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Science Buddies: An Authentic Context for Developing Preservice Teachers' Understandings of Learning, Teaching, and Scientific Inquiry

Christine Moseley
The University of Texas at San Antonio

Sarah J. Ramsey
Lock Haven University

Kristin Ruff
Tulsa Public Schools

Methods courses in teacher education programs have made a transition in the last years toward field-based experiences as part of the preparation for teaching science in the elementary school. However, little conclusive evidence exists as to any desirable influence field experiences are having on science teaching attitudes and learning.

The purpose of this qualitative study was to explore the process, discuss the effectiveness and impacts, and highlight the implications of an extended field experience – the Science Buddy Program - on elementary pre-service teachers' learning and conceptualization in the context of science teaching.

Results indicate that participation in this field experience that included pre-service teachers facilitating science learning with elementary children was beneficial in the construction of the pedagogical content knowledge of the pre-service teachers. This experience also fostered positive attitudes toward science and science teaching and offered an excellent opportunity for future educators to observe science learning in progress.

Introduction

The consensus among both education researchers and students preparing for teaching careers indicates a need for more direct, practical experiences in classrooms prior to student teaching (National Research Council, 1996; Weld & French, 2001). Haberman (1988) states, "Teacher education programs . . . prepare students for the best of all non-existent worlds and then toss them into public schools where, quite frequently, the antithesis of everything the university program is trying to teach is an accepted, operating norm" (p. 1). Further, Clinchy (1994) contends that future teachers are educated in a disconnected, decontextualized environment.

Evidence indicates that more "real world" opportunities for preservice teachers to practice their skills will help them gain necessary skills faster (Schoon & Sandoval, 1997). Sociological studies have concluded that preservice field experiences are important for learning needed practical skills as well as acquiring significant socialization regarding the school environment (Lortie, 1975). The effectiveness of education courses are said to be substantially increased when accompanied by field experiences (Weld & French, 2001). Other benefits of the field experience are that it serves as a means of developing a commitment to the teaching profession and as a mechanism by which future teachers learn valuable knowledge about themselves (Applegate, 1987). In a study done by Fleener (1998), candidates who received increased amounts of field experience in their teacher preparation programs remained in the professions at significantly higher rates than those prepared through traditional campus-based programs. Perhaps the most compelling evidence for increasing the amount of field experience in the preparation of future teachers comes from research that indicates that more of such practical experience improves preservice teachers' performance of the specific behaviors modeled and encouraged in the methods courses (Sunal, 1980; Yager, 1996).

Within the last two decades, a number of national reports have stressed the need for major improvements in the preparation of teachers as a foundation for other educational reform efforts. The Carnegie Forum on Education and the Economy (1986), the Holmes Group (1986), the National Commission on Teaching and America's Future (1996), and others (Darling-Hammond, 1997; Goodlad, 1990; National Commission on Excellence in Education, 1983) have recommended that future teachers have more rigorous preparation and more authentic experiences to enable them to cope with the increasing complexity, challenges, and diversity of current schools and classrooms. What has been advocated is a more holistic conceptualization of the preservice teacher experience and increased collaboration between public schools and universities (McIntyre, Byrd, & Foxx, 1996).

The Association of Teacher Educators (1986) has developed guidelines related to the professional experiences of preservice teachers. Two statements directly related to the relationship between schools and universities within these guidelines are that teacher education programs are (1) to provide opportunities to relate the knowledge, the skills, and the attitudes learned in teacher education to direct experiences, and to perform professional teaching duties; and (2) to provide opportunities to apply and test principles of learning and teaching strategies. Teacher preparation institutions, state certification boards, and preservice teachers themselves all consider field experiences to be essential for teacher training. Many teacher education institutions have adopted field experiences as a required component of their preservice education programs.

Prior to the 1980s, the dominant mode of teacher preparation consisted of coursework on a university campus followed by one semester of student teaching (Huling, 1998). Today, quality teacher preparation programs provide candidates with a multitude of early field experiences in a variety of settings to lay the foundation for and to supplement the capstone or culminating field experience of student teaching. As evidence of this shift in attitude towards the importance of field experiences, a study of 240 teacher preparation programs done by Bischoff, Farris, and Henniger (1988) found that 99% required the completion of some type of field experience.

Proponents of field experiences have outlined a number of potential benefits such as the following: (1) to bridge the gap between theory and classroom practice

(Krustchinsky & Moore, 1981); (2) to socialize prospective teachers for their roles in the classroom (Dueck, Altman, Haslett, & Latimer, 1984); and (3) to refine basic teaching skills (Henry, 1983). There is evidence to suggest that preservice teachers benefit from active, learner-centered constructivist environments (Brindley, 2000; Holt-Reynolds, 2000; Kelly, 2000). Embedded in knowledge construction is the importance of authentic learning contexts (Cochran, DeRuiter, & King, 1993) and learning in social contexts (Bullough & Gitlin, 1991; Piaget, 1970; Vygotsky, 1978). Thus, authentic field experiences have the potential of positively influencing knowledge construction of preservice teachers.

