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ABSTRACT

Valdosta State University (VSU), fulfills the academic needs of the South Georgia area. Student performance on the state mandated science assessment was well below achievement levels compared to other subject areas. VSU must reach out to science teachers in the area to improve teaching skills if their students are to become productive, contributing members of local communities. It was with these needs in mind that the inquiry learning and technology utilization project for middle grades and high school teachers was developed. The educational significance of this study was to advance the existing body of knowledge and improve science classroom instruction by assisting middle and high school teachers to become knowledgeable and proficient with inquiry-based teaching consistent with both state and national educational reform efforts, and to obtain necessary experience and skills to incorporate instructional technologies into the inquiry-based teaching format. Due to the one-year length of the project, teachers were supported through concerns identified with three distinct stages of change implementation: preparation, acceptance, and commitment, allowing discipline-wide adoption and considerable change in practice to be achieved. Participants of the research project included 50 public school teachers from four countries in South Georgia, certified to teach either middle grades or high school science. A Florida group included 20 teachers certified to teach grades 4-12. Student pre- and posttest data indicated adequate to high levels of science achievement. More importantly, teachers noted, via reflective writings, an increase in student enthusiasm. Teacher response was overwhelmingly positive. Worthwhile educational change requires new knowledge, attitudes and behaviors. The inquiry-technology integration project seemed to effectively supply these key requirements to science educators in South Georgia. (Contains 18 references.) (AEF)

Integrating Technology and Inquiry Pedagogy: Needs-Based Professional Development

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Introduction

In recent years, academic deficiencies of U. S. science students have been of primary concern to both the U. S. Department of Education (Henry, 1997) and the National Research Council (NRC) (1996). More specifically, Georgia students scored in the lowest 25% of students tested in 40 states and 51% scored at the "below basic" level of understanding science. In light of such reports, strategies to improve science teaching and learning have become a focus of professional development efforts around the country.

Due to the dynamic nature of teaching and learning science in our modern, technological world, it would be reasonable to assume that teachers, not just their students, should be dedicated learners. The job of teaching must be redefined to include continuous teacher learning (Berlin, 1996). According to the National Science Education Standards (NSES) (1996), learning has a two-fold purpose in science education: (1) to keep current in science and (2) to deepen the understanding of effective science teaching strategies. Such educational strategies should be aligned with the NSES to include science as inquiry, utilization of technology, and collaboration among educators. Additionally, successful professional development activities provide explicit connections to teacher needs as well as a sense of ownership in the learning process.

The NSES clearly outlined objectives for teaching and learning science. Paramount to all science education was science as inquiry. Inquiry, the watchword of constructivist reform, dictates that any knowledge and understanding must be (1) actively acquired; (2) socially constructed; and (3) created and then recreated for individualized meaning (Perkins, November 1999). NSES guidelines vary greatly from the passive mode of learning that pervades education today, and logically teachers would require substantive support and education to master the inquiry techniques advocated.

As students become more fluent with technology, it is imperative that educators, as well, increase their technological comfort level and rise to meet the needs of their students. According to Jane Healy, as cited in Tell, (October, 2000), technology is a great gift to education and affords teachers and students opportunities to initiate important learning. Such learning, while easily aligned with constructivist ideals, must be planned and guided by teachers. Fundamental, then, to any professional development effort is providing school staff with ongoing training to increase teacher fluency as well as link technology with authentic work (Dooling, October, 2000).

Finally, as mandated by the NSES, collaboration should be at the heart of teaching and learning. As mentioned previously, constructivist learning is a highly social process. Knowledge and understanding for students and teachers are constructed in dialogue with others (Perkins, 1999).

A regional university of the University System of Georgia, Valdosta State University (VSU), fulfills the academic needs of the South Georgia area. The area serviced by VSU contains a high proportion of minorities and students from economically disadvantaged families. Student performance on the state mandated science assessment, the Georgia High School Graduation Test, was well below achievement levels compared other subject areas (Georgia Department of Education, 1999). VSU must reach out to science teachers in the area to improve teaching skills if their students are to become productive, contributing members of local communities. It was with these needs in mind, that the inquiry learning and technology utilization project for middle grades and high school teachers was developed.

The educational significance of this study was to advance the existing body of knowledge and improve science classroom instruction by assisting middle and high school teachers to (1) become knowledgeable and proficient with inquiry-based teaching consistent with both state and national education reform efforts (GIMS, 1996; NRC, 1996), and (2) obtain necessary experience and skills to incorporate instructional technologies into the inquiry-based teaching format. Due to the one-year length of the project, teachers were supported through concerns identified with the three distinct stages of change implementation: preparation, acceptance, and commitment (Rogers, 1996; Salisbury, 1996) allowing discipline-wide adoption and considerable change in practice to be achieved.

