her), students were actively reasoning and explaining their solutions to real-life problems. For example, Maxxia, a very quiet child, wrote in her math log an extensive description of how she had arrived at an answer. Likewise, students felt secure enough not only to share their own strategies, but also any misunderstanding they had. Shatorya, who had a history of an especially difficult time catching on, felt secure enough to ask for clarification on more than one occasion. Other children expressed a willingness to assist her. Warren, for instance, volunteered to help her (with success). Shatorya not only accepted his help, but Warren's self-esteem and confidence were increased (which he needed).

Moreover, Stacy carried over these techniques when she taught science. For example, she assigned students [*sic*] that required them to think ("wait time"), write, and share their predictions about the hardness of the rocks that were presented. After tests were made and observations written, time was then given for several students to read aloud their results, thereby increasing student understanding as well as clearing up any confusion. Another way Stacy enhanced learning was to ask the class reasons for doing an activity. This helped the children connect what they were to going do to real life, and they were able to see the importance of the lesson.

Since Stacy had been observing and listening to me reflect on lessons I taught, heard me discuss the pedagogical experiments I took, the successes I experienced, and the future improvements I identified, she felt the freedom to do the same with me. I believe that since I was open with her and enlisted her help and suggestions, she was able to reciprocate. Hence, she began to understand the reasons for instructional decisions; was able to analyze past, present, and future teaching/learning situations; and could plan accordingly.

In conclusion, it was very rewarding to have witnessed and participated in the development of a new teacher. However, I wish that there had been time to have worked further with Stacy (or any teacher candidate, for that matter) for several reasons. I would have loved to have heard/learned her other creative ideas and to have seen them implemented in the classroom. It would have been more satisfying if I could have assisted her in employing additional teaching strategies in order to better equip her for her own class. Furthermore, it would have been beneficial to have helped her in solving the dilemma that all reform-oriented teachers experience. That dilemma is this: allowing the opportunity for students to construct meaningful thinking/learning and at the same time "cover" the required amount of objectives for each grading period. It would have been advantageous for Stacy to have had the experience to share in more adaptations that were successfully made, so she could apply them and know the reasoning behind them for future lessons.

3. "A Comparison of Interns" by Mary Beth Johnson

I teach in a public elementary school in a county characterized by having a diverse population. Our school has two full-time ESOL teachers and is a Title One school.

For two years, I have had interns from science methods classes that came two days a week. I then actively advocated for having these students for a second semester for their student teaching.

The first MCTP intern "Anna" was someone who had worked with me in a science lab at my old school. Students in grades 1-5, attended science enrichment classes once a week in the science lab. Anna and I were responsible for developing and delivering our own curriculum based on the National Science Education Standards. This atmosphere allowed us to work as a team in planning and implementing science and math curriculum. This science instruction was to extend the lessons taught by the classroom teachers. It also allowed the intern to use some of the strategies and skills gained from the MCTP internship program.

When I moved to my new school which was designated a "global access" school by the county, Anna and I had more opportunity to integrate technology into our instruction. We had weekly access to a computer lab with thirty computers as well as a classroom networked computer. Training opportunities for computer-aided instruction were also provided. The planning process involved looking at current requirements in math, science, reading and social studies plus updating materials or revising good lessons to incorporate new goals and strategies.

From the beginning, Anna was eager to be part of the new school year. She came to school before the college semester started and helped decide how the room would be set up and what activities we would do. She worked along side of me to have the room and first week activities prepared. When the students came, she was considered part of the teaching team. Parents met her on Back-to-School Night and accepted her as a valuable asset to the classroom and their children. When we had conferences, she sat in on the discussions and note-taking with me.

As the semester progressed, one of the first areas Anna took over was the mathematics. As we planned, she incorporated the "new" enriched math curriculum that the county was implementing. Both she and I attended the training and worked together planning the logistics of delivering the new materials to our students.

Later, Anna added science to her teaching duties. We were working on a rock unit and had many resources to use from the science kit. We also used materials from trade books and experiences in the science lab. Anna was able to engage the students and have them eager to do the required work as well as exciting extensions such as their own rock and mineral research. Eventually, their final products—a brochure "selling" their mineral or rock—were proudly displayed in the hallway.

Anna taught all subjects by the fourth week. This included three reading groups, spelling, and social studies content about Maryland. She was always prepared and added touches such as Math Jeopardy that the students loved. She was willing to follow my classroom rules so as to provide continuity for students. Anna helped from the first to the last day make decisions and I felt that we worked as a team.

My next MCTP intern "Bette" also came as [a] block methods student, but I had just changed grade levels, from fourth grade to third. After moving rooms, materials and books were shifted but it was sometimes difficult to locate the exact materials needed. The county did not offer any content training for teachers switching grade level. I had an exhausting summer of teaching and taking challenging courses -- which I enjoyed but were not restful. Bette did not join our classroom until late September.

This class had some children with difficult problems. Things seemed to be going fairly smoothly but in October, everything broke loose. One student was disruptive and had to be physically removed from the room by the principal; several others were "stimulated" by all the unusual behaviors and "acted out." Parents were concerned and sent in notes. To quote Bette, it seemed like a "special education" class. The administration was very supportive, and I tried to be fair and consistent. Eventually, the disruptions became less and less. The entire staff - administration, health aide, counselor, and other classroom teachers and students help defuse situations when needed.

Bette almost immediately took the responsibility of one of the reading groups. Together we planned the work and she took responsibility for grading work as well as running the reading group on Tuesdays and Thursdays. In the other subject areas, she would teach a lesson that we had both decided on. She would plan it thoroughly, and she was able to deliver it very well. I was able to maintain the peace and quiet while she was teaching and she assisted individual students while I taught small groups.

Unfortunately, this routine was broken when Bette had to go to another placement prior to doing her elementary student teaching. When she returned from this placement, she seemed "bothered" by the elementary classroom. Almost immediately she wanted to change the seating assignments to reduce the chatter and off-task behavior. She had been very engaged and even developed extra activities in social studies during the first semester; however, the "spark" that was there in the first semester was absent. I asked if there was a problem. The answer was that in contrast to the other placement teacher, I seemed "laid back." We still continued to be getting along because she said that she was just adjusting to elementary school again. She really wanted a middle school placement in science and math because there was much less preparation. Things seemed all right for awhile and I again asked if there was a problem. Apparently there were some family problems but I too was going through some health problems with my family members.

Just as Bette was ready to teach all subjects, about week four, it seemed my ideas were not adequate for what she wanted to do. I sought out additional resources from my collection and even resources from other teachers, but she wanted to do [*sic*] use what she had obtained from another teacher. I applauded her initiative, but I realized that what my students needed prior to testing was review. I put my foot down and presented her with limited options from which to choose. She did, and did a good job of teaching that curriculum.

I don't know what made the difference in the interns' experiences. Perhaps it was seeing me at my strength—science in the lab rather than struggling to learn a new curriculum. Perhaps the milder make-up of the first class versus students with emotional problems made a difference. The disruption in the flow of teaching styles and locations could have made a difference. Individual expectations and attitudes towards the diverse requirements of elementary teaching could have also clouded the experience. I felt I gave both interns as much time and energy as I had. I was invited and went to both graduations and feel that I still have a good relationship with each. Again the children were the beneficiaries of two teachers working together in their behalf.

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