Unfortunately, there has been little or inconclusive research in demonstrating and substantiating the benefits of field experiences in the preparation of potential teachers. Most of the work done has been anecdotal in nature, based on observations and “gut feelings.” As early as 1984, after reviewing the literature, Lasley and Applegate (1984) concluded that studies “describing what reality confronts pre-service teachers once they are directly exposed to the classroom during these early field experiences” (p. 3) are needed. These authors, likewise, found few studies in their literature review of research, both quantitative and qualitative, pertaining to the effects of field experiences on preservice teachers’ acquisition of knowledge and skills for teaching.

Rationale for Study

Each semester, at the conclusion of student teaching, elementary preservice teachers at the university involved in this study complete a written evaluation of their teacher education program and its effectiveness in preparing them to be teachers. One of the leading complaints from students each semester has been a lack of field experiences during the methods courses and not enough experiences in a real classroom working with children prior to student teaching. As a result, a field component was implemented which was directly tied to the science methods course. Questions still arise, however, as to the actual effectiveness of the field experience on the preservice teachers’ learning. Quality field experiences can be time and labor intensive and involve much more than teaching a scheduled course on a university campus. Faculty desire to know if arranging and supervising field experiences are worth their time and effort.

Studies that examine factors affecting the construction of teachers’ knowledge, learning, and context can make significant contributions in strengthening the preparation of teachers and complement a growing knowledge base for teaching. In teaching elementary science, the expectation is that the new teacher is well-grounded in pedagogical strategies that promote learning science content. Shulman (1986) refers to this knowledge that combines content and pedagogy as pedagogical content knowledge (PCK). PCK is that domain of teachers’ knowledge that combines subject-matter knowledge (what they know about what they teach) and knowledge of pedagogy (what they know about teaching) (Lowery, 2002; Tobin, Tippins, & Gallard, 1994).

Raizen and Michelsohn (1994) believe that many of the pedagogical strategies used in the science methods course are lost in the real elementary classroom because teachers cannot connect content with appropriate strategy. They believe that this lack of PCK occurs between science content courses, which focus on subject matter, and science methods courses, which emphasize pedagogy and process. Thus, preservice teachers often do not have the requisite background knowledge to integrate content and pedagogy on their own. Many students entering the elementary science methods course have a vision of themselves as science teachers that is in reaction to their experiences as science learners (Abell et al., 1995). Many of these prospective teachers have experienced years of passive, didactic, lecture- and textbook-driven science instruction at the elementary, secondary, and college level. Thus, many new teachers teach science the way they were taught in their own classes (Doyle & Ponder, 1977; Fullan & Stiege, 1991; Michelsohn & Hawkins, 1994), and the lecture mode of teaching science with heavy reliance on textbooks is preserved and perpetuated in the elementary classroom (Anderson & Smith, 1987; Mestre, 1991; Slater, Carpenter, & Safko, 1996; Stepans, McClung, & Beiswenger, 1995); however, according to Abell and Bryan (1997), these elementary preservice teachers recognize that their past experiences in science classes are inadequate in helping them enjoy and understand science and that most want to promote hands-on, discovery, child-centered instruction that will assist their students in enjoying and learning science. Tensions arise, however, as they gain more experiences working with children and as they struggle with their ideal of discovery learning versus their perception of the role of teachers as people who give students the right answers.

Studies that examine factors affecting the construction of teachers' knowledge, learning, and context can make significant contributions in strengthening the preparation of teachers and can complement a growing knowledge base for teaching PCK; however, research of PCK is limited in elementary school science (Lowery, 2002). The following research study was conducted in a school-based setting focusing on the construction of the PCK of preservice teachers in elementary science. It was designed to provide teacher educators with additional data regarding the impact of field experiences on preservice teachers' learning to teach science.

Purpose of Study

Methods courses in teacher education programs have made a transition in the last years toward field-based experiences as part of the preparation for teaching science in the elementary school. The purpose of this study was to explore the process, discuss the effectiveness and impacts, and highlight the implications of an extended field experience—the Science Buddy Program—on elementary preservice teachers' learning and conceptualization in the context of science teaching. The following research question was of primary interest for this study: "What are elementary education preservice teachers learning and conceptualizing regarding science pedagogical content knowledge from extended field experiences connected to a science methods course?"

Program Description

The Science Buddy Program was developed with two major goals in mind: (1) to give elementary education preservice teachers experience in facilitating inquiry-centered science investigations with elementary age children, and (2) to give the preservice teachers much needed personal experience in conducting science investigations utilizing the scientific method of inquiry. The field-based experience takes place over a series of six consecutive weeks. Each week, the preservice elementary teachers enrolled in the Elementary Science Methods course, meet at an elementary school during class time. Each preservice teacher is assigned an elementary age child as a science buddy. The buddies meet for a total of five two-hour time periods and also one culminating session in the evening with parents for Family Science Night. During these meetings, the buddies are not only getting to know one another but also planning and carrying out a scientific investigation following a process of scientific inquiry. The preservice teacher is there to facilitate the elementary student's understanding of science and scientific inquiry.