Review of Related Literature

Worthwhile educational changes require new knowledge, attitudes, and behavior (Fullan, 1991). A striking departure from the classroom norm, constructivist theory and science as inquiry demands the active participation of the learner, not passive receptivity. The authoritative role previously played by teachers has been transformed into one of facilitator (Mancino, 1995). Additionally, while there are growing pressures for teachers to embrace technology in the classroom, where there exists no specific mandate to do so, there will be continued reluctance on the part of teachers to change from what is familiar and comfortable (Robinson, 2000).

Professional Development

Dorit (1999) hypothesized that professional development programs should put teachers in the role of learners in an attempt to facilitate epistemological change and influence their use of technology and constructivist teaching practices. Within the realm of a multimedia constructivist program, science teachers worked cooperatively, with minimum supervision, and conducted investigations regarding the utilization of a multimedia package in their classroom. The study suggested that collaboration, time for reflection, and active teacher participation as learner all contributed to the success of inquiry-based learning and a change in teacher thinking.

Effective professional development for science education should draw from a synthesis of standards posited by the NRC (1996) (Loucks-Horsley, Stiles, and Hewson, 1996). Included in these standards is the development of a learning community. Stein (1998) provided a view of professional development at its best: a systemic investment in building teacher capacity through collaboration. In this case, professional development was seen as everyone's job and everyone viewed themselves responsible not only for their learning but also for the learning of colleagues. Such a collaborative effort led to teacher change, a newly implemented constructivist approach to teaching and learning, and improved student performance district-wide.

Teachers, like students, learned science as inquiry best by doing science as inquiry by investigating for themselves, and building their own understanding (Supovitz, Mayer, and Kahle, 2000). A standards-driven inquiry-based professional development effort in Ohio produced strong, positive, and significant growth in teachers' attitudes toward inquiry-based instruction, as well as their use of inquiry in the classroom. Not only did change occur, it was sustained for up to three years following involvement.

In a five-year, longitudinal study, Berlin (1996) evaluated the effects of action research on teacher attitude toward inquiry, as well as improved teaching and learning. Berlin's model mimicked the stages of the learning cycle: Awareness, Research and Development, and Application. Not only were science educators introduced to the philosophy of science as inquiry, professional development strategies were inquiry-based. To repeat, teachers learned inquiry by doing inquiry. Quantitative and qualitative data suggested that inquiry-focused action research enhanced teacher attitudes towards both educational research and inquiry-based instruction. Additionally, action research facilitated the implementation of educational innovations in the classroom and improved teaching and learning.

The results of past learning cycle institutes, sponsored by the National Science Foundation, have documented long term changes in teaching strategies of the participants (Marek, Haack, and McWhirter, 1994). Most significantly, 93% of participating science teachers continued to use learning cycles in their science programs nearly a decade after the institute. Teachers stated that the learning cycle procedures:

- Involved students actively in the learning process
- Produced deeper understanding and greater retention of concepts
- Developed students' thinking and communication skills
- Included teaching process as well as content
- Made science relevant and meaningful to students.

As mentioned previously, teachers learned inquiry by doing inquiry. If, indeed, the learning cycle so greatly impacts student learning, one would expect similar results on teacher learning as well.

Methods and Procedures

Participants

The participants of the research project included 50 public school teachers from four counties in South Georgia, certified to teach either middle grades or high school science. A Florida group included 20 teachers certified to teach grades 4 – 12.

Procedure

Exploration phase. Science teachers met for five days during the summer from 9 a.m. to 3 p.m. During the first ninety minutes they attended seminars lead by science education professors to examine (a) the structure of science; (2) the nature of human learning; and (3) authentic assessment strategies for student evaluation in learning cycle curricula. Teacher-participants spent the rest of each day in laboratory session lead by project staff. These sessions included (1) technology activities designed to familiarize teachers with the use of various educational technologies and (2) science laboratories modeling the learning cycle procedure led by in-service middle and high school teachers experienced in inquiry teaching.

Application phase. Once school started in August, teacher-participants met with project staff every alternate Saturday for eight weeks from 8 a.m. until 3 p.m. Teachers received copies of learning cycle curriculum, and with the assistance of project staff, modified two weeks of current science curriculum into inquiry-based lessons. Successes and difficulties of implementation were discussed on a regular basis.

Follow-up phase. For the remainder of the school year a member of the project staff conducted four observations of each participating teacher utilizing the learning cycle in the classroom. Following each observation, a meeting between teacher and staff member was conducted to discuss implementation of inquiry-based teaching procedures, incorporation of technology, assessment, or other factors associated with teaching change. In addition to individual meetings, two meetings with all teachers and project staff were conducted to brainstorm solutions to problems and to share successes.

Instrumentation

An Advisory Panel, consisting of a scientist, educational technologist, certified Teacher Support Specialist, two middle school and two high school teachers, and two science education professors, developed a preliminary survey administered previous to participation in the summer workshop and designed to measure teacher attitudes and pedagogy. A follow-up survey was designed to measure attitudinal change immediately following the Saturday workshops. Teacher observations were conducted using a checklist developed in conjunction with survey data and teachers submitted reflective responses during follow up sessions. Student achievement was ascertained via pre and post subject-matter tests administered by participating teachers.

