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Technology Integration Enhancing Science: Things Take Time

A process is outlined in which a professional development program allows K-8 teachers to make the transition from a traditional classroom to one where technology is imbedded and becomes an integral part of teaching and learning.

Project TIES (Technology Integration Enhancing Science), a four-year Technology Literacy K-8 project, combines technology as a tool for teaching and learning with earth and environmental science education. The project provides K-8 teachers in two school systems in the Central Piedmont area of North Carolina with professional development as well as equipment and materials. The resources enabled teachers to make the transition from a traditional classroom to one where technology is an imbedded and integral part of teaching and learning. During this process, TIES teachers participated in professional development involving science content, the inquiry process, student-centered projects, and the use of technology as a tool for teaching and learning. TIES teachers have taken on leadership roles including presentations at state science teachers and educational technology conferences and provision of professional development within their school systems. The project is being sustained because the expertise and leadership resides within the schools.

Project TIES began as a serendipitous juxtaposition of three seemingly unrelated events. First was the publication of the National Science Education Standards (National Research Council, 1996). Next was the announcement of a request for proposals by the North Carolina Department of Public Instruction for the Technology Literacy Challenge Fund. This was followed by the hiring of a building-level technology specialist and science specialist in one school and a technology director in another school system. These individuals approached a university collaborator and asked her to become the project director. Subsequently, an external evaluator was recruited from another university. Thus began a four-year saga of change and innovation.

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Things Take Time

> "It is clear that, for science and mathematics professional development to be effective, experiences for teachers must occur over time, provide ample time for in-depth investigations and reflection, and incorporate opportunities for continuous learning. [T]he idea of building new understandings through active engagement in a variety of experiences over time, and doing so with others in supportive learning environments, is critical for effective professional development" (Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003, p. 81-82).

Although the project was nearing completion as this caveat was published, Project TIES was designed with the precept of providing ten days of professional development over the course of the school year; TIES allowed teachers the time to assimilate new pedagogies and implement them in their classrooms. Change is not easy; for pedagogical change to occur, teachers must be afforded the opportunity to learn new teaching methodologies, incorporate those methodologies into their classroom practices, modify any practices that do not work for them, and retest the modifications.

For this particular technology-based project, it is accurate to add the admonition that "Things Take Materials." The intention was to provide sufficient resources for teachers to make the transition from traditional practice to a classroom where science and technology are imbedded and become integral parts of teaching and learning. The availability of the equipment and software in sufficient quantity for easy student access, as well as the know-how for using it, permitted students and teachers to use technology on a regular and frequent basis to allow for integrated, project-based instruction. The combination of new knowledge and behaviors as a result of professional development, combined with the needed equipment, helped to provide profound and lasting change.

Project Description

The overarching goal of the TIES Project was to produce a successful, creative, and replicable model for inquiry- and project-based instruction that uses technology to integrate science and other curricula. To attain this, teachers developed long-term inquiry-based science projects appropriate for their K-8 students. Underlying these projects, as well as other classroom instruction, was the seamless blending of technology with science content and project-based instruction. The ensuing professional development not only incorporated project-designed activities, but also a wide array of nationally recognized curriculum materials and activities including The GLOBE Program, Project WET, Streamwatch, GEMS, and AIMS. These programmatic components were phased into the implementation over the project's first three years, with full implementation achieved in Year 4.

Another goal was the sustainability of this project. This priority was attained by way of five strategies. First, TIES implemented a process of collaborative team efforts utilizing the leadership of experienced TIES teachers. Year-1 and Year-2 teachers became mentors for teachers who entered the project in Years 3 and 4. This allowed experienced teachers time to gain confidence with the pedagogical changes in their classrooms before they were responsible for working with new teachers. Second, experienced teachers assumed leadership roles as they participated in providing professional development sessions in Years 3 and 4. Third, the equipment, including, computers, software, probeware, and a digital camera, was housed in teachers' classrooms. In this way, technology was available immediately for use as an integral part of the teachers' repertoire of teaching tools. Fourth, teams of TIES teachers disseminated knowledge gained and lessons learned from the project as they presented TIES at science and technology conferences and at parent and faculty meetings. Finally, participating schools have now included TIES in their school-based budgets, thereby ensuring continuation of the project.

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Collaborations

The TIES Project was built on the strong collaborations of four schools in two school districts, the Center for Mathematics and Science Education in the University of North Carolina at Chapel Hill (CMSE), the North Carolina Department of the Environment and Natural Resources (DENR), LEARN NC (a statewide technology network), the North Carolina Department of Parks and Recreation, the Eisenhower Consortium at SERVE, and the GLOBE Program. The CMSE staff provided both professional development and project coordination; the other five partners provided professional development for the teachers during one or more years of the project.