During the first session, the elementary student chooses what scientific question he or she would like to explore. Next, the buddies develop their expectation statement and also design the procedure they will use for the investigation. The preservice teachers also introduce the science notebook to the elementary students, in which, each week, the elementary students will record the steps involved in the investigation, the data, the results, and final conclusions.

When the buddies meet for the second time, they carry out the investigation and record the data in charts in their science notebook. A minimum of three conditions and three trials are required for each investigation. Thus, students are shown the importance of multiple trials and the averaging of data in science investigations. The third session is for students to complete the investigation, construct graphs from the data collected, and draw conclusions. At the fourth session, the buddies begin work on their project display that will showcase the results and conclusions of the investigation in graphs and charts. The buddies can refer back to their science notebooks to help them in the creation of their project display.

At the fifth meeting of the science buddies, they complete their project display board that includes the materials used, research question, expectations, procedure, data, results, and conclusions. Pictures are also included on the display board that show the students conducting the investigation or that may show other aspects of the investigation. Once the display board is complete, the preservice teachers help their buddies practice the oral presentation.

The sixth and final session of the Science Buddy Program is the Family Science Night when all of the science buddies display their projects. It is held in the evening so that families, teachers, and the community can come see what the students have accomplished. When the elementary buddy has an audience, he or she gives an oral presentation about the inquiry that was conducted with his or her buddy. The elementary students talk about what steps they went through, what their expectation statement was, the results and conclusions, and also about any other information they learned during the process.

The preservice teachers have different components that they must complete during the science buddy process. Before the initial meeting with their buddies, the preservice teachers write an introductory letter to their buddies and also to their buddies' parents. They continue sending a weekly letter home to the parents after every meeting, explaining what their child is doing in the project, the topic their child chose, how much they are enjoying working with the child, and also they remind the parents about Family Science Night. After the Family Science Night, the preservice teachers prepare a closure letter for the buddies and parents, including a list of references, books, and websites that parents and their children can search for further information.

For each session with their science buddy, the preservice teachers create a lesson plan that follows the 5E instructional model of the learning cycle (Trowbridge, Bybee, & Powell, 2000), which is based on a constructivist view and has five phases: (1) engagement, (2) exploration, (3) explanation, (4) elaboration, and (5) evaluation. The lesson plan serves as a guide to help the buddies stay on track and finish what needs to be done at each session. They also keep a science notebook similar to what their buddy is completing, in which they reflect on the process after each meeting with their science buddy. The preservice teachers also complete a lab report of the investigation. In the report, they include the title of the inquiry; the problem written as a question; the hypothesis; the equipment and materials that were used; the procedure written in sequential order; the variables manipulated and controlled; the data collected in the form of charts, tables, or graphs; the results; and the conclusion.

Methodology

Context

The site for the methods instruction was located on a suburban public elementary school campus (K-5) in a nearby school district with an enrollment of 450 students. This elementary school serves as the major campus in the community for the English as a Second Language program, with children representing over 40 foreign countries in attendance. The school has designated a classroom for the university to hold sessions and both large and small discussions. Although not officially designated as a professional development school, the school and the university have maintained a history of collaboration and support of the teacher education program.

During the two semesters in which this study was done, the preservice teachers worked in two fifth-grade classrooms. The Science Buddy pairs could choose to work in either one of the classrooms, in the university designated classroom, the library, and/or outside, if weather permitted. The university students met prior to and immediately after the project for reflective sessions in the designated classroom. The research team of one professor and two graduate students (one doctoral and one master's) led the reflective sessions and served as observers and facilitators during the time the buddies worked on their investigations, mentoring each pair as needed. The classroom teachers worked in their individual classrooms during this time, assisting with materials, equipment, and any student issues. The teachers also assisted with the organization and set up of the Family Science Night.

Sample

The 55 participants in this study were purposely selected in the Spring 2001 and Spring 2002 semesters. Although this was a fairly homogeneous sample, it reflected the demographics of elementary teachers in general. Most of the participants were white, middle-class females between the ages of 22-25. The participants were all senior elementary education majors at a large Midwestern university enrolled in a required one semester long science methods course that fulfills state certification requirements for elementary instruction (K-8). This course is taken the semester prior to the student teaching experience. A school-based setting for the Science Buddy project was selected to allow simultaneous interactions with the school environment.