Results

Students

Student pre and post-test data indicated adequate to high levels of science achievement. More importantly, teachers noted, via reflective writings, an increase in student enthusiasm. Students appeared genuinely eager to be engaged in science and actively participated in providing suggestions for classroom investigations. One teacher noted how the inquiry format facilitated learning for all students. Non-reading middle grade students could readily participate in hands-on science activities while she monitored their learning through performance based assessments rather than traditional paper-and-pencil items. Another teacher commented on the development of classroom cooperation through increased use of inquiry activities. Inclusion students, usually excluded from science learning due to the traditional lecture format, were now able to actively participate within cooperative inquiry groups.

The spirit of cooperation and inquiry spilled over into other learning opportunities as well. A student in a tech-prep biology class instructed classmates how to use PowerPoint to present data collected during an inquiry activity while another student taught classmates in ecology how to use the school's digital camera to record data for a science investigation. Cooperative activities lead to instances of shared responsibility in other areas as well. When a student acted inappropriately on the school grounds while looking for rocks, the teacher took that opportunity for the class to look for solutions to resolve the incident.

At first glance, many classrooms seemed noisy and disorderly. In reality, after implementing inquiry activities and increasing student input, teachers had fewer discipline problems. Active engagement in learning science really was just that and students who were busy doing science did not have time to cause problems.

Teachers

Teacher response was overwhelming positive. Answers to attitudinal survey questions ranged from "agree" to "strongly agree". Not only did the participants state that the professional development addressed their needs, they also stated at the end of the weeklong meeting, that they agreed with the educational approaches presented and would be able to incorporate both inquiry and technology into their daily lessons. Individual comments included such things as "empowering", "energizing", and "a reminder that science is supposed to be active and exciting".

Additional meetings and correspondence with teachers indicated unwavering support. At the initial 2-week interval meeting, one group of middle school teachers had converted 10 weeks of lesson plans to inquiry format. Lack of textbook support materials caused some teachers to voice concern, but the support of the project's master teachers spurred them on the inquiry path. One early disbeliever, by the third meeting, had taught an entire three-week science unit using the inquiry format. She gave credit for her conversion to the master teacher who helped her design the unit.

If there was a single result that stood out among all others it was the evolution of teachers to teacher-collaborators. After the summer session, teachers shared a vision of change in the science classroom. Incorporating technology and modifying existing curricula to an inquiry format is a huge task for one person. Recognizing that there is strength in numbers and acknowledging the skills of some to lead the way, the groups of teachers from each system became collaborators. As 2002 is also science textbook adoption year, teachers have decided to collaborate on the selection of textbooks to facilitate incorporating the goals of this project. There are plans to develop a web site for sharing of ideas and inquiry formatted lesson plans as well.

Individually, one teacher commented on how the newly generated student enthusiasm for science as energized her as well. A physical science teacher discussed how this format seemed more efficient to her since many of her students rarely read the material in the text anyway. Once their interest was piqued by the inquiry activities, they were more likely to go back and read pertinent textual information. Another science teacher recently relegated to P.E. duty, incorporated inquiry activities into the health/P.E. arena by guiding students through an investigation of respiration, pulse rate, and physical activity. She commented on what a great opportunity that provided for integrating health, science, and mathematics in an otherwise academic-free zone.

On a broader scale, teachers acknowledged the importance of the support offered by the project staff. One teacher commented on previous staff development activities: "They spend a day or two with you and then they leave. You don't know what to do and no one else does either." In contrast, the continued support by the project leaders in this instance was empowering. The same teacher added: "I know I can count on this group (project leaders) if I need help."

The support by the project members and co-workers has inspired several veteran teachers to venture into uncharted territory. Traditional lecture-driven classrooms were coming alive with the noisy hum of inquiry activities. Teachers who never wanted a computer in their room now were asking for several student computers to be installed. One school system, in support of their science educators, applied for and received a $125,000 math and science technology grant. This money will be spent on installing a presentation station in each science classroom as well as purchasing a set of 15 laptop computers with Internet access.

Conclusion

Transformation may be the watchword of education today. As we charge into the information age, priorities and paradigms shift. What was valued a few decades ago, mass-produced knowledge, has been replaced by individually constructed knowledge. Active replaces passive. Teachers, too, must become active learners to master the changing scene in education, a scene that requires science as inquiry and the integration of technology. The key concepts described in the NSES formed the foundation for this project through the use of inquiry-based learning cycle teaching procedures, technology integration, and system-wide collaboration of science teachers. Worthwhile educational change requires new knowledge, attitudes, and behaviors (Fullan, 1991). The inquiry-technology integration project seemed to effectively supply these key requirements to science educators in South Georgia.

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