TIES Project schools represent a diverse K-8 student population. The schools are located in both suburban and rural communities; two of the schools qualify for Title 1 funding; and minority enrollment varies from 30% to 60%. The CMSE brought strong leadership capabilities in grant administration and professional development, as well as technical guidance in developing and implementing educational models. The DENR brought expertise in assessing and understanding the environmental resources of TIES school sites. Its curriculum projects, including Project WET and Streamwatch, are national programs with outstanding materials that fit well with the K-8 North Carolina Standard Course of Study. LEARN NC, a statewide network of educators using Internet technologies, provided teaching resources, lesson plans keyed to the North Carolina Standard Course of Study, and an online outlet that allowed TIES teachers to share their expertise with other educators. An integral part of the project included The GLOBE Program, a hands-on environmental science education program currently in use in nearly 11,000 U.S. schools and more than 100 countries.

Objectives.

Project TIES had several objectives: providing technology within the context of project goals, acquiring adequate technology for partner schools to insure access; providing opportunities for TIES participants to learn to utilize their school grounds to enhance their instruction in the context of the science curriculum and technology; providing opportunites for TIES leaders to share their expertise with new TIES teachers, as well as other teachers in their school; and forming a colloboration of partner schools to enhance and support each other.

Implementation

Technology can be a powerful entity in classroom instruction when adequate resources are seamlessly incorporated into instructional approaches and strategies. One way to accomplish this is to provide teachers and students with a vehicle for instruction that brings applications to the world beyond the classroom. To implement these real-world projects successfully, teachers must develop skills in integrated instructional strategies, have exposure and experience with specific projects, and be proficient in the appropriate use of technology as a tool for instruction and learning. Administrative support and participation is crucial. Significant commitments of personnel, financial resources, and time are required for a single school to make improvements in these arenas. The need for collaboration is important so teachers, struggling for time to make improvements in their individual classrooms, do not waste time "reinventing the wheel."

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In the October 1,1998, issue of *Education Week*, Jeff Archer reported on research conducted by Harold Wenglinsky, an associate research scientist at Educational Testing Service. According to Wenglinsky, the positive benefits of technology's effectiveness depends on how it is used. "One of the positive benefits of technology's effectiveness depend on how teachers and students relate to each other." Archer concurs, saying, "... a growing number of education technology advocates argue that the 'constructivist' approach toward learning—in which students work in rich environments of information and experience, often in groups, and build their own understandings about them—taps into the computer's greatest strengths." Archer further quotes William Fiske, educational technology specialist at Rhode Island's Department of Education, "Kids learn by doing, by presenting, by displaying, by engaging. Learning happens best when the youngsters are doing the heavy lifting" (pp. 6-10). These remarks speak directly to the impact a project like TIES can have on students.

To build and apply skills for using available infrastructure effectively, each year TIES classroom teachers, project support staff, and administrators participated in ten days of professional development, including two days at the North Carolina Science Teachers Association annual conference and/or the North Carolina Educational Technology Conference. Professional development introduced authoring tools, word processing, databases, spreadsheets, and the effective use of the Internet (including Internet mechanics, Web Quest inquiry projects, various science URLs, and web site evaluation). It also provided hands-on experiences for the understanding of science content—especially in the area of earth science, which successfully blended with the TIES "outdoors as a classroom" focus.

TIES teams implemented projects based on content and integrated instructional strategies developed during professional development sessions in their own classrooms. This implementation strengthened team building, leadership skills, and mentoring opportunities for TIES teachers and administrators. In TIES, the power of technology merges with a constructivist pedagogy in student-centered, project-based classrooms. To support curriculum and standards requirements, TIES project development used instructional approaches as described below. These pedagogies are advocated in the many current publications stemming from recent brain research such as *How People Learn: Mind, Experience, and School* (Bransford, Brown, and Cocking, eds., 1999), *Teaching with the Brain in Mind* (Jensen, 1998), and *A Celebration of Neurons: An Educator's Guide to the Human Brain* (Sylwester, 1995).