Data Collection and Analysis

Data were collected from multiple sources, including field notes from observations of buddy sessions and large group reflections and documents (i.e., individual reflections and large group reflections). After each teaching session, the research team facilitated an oral group reflection session with all of the preservice teachers on site at the elementary school, and field notes were taken at this time. In addition, the participants wrote individual weekly reflections about their experiences, which were reviewed by the research team. At the completion of the entire program, a large group oral reflective session on the university campus was held and the discussion was documented. Further, the large group was divided into smaller groups, at which time they responded to specific questions.[1] Each group recorded their reflective answers to the questions and reported their ideas back to the entire group. Finally, participants wrote individual reflective summaries.[2]

The data were analyzed using a constant comparative method enabling categories to be drawn (Creswell, 1998; Strauss & Corbin, 1994). The researchers read the individual reflections, making comments and asking questions about what was written as well as implied. In addition, at the conclusion of each science buddy session, the researchers met and discussed the noticeable themes that were emerging in regards to the participants' views of teaching and learning. These themes were supported in the final analysis of the documents and field notes. From the combined sources, an explanation of the study findings was generated.

Findings

An analysis of the data revealed an understanding in three broad categories in the educative process in the context of science education: (1) teachers, (2) students, and (3) parents. It became apparent that these three categories naturally revealed those notions that the preservice teachers viewed as essential to the understanding of the teaching and learning process. The discussion that follows presents those notions and is organized around the three identified components in science education.

Conceptualizations about Teachers

The preservice teachers began to develop an understanding of the nature of teaching. They experienced first hand that certain skills and attitudes associated with teaching are essential, particularly in the teaching of science.

Teachers are planners. Preparation is essential, and a teacher cannot rely on her enthusiasm for or knowledge of science to replace adequate preparation. One participant commented,

> I know this seems naïve but going into this project I truly did not think teaching science would be hard because I like science. Now, after this experience, I have learned that it is very hard to teach. I had numerous problems . . . [which] told me that before I do an experiment with my class I need to first try it myself, research it, and have a set plan of how the lesson will go.

Although preparation is seen as essential, one can never plan enough. The participants expressed frustration in relation to those things that were out of their control, but they realized that flexibility in planning and delivery is a key characteristic for all teachers. One participant noted, “Nothing seems to go as you planned, and you have to continually have a back-up plan. I either had too much free time or never had enough time.”

Teachers are flexible. The preservice teachers witnessed the unpredictable nature of schools. Unexpected events presented themselves at each session. Students were absent, the book fair was scheduled during Science Buddy time, and one of the classroom teachers was in a serious car accident. The substitute teacher entered into the project with no background knowledge and was able to contribute only limited assistance to the preservice teachers. Flexibility soon became an important characteristic for the preservice teachers in order to provide their buddies with the satisfaction of completing their investigation:

> I now realize that nothing is ever set in stone when you are dealing with children. I had always heard that flexibility is a big part of teaching, yet I had never really thought about this idea until I had to practice flexibility during this experience.

Teachers are facilitators. As is often the case when using inquiry-centered teaching strategies, the preservice teachers began to see themselves as facilitators of the students’ learning rather than the possessors of all knowledge. The participants quickly realized that patience is at the heart of carrying out the role of facilitator:

> Through this experience I learned that as a teacher I have to stand back and let the students think for themselves. I have a tendency to jump in when I see a problem instead of letting the student figure things out.

Further, they saw questioning as a facilitation skill that was at the forefront of their practice and they connected patience with being a good questioner: “I have to learn to wait and let the student have time to process the question and think about the answer.” Finally, questioning was seen not as a haphazard event but as something that requires planning and analysis prior to the teaching act:

> I noticed that I need more practice asking questions that are open-ended instead of closed. . . . . In the future I think I will include in my lesson plan a list of possible questions I could ask throughout the lesson; this way, I could start to analyze which questions are good discussion starters and which are easy one-word answers.

Teachers are learners. Through the Science Buddy Program, the participants associated the notion of life long learning with teaching, particularly in connection with science: “I realized that science is a journey to discovery. In teaching science, I will continue to learn new things and explore my own ideas.” Further, they expressed that learning from students is inevitable as well as rewarding:

> [We] voiced our ideas and listened to one another. In listening to one another, we learned from one another. Because of this experience I will always listen to my students' ideas. I have come to realize that not only can my students learn from me, but I can also learn from my students.

Even when using inquiry-centered strategies, a thorough understanding of the topic is required before teaching: "I discovered that you had to really understand what you are trying to teach before trying to get someone else to understand it."

Experience is the best teacher. Learning to teach science cannot be done in the isolation of a university classroom; it requires practical experience in an authentic setting. Preservice teachers desire authentic experiences that give them opportunities to merge theory and practice. Several participants expressed this feeling: "I feel as though one could lecture me for hours on how to teach using inquiry, but until I actually try it, all instruction is useless. This project allowed me to bridge the theory with actual practice"; "I feel that field experience is the most important part of preparing students who are pursuing a career in teaching"; and "The best way to become a better teacher is to practice teaching. During our methods courses, we learn the best strategies for teaching; however, it is more worthwhile to go into a school and practice those strategies."