- *Constructivist, Student-Centered Learnings*: Students learn best when they construct their own knowledge based on multiple experiences with a concept or skill. Through active, hands-on experiences, they correct their misconceptions, extend what they know, and connect their knowledge to other concepts they understand. Student motivation is enhanced when students pursue answers to questions they have developed.
- *Collaborative Learning*: Most students like to work with their peers and learn more from doing so. Working collaboratively is a required workplace skill for the Information Age. Many everyday activities are collaborative, with students working in small groups to solve a problem.
- *Authentic Learning*: Students learn best when their learning is not artificial—when activities are authentic and connected to the world outside the classroom.
- *Student as Worker, Teacher as Facilitator*: A teacher serves as a facilitator to student learning by arranging the environment so that students will ask important questions and discover ways to answer them.
- *Sustainability*. There are two types of sustainability connected to this project: 1) intra-school sustainability within the school(s), where a project began after external funding was expended; and 2) inter-school sustainability attached to projects that are models able to be transferred to and used by other schools and districts. Project TIES has the ability to promote both types.

Intra-school sustainability requires having key elements of materials, equipment, personnel, and leadership in place in a school(s) so a project can continue after funding expires—to have a "life of its own," so to speak. Continued financial support to update equipment and replenish consumable materials is usually necessary as well. To spread within a school, it may also be necessary to have a project that is adaptable by virtue of scalability and replicability. The project, as it exists in particular classrooms, may need to be modified to be successful in other classrooms. These latter two qualities are discussed below under inter-school sustainability.

Local school district budgets have been modified to accommodate updates and repairs of project hardware and software.

Great efforts were made with Project TIES to ensure it has the support needed to continue in current schools long after the conclusion of the grant period. Hardware, including computers, probeware, and digital cameras, and software are in place, and professional development has been provided to enable teachers to utilize this equipment and materials in an effective manner. Local school district budgets have been modified to accommodate updates and repairs of project hardware and software. In addition, extensive professional development has been provided so participants understand how to implement inquiry- and project-based instruction that uses technology as a tool for instruction. Returning teachers have also emerged as leaders to provide on-going professional development to others in their schools and districts.

In addition to project participants, others in the districts and community have been involved in Project TIES. Area teachers, building and central office administrators, and parents know about and support the project. Presentations about the project have been made to County Commissioners; parent-teacher organizations have been helpful in fundraising for various components of the project; building-level administrators have been involved in the planning and implementation of the project; and other teachers have been included in professional development presentations. These actions have created school-level involvement, as well as community support, which have helped sustain the project.

Since the grant period terminated, partnerships that enhanced the grant have been put in place and continue to influence the schools. Because of the project's successes, others within the schools and beyond have shown a sustained interest in the project. Current project schools have committed financial resources to support the project, and plans are in place for continued funding of additional teachers and classrooms at each school. Experienced TIES teachers are poised to provide continued leadership at their schools. They have shown their leadership by being mentors to new TIES teachers, presenting at conferences, and by developing and presenting technology seminars. We believe TIES teachers will continue to display this leadership.

Inter-school sustainability is attained through adoption by other schools and districts. Sustainable projects must have the qualities of replicability, the ability to be used and modified by others, and scalability, the ability to work within schools of varying size and budget. Project TIES exemplifies both of these qualities. Project TIES is definitely replicable—it can be reproduced in a wide variety of settings. Because of the dedication of TIES participants, as well as the design of the project, TIES is well known within North Carolina. Details of the project are available from individual schools. Web sites describing and explaining TIES have been developed by various teachers and their classes. Information about TIES has been disseminated at state science teachers and educational computing conference sessions.

Project TIES is scalable because it models good teaching and learning using technology as a tool for instruction. It can be implemented in any school setting in schools of varying size, and it can be used at any grade level. While hardware is important, the change process inherent to moving from one type of teaching to another is even more critical. More than just hardware is necessary for change; the change process moved teachers to a different way of using hardware.

Obstacles

While none of the difficulties was monumental, procuring and setting up equipment, allocating teacher and classroom time, and finding a sufficient number of substitutes were obstacles in this project. Existing practices created an additional difficulty.

To many teachers, the idea of student-centered inquiry- and project-based instruction was novel. This new instructional approach differed considerably from their more traditional, textbook-based approach, and the learning curve was sometimes steep. This, along with lack of experience with technology, created consternation for some. When frustrations developed, there was a tendency to revert to traditional modes of instruction rather than implementing inquire- and project-based instruction. While some participants were able to begin their projects quite readily, others needed more guidance and support.

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Each year, one of the most significant and challenging barriers reported by the project team was a difficulty inherent to any change effort—aversion to change or fear of the unknown. The change from a traditional to a technology-based pedagogical approach is very dramatic and met with resistance in some classrooms. Overcoming that resistance through a slow and on-going change process and reaching the levels of enthusiasm now in place in TIES classrooms are certainly two of the most important accomplishments of the project.