Conceptualizations about Students

In working with the students, the preservice teachers' ideas about students were confirmed. At the same time, some of their theories needed revising. They discovered the complexities of human learning and realized that students are individuals and teachers should treat them as such. Further, they realized that all students can do science, and they learn best through experiences in which they are genuinely interested.

Students are individuals. Although they may not all like science, all students can do science. Regardless of perceived academic ability, all students can learn something by participating in science activities. To accomplish this, it is important to let students work at their own pace while highlighting their strengths. Additionally, one preservice teacher acknowledged that, "It is important to consider every student as an individual and not to let preconceived notions . . . influence your view of a student's abilities." It is perhaps this lack of expectation that explains the surprise many preservice teachers expressed in regard to what the students did or did not know about the processes and content of science.

Further, several characteristics were identified as the preservice teachers interacted with the students. They discovered that students are independent, naturally inquisitive, and creative. One preservice teacher explained,

> Students can learn to be independent and think for themselves. They can develop their own strategies for solving problems. They can use strategies that help them understand. In my grade school experience, I learned to be dependent on the teacher for answers to my questions. Through this experience, I have learned that students can develop strategies and find the answers with guidance from the teacher.

Teachers must understand that students' lives outside of school affect their ability to participate in school activities. Students are often distracted by personal issues. The study participants acknowledged that in order for students to engage in academic endeavors, they must have dealt with any personal problems or issues that may be consuming their minds.

Science is student centered. In learning about the nature of teaching, the participants expect to be facilitators of experience rather than transmitters of knowledge. This role of facilitator is critical to student-centered education. The preservice teachers discovered that for students to be successful with scientific inquiry and enjoy science, they must control the inquiry.

Just as preservice teachers desire authentic learning experiences, they believe the same is true for all students. Therefore, students need to actually do science in order to learn science. In addition, according to the study participants, the actual doing of science should be student centered. Giving students a choice emerged as a central piece in making investigations important to students:

> I discovered that allowing children to have choice in science is very important. On the first session, I gave Brittany a list with ten possible questions we could explore. Because she picked a question that she was interested in exploring, she was eager to get started and took a great deal of responsibility for doing the project.

Further, the preservice teachers recognized that students are successful when doing science if a learning cycle type structure is used. Students must first be interested or engaged in the experience, and then they must be allowed to explore the concepts and develop strategies to answer their own questions. Finally, students must be given the opportunity to share their thinking and explain their findings.

As the teachers were trying to make science student centered, they asked students to make decisions about all aspects of their investigation. In addition, the teachers used questioning as a strategy to encourage student thinking and analysis. Through the use of these strategies, the preservice teachers discovered that students need time to think. They learned that giving students time to think about questions to investigate, procedures for investigation, data collection, and other aspects of inquiry is essential. Further, they learned that giving students time to think about their answers to questions ensures a more thoughtful, meaningful response.

Conceptualizations about Parents and Families

In addition to facilitating instruction, the preservice teachers received the benefit of interacting with parents and families. The participants discussed the role of families in teaching and learning. They felt that "interacting with parents will be a big part of our jobs when we teach" and saw the components in the program that encouraged interaction with parents as positive: "It is important that all teachers learn to communicate effectively with parents through letters and conferences. This experience gave me the opportunity to develop communication skills I will need when I become a teacher." The participants were also encouraged to know that parents are interested in their children's education and were "still finding time to appreciate their children . . . [and] interested in the hard work their children had done. I have found not to give up hope with parents. Parents want to be involved and I witnessed this during this experience [Science Buddies]."

Conclusions

Learning to teach science involves clarifying, confronting, and expanding one's ideas, beliefs, and values about science teaching and learning (Abell & Bryan, 1997). The Science Buddy Program required preservice teachers to identify some of their existing ideas, beliefs, and values about science teaching and learning as well as helping them to accommodate new ideas, beliefs, and values. Additionally, this study provided further support of Lowery's (2002) study in which she contends that "content-specific, school-based experiences may afford pre-service teachers greater opportunities to focus on content and instructional strategies at deeper levels which will aid in reducing the anxiety often associated with teaching science while at the same time increasing confidence" (p. 76).

The primary goal of the Science Buddy Program was for preservice teachers to experience successful science teaching in the real-world context of the elementary school classroom with elementary children. Participation in this site-based field experience that included preservice teachers facilitating science learning with elementary children was beneficial in the construction of the PCK of the preservice teachers. It also provided many opportunities for the preservice teachers to apply and transfer learning (theory to practice) through authentic learning experiences. The preservice teachers were able to work with real teachers, real children, and real lessons in a real school environment. The Science Buddy Program provided an extended field experience for preservice teachers in which they came to know teaching science as a collaborative endeavor involving teachers, students, and parents. Further, they identified specific content pedagogy and teaching strategies that were effective in the context of facilitating open inquiry in an elementary classroom.

The Science Buddy Program offered the opportunity for preservice teachers to view the role of the teacher of science as a problem solver who designs and facilitates instruction that encourages learners to identify, access, learn, and apply scientific knowledge within contexts that require higher-level thinking skills. From these experiences with the elementary students, the preservice teachers constructed teacher knowledge in science. They learned grade-level appropriateness, content, and lesson structure and implementation. The direct interaction in the classroom with a child provided needed experiences in questioning, behavior management, and the daily logistics of teaching. Through this experience, the preservice teachers discovered that "science for all" is not just a catch phrase. By organizing student-centered learning opportunities and implementing a learning cycle approach, the elementary students were excited to do science and exhibited their independence, curiosity, and creativity. Finally, the study participants were encouraged by the parents' interest in their child's learning and recognized that frequent communication with parents is a key in completing the collaborative education of the whole child.

Future Research

Current reform movements have generally called for an increased amount of field or clinical experience for students during teacher preparation. McIntyre's (1983) summary of research on field experiences revealed that early field experience components do provide several benefits to prospective teachers and to a teacher education program. These benefits include (1) allowing students to discover early if they like children and want to teach, (2) permitting programs to determine students' potential, (3) enabling students to practice instructional skills prior to student teaching, (4) developing the student's base of perceptions of classroom life, (5) improving communication between public schools and universities, and (6) accelerating passage through the stages from student to teacher.

There is limited research in regards to what field experiences work best or if longer periods of early field experiences are more effective than shorter versions. Does increasing the length of field experiences make the experience better? Should programs be modified without truly knowing if one type of program produces more effective teachers than others? Should the context of the field experiences be modified without knowing if one method is more effective than another?

According to McIntyre et al. (1996), research on field experiences has not been conducted in a systematic fashion as a result of a lack of a well-conceived theoretical base for field experiences. They further state that a shorter field component with well-integrated experiences is more likely to produce effective teachers than a longer program whose major attribute is only increased time of the experience. Armstrong (1990) also states that more research is needed in this area of teacher education. He believes that three broad areas of research in field experience need to be addressed: (1) What do students know about what they see? (2) Do early field experiences adequately model the "reality" of teaching? and (3) What is the effect of early field experiences on students' instructional behaviors?

The authors of this study support the above suggested areas for research in field experiences. The following future research questions have arisen from this study:

- Does increasing the length of the Science Buddy field experience allow for increased preservice teacher learning and understanding of scientific inquiry and about student learning and conceptualization of science?

- What impact would the experience have if conducted with a full classroom of students rather than a one-on-one situation of student and teacher learning and achievement?

- In a longitudinal study, what areas, if any, of the Science Buddy Program do the preservice teachers implement during student teaching and the first year of teaching?

These longitudinal studies should include follow-up interviews with those preservice teachers who participated in the Science Buddy Program to determine what has changed in their attitudes and understandings about inquiry, as well as what barriers have prevented them from implementing scientific inquiry into their own classrooms.

Implications to Teacher Education

Understanding preservice teacher thinking should be a major goal for teacher educators. Teacher educators should provide instruction to assist preservice teachers in the construction of viable science teaching and learning theories and classroom practices. The ultimate goal is that science teaching will begin to approach the vision of the National Science Education Standards:

> Good teachers of science create environments in which they and their students work together as active learners. They have continually expanding theoretical and practical knowledge about science, learning, and science teaching. They use assessments of students and of their own teaching to plan and conduct their teaching. They build strong, sustained relationships with students that are grounded in their knowledge of students' similarities and differences. And they are active as members of science-learning communities. (NRC, 1996, p. 4)

The preparation of teachers in authentic methods and contexts is a valid alternative to the limitations of a campus-based preparation. Content-specific, school-based experiences afford preservice teachers with greater opportunities to focus on content and instructional strategies at deeper levels, to address anxieties typically associated with the teaching of elementary science, and to become more confident and competent teachers. Providing teacher education students with more field experiences will provide them with the authentic context necessary to construct knowledge essential to their success as teachers.

In a study done by Cochran et al. (1993), it was concluded that learning to teach often demands teaching specific content to specific students in specific situations. Preservice teachers need to be involved in realistic contexts, such as case studies, peer coaching, cooperative classroom methods, microteaching, and team teaching, in which "active" learning can occur and in which the social construction of knowledge can best be fostered.

Research suggests that science methods courses should include experiences which do the following: (1) model the teaching of process skills, not in isolation, but through activities and projects in which these skills are used in context; (2) allow preservice teachers to discover what they did not know before and problem solve to find their own answers; and (3) encourage teamwork (Jarrett, 1998). The Science Buddy field experience addresses all three of these areas and provides a model for other science educators.