Successes

At the beginning of each year, teachers set goals and objectives, planned their projects, and proceeded to develop and implement them with the assistance of project staff. Each year, all TIES teachers met the objective of creating this hands-on technology-based project within their classrooms. In addition, as the project progressed, TIES teachers became instructional leaders who took on responsibility for professional development and mentoring. They also participated in project dissemination as they presented sessions at the state science teachers and educational computing conferences. Other successes that emerged from the evaluation of the project included positive attitudinal changes toward the objectives of the project; development of technology nights for parents; and statewide administrator intern site visits to TIES classrooms, with an eye toward using TIES as a model of technology integration.

Schools in the project have strong technology and science resource support systems in place, including TIES mentors from previous years. In spite of time issues, participants who were in the project during the first two years were very helpful to the new project participants. They helped in the technical aspects of how to use equipment and in the pedagogical aspects of using technology as a tool for effective instruction. Returning teachers were very willing to share classroom management techniques with teachers struggling to adapt their classrooms to a new mode of instruction. Participants have been particularly pleased with their presentations at state technology and science conferences. They report that these presentations have been challenging to prepare but also gave them increased levels of confidence in their abilities as teachers.

Results

The overarching goal of the TIES Project was to produce a successful, creative, and replicable model for inquiry- and project-based instruction that uses technology to integrate science and other curricula. Quantitatively, we saw an increase in competency rankings in technology knowledge and skills, as measured by the *TIES Technology Expertise/Comfort Survey* and on the *Levels of Use of Technology in the Classroom* scale (adapted from the CBAM research, 1987). Other evaluation strategies included site visits, workshop observations, interviews with project personnel, interviews with participants, and comment cards reflecting attitudinal changes from participants. Outcomes anecdotally reported by teachers include shifts in their beliefs and actions from instructionism to constructivism.

TIES Technology Expertise/ Comfort Survey was developed to reflect the technologies incorporated into the project and to help participating teachers gauge their own perceptions of their progress in learning to use the technologies effectively. The survey was a self-report instrument, with rankings from 0 to 10 (0 = no expertise, 5 = some expertise, and 10 = a great deal of expertise). Participants showed a gradual increase in their expertise/ comfort levels with technology over the course of the project, with the exception of their first year. During the first year, most participants reported a dip in their Expertise/Comfort scores as they came to understand the breadth of the capabilities of the hardware and developed more realistic perceptions of their actual expertise levels.

The *Levels of Use of Technology in the Classroom* self-report scale (adapted from the CBAM research, 1987) was administered to all participants in the third and fourth years of the project. A clear distinction can be made between the levels of use of participants new to the project and those who had been with TIES for one or two years prior to the administration of the instrument. While new participants reported a wide range of levels of use, beginning at Level 0 (Nonuse) and continuing upward through Level IV (Refinement), no returning participant reported a level of use below Level III (Mechanical Use). Also of interest is the rapid movement of Year 3 participants up the Levels of Use scale, as compared to a more gradual movement for teachers who began the project in the first two years. Based on participant comments to a series of open-ended questions and on their interview responses, this is presumed to be a result of mentoring provided by Year 1 and 2 teachers, as well as indirect exposure to the project before actually becoming a part of it. Year 4 participants showed limited growth; however, they were only in the project for one year, which is too short a period to allow for valid, reasonable conclusions to be drawn.

The project team noted some unanticipated beneficial outcomes. The comment cards used for formative evaluation indicated that the internal mentoring, support, and coaching network was much stronger than proposers initially anticipated. Additionally, teachers reported that students wrote about their TIES projects with much less prodding than in traditional writing assignments. The project team was also surprised, not that teacher attitudinal changes occurred, but by the extent of those changes, as evidenced in the comment cards. The magnitude of observed and anecdotally reported changes from a didactic to a student-centered teaching environment was much greater than proposers anticipated at the outset.

Implications

"Fundamental beliefs are formed over time through active engagement with ideas, understandings, and real-life experiences. Deep change occurs only when beliefs are restructured through new understandings and experimentation with new behaviors" (Loucks-Horsley, S., et al., 2003, p. 49). For change to occur, things take time. This study exemplifies these beliefs. Teachers who participated in the project for three or four years showed greater changes than those with only one or two years experience. Only participants who were in the project for more than two years reached Level V (Integration) or VI (Renewal) on the *Levels of Use of Technology* scale; and not all veteran participants ever rose above Level IV (Refine-ment). The change literature, as well as our own experiences with this project, have led us to conclude that significant behavior changes require at least three to four years of implementation and on-going support to become institutionalized within the classroom.

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