For meaningful experiences to occur in the field experience component of the teacher education program, the program structure and the processes within the structure must be meaningful to the participants. To increase the probabilities for meaningful experiences for preservice teacher candidates, a conceptual framework of the program that illustrates the organizational structure and the processes valued in the program must be communicated to students prior to the experience and then reflected upon after the experience. Reflective periods during and after experiences are vital to the success of the field experience to continually link what is being experienced to the conceptual framework of the program and goals of the course.

There is a need for preservice teachers to be educated in a manner consistent with the latest educational reform movement and the wisdom of best practice. Within this context, there is a need to go beyond only teaching teachers how to teach science and how to become science teachers. Preservice teachers must be involved in their own learning; they must interact with all contexts of the school environment—teachers, children, parents, administrators, and university educators—for their own conceptualization and construction of content and pedagogical knowledge.

Finally, teaching and doing science should be fun and engaging. As one science buddy participant concluded,

> This experience is also valuable because it allows preservice teachers to get into the schools and "have fun" with the students. This program teaches both students and elementary students that science can be fun. It is important to know that you can have fun while you learn.

Notes

[1] Questions for summative large group reflection:
- What did you discover about science and yourself teaching science?
- What did you discover about a child's understanding of science?
- What do you consider to be some of the positive aspects of the Science Buddy Program?
- What did you learn from this project that could be implemented in your future classroom?
- What did you learn about parent involvement?

[2] Questions for individual summative reflection:
- What are three things you discovered about science or yourself as a science teacher that you did not know before?
- What were you surprised by regarding your buddy's understanding of the scientific concepts?
- What were the positive aspects of your participation in this project?

References

Abell, S. K., & Bryan, L. A. (1997). Reconceptualizing the elementary science methods course using a reflective orientation. *Journal of Science Teacher Education, 8*(3), 153-166.

Abell, S. K., Bryan, L. A., Anderson, M. A., Cennamo, K. S., Campbell, L. M., & Hug, J. W. (1995, April). *Investigating the process of becoming reflective: The use of video cases in elementary science teacher preparation.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Anderson, R. D., & Smith, E. L. (1987). Teaching science. In V. Richardson-Koehler (Ed.), *Educators' handbook: A research perspective* (pp. 84-111). New York: Longman.

Applegate, J. (1987). Early field experiences: Three viewpoints. In M. Haberman & J. M. Backus (Eds.), *Advances in teacher education (*Volume 3, pp. 75-93). Norwood, NJ: Ablex.

Armstrong, D. (1990). Early field experiences: Some key questions. *The Teacher Educator*, *25*(3), 2-7.

Association of Teacher Educators. (1986). *Guidelines for professional experiences in teacher education.* Reston, VA: Author.

Bischoff, J., Farris, P., & Henniger, M. (1988). Student perceptions of early clinical field experiences. *Action in Teacher Education, 10*(3), 23-25.

Brindley, R. (2000). Learning to walk the walk: Teacher educators' use of constructivist epistemology in their own practice. *Professional Educator*, *22*(2), 1-14.

Bullough, R., & Gitlin, A. (1991). Educative communities and the development of the reflective practitioner. In R. Tabachnick & K. Zeichner (Eds.), *Issues and practices in inquiry-oriented teacher education* (pp. 33-55). London: Falmer.
Carnegie Forum on Education and the Economy, Task Force on Teaching as a Profession. (1986). *A nation prepared: Teachers for the 21st century.* New York: Carnegie Corporation. (ERIC Document Reproduction Service No. ED 268 120)
Clinchy, E. (1994). Higher education: The albatross around the neck of our public schools. *Phi Delta Kappan, 75,* 745-751.
Cochran, K., DeRuiter, J. A., & King, R. A. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education*, *44*(4), 263-272.
Cresswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage.
Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching.* New York: National Commission on Teaching & America's Future.
Doyle, W., & Ponder, G. (1977). The ethic of practicality: Implications for curriculum development. In A. Molnar & J. A. Zahorik (Eds.), *Curriculum theory* (pp. 74-80). Washington, DC: Association for Supervision and Curriculum Development.
Dueck, K., Altmann, H., Haslett, K., & Latimer, J. (1984). Early exploratory field experiences in teacher preparation programs. *Education Canada, 24*, 34-38.
Fleener, C. E. (1998). *A comparison of the attrition rates of elementary teachers prepared through traditional undergraduate campus-based programs and elementary teachers prepared through centers for professional development and technology field-based programs by gender, ethnicity, and academic performance.* Unpublished doctoral dissertation, Texas A&M University, Commerce, Texas.
Fullan, M., & Stiege, S. (1991). *The new meaning of educational change.* New York: Teachers College Press.
Goodlad, J. I. (1990). *Teachers for our nation's schools.* San Francisco: Jossey-Bass.
Haberman, M. (1988). Toward more realistic teacher education. In J. Sikula (Ed.), *Action in teacher education, tenth-year anniversary issue* (Commemorative ed., pp. 1-11). Reston, VA: Association of Teacher Educators.
Henry, M. (1983). The effect of increased exploratory field experiences upon the perceptions and performance of student teachers. *Action in Teacher Education, 5*(1-2), 66-70.
Holmes Group. (1986). *Tomorrow's teachers: A report of the Holmes Group.* East Lansing, MI: Author. (ERIC Document Reproduction Service No. ED 270 454)
Holt-Reynolds, D. (2000). What does the teacher do: Constructivist pedagogies and prospective teachers' beliefs about the role of a teacher. *Teaching and Teacher Education, 16*(1), 21-23.
Huling, L. (1998). *Early field experiences in teacher education*. Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education. (ERIC Document Reproduction Series No. ED 429 054)
Kelly, J. (2000). Rethinking the elementary science methods course: A case for content, pedagogy and informal science education. *International Journal of Science Education, 22*(7), 55-77.
Krustchinsky, R., & Moore, B. (1981). Early field experiences: A vital part in the training of elementary teachers. *Kappa Delta Pi Record, 17*(4), 119-120.
Lasley, T., & Applegate. J. (1984). *Problems of early field experience students.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lortie, D. (1975). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

Lowery, N. V. (2002). Construction of teacher knowledge in context: Preparing elementary teachers to teach mathematics and science. *School Science and Mathematics, 102,* 68-83.

McIntyre, D. J. (1983). *Field experiences in teacher education: From student to teacher.* Washington, DC: Foundation for Excellence in Teacher Education and ERIC Clearinghouse on Teacher Education.

McIntyre, D. J., Byrd, D. M., & Foxx, S. M. (1996). Field and laboratory experiences. In J. Sikula (Ed.), *Handbook of research on teacher education* (2nd ed.) (pp. 171-193). New York: Macmillan.

Mestre, J. P. (1991). Learning and instruction in pre-college physical science. *Physics Today, 9*, 56-62.

Michelsohn, A. M., & Hawkins, S. (1994). Current practice in science education of prospective elementary school teachers. In S. Raizen & A. Michelsohn (Eds.), *The future of science in elementary schools: Educating prospective teachers* (pp. 151-161). San Francisco: Jossey-Bass.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for education reform*. Washington, DC: U.S. Department of Education.

National Commission on Teaching and America's Future. (1996). *What matters most: Teaching for America's future.* New York: Author. (ERIC Document Reproduction Service No. ED 395 931)

National Research Council (NRC). (1996). *National science education standards.* Washington, DC: National Academy Press.

Piaget, J. (1970). *Science of education and the psychology of the child.* New York: Viking.

Raizen, S., & Michelsohn, A. (Eds.). (1994). *The future of science in elementary schools: Educating prospective teachers*. San Francisco: Jossey-Bass.

Schoon, K., & Sandoval, P. (1997). The seamless field experience model for secondary science teacher preparation. *Journal of Science Teacher Education, 8*, 127-140.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Slater, T. F., Carpenter, J. R., & Safko, J. L. (1996). Dynamics of a constructivist astronomy course for in-service teachers. *Journal of Geoscience Education, 44*, 523-528.

Stepans, J. I., McClung, P. A., & Beiswenger, R. E. (1995). A teacher education program in elementary science that connects content, methods, practicum, and student teaching. *Journal of Science Teacher Education, 6*, 158-163.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology: An overview. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 273-285). Thousand Oaks, CA: Sage.

Sunal, D. (1980). Effect of field experiences during elementary methods courses on pre-service teacher behavior. *Journal of Research in Science Teaching, 19*, 167-175.

Tobin, K., Tippins, D., & Gallard, A. (1994). Research on instructional strategies for teaching science. In D. Gable (Ed.), *Handbook of research on science teaching and learning: A project of the National Science Teachers Association* (pp. 45-91). New York: Macmillan.

Trowbridge, L. W., Bybee, R. W., & Powell, J. C. (2000). *Teaching secondary school science: Strategies for developing scientific literacy* (7th ed.) Upper Saddle River, NJ: Prentice-Hall.

Vygotsky, L. (1978). Mind in society. Cambridge, UK: Cambridge University Press.

Weld, J., & French, D. (2001). An undergraduate science laboratory field experience for pre-service science teachers. *Journal of Science Teacher Education, 12*(2), 133-142.

Yager, R. (1996). Science teacher preparation as part of systemic reform in the United States. In J. Rhoton & P. Bowers (Eds.), *Issues in science education* (pp. 24-33). Arlington, VA: National Science Teachers Association.

Correspondence regarding this article should be directed to

Christine Moseley
Associate Professor
Department of Interdisciplinary Studies and Curriculum and Instruction
University of Texas at San Antonio
2.210E MB
6900 North Loop 1604 West
San Antonio, TX 78249
(210) 458-5992
christine.moseley@utsa.edu

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