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Science Professors Serve as Mentors for Early Childhood Preservice Teachers in the Design and Implementation of Standards-Based Science Units

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This study examined the use of science professors acting as mentors to enhance the science competency of early childhood educators. Findings indicate that mentor-mentee dyad interactions varied; however, mentors were able to assist with curriculum, science content, and resources. Although standards-based units were developed, there was little "real" science inquiry present. Findings did not support a higher-quality product that involved a mentoring relationship versus a nonmentoring relationship. The mentors' lack of impact may have resulted from how the teacher candidate/science professor dyads "positioned" themselves relative to the others in developing a standards-based science unit.

Introduction

Many early childhood educators who graduate from undergraduate teacher education programs lack the acumen to teach science to their students in a high-quality manner. Reasons range from their inability to translate theories from their preservice science courses into meaningful lessons to lack of opportunities to teach science in their practicum or student teaching placements. A survey of new teachers (3 to 5 years of teaching experience) from teacher education programs in the United States reported less positive views about their science preparation than their English and math preparation (Market Research Institute, 2004). In addition to ineffectual teacher preparation, student science scores were low in many states based on the 4th grade National Assessment of Educational Progress's (i.e., "Nation's Report Card") year 2000 results. More than one third of the states were below the national percentile for science proficiency (National Center for Educational Statistics, 2003). Initiatives to lower credit course hours and graduate preservice teachers as quickly as possible to fulfill the demand of teachers in the workforce make it increasingly difficult to include all the teacher competencies in teacher preparation programs. One of the competencies in No Child Left Behind (2002) is for teachers to have a command of their subject matter. Most teachers in the early primary grades find this aspect of the legislation challenging because they are responsible for student learning in not just one subject area but in several areas such as reading, math, social studies, and science. To strengthen preservice teachers' understanding of subject matter, teacher preparation programs are using creative strategies in graduating strong teachers by collaborating with other disciplines such as math, science, and social studies. This study explores the use of professors in the science disciplines of biology, chemistry, physics, and astronomy acting as mentors to enhance the science competency of early childhood teacher candidates.

Theoretical Framework

Mentoring programs have been implemented in postsecondary institutions to increase student interest and knowledge within the science disciplines. Some of these endeavors have involved mentoring students in introductory science courses (Hedges & Mania-Farnell, 2002; Quinn, Muldoon, & Hollingworth, 2002) while other programs have been directed towards preservice (Hudson, 2003; Van Zee, Lay, & Roberts, 2003) and inservice teachers (Koch & Appleton, 2003) in preK-12 settings. These studies demonstrate positive outcomes but do not address teacher candidates in early childhood education. Furthermore, there is more information needed regarding the reasons these relationships promote or hinder positive outcomes. Sandra Odell (2003), leading researcher in mentoring models within educational settings, calls for the need to conduct more research within mentoring programs that focus on interactions between mentors and mentees (e.g., their roles, their personal and professional identities that are manifested within these relationships, and other variables of contextual features that affect these relationships). All of these programs have variations of mentoring strategies, but most of them operate from a mentor/mentee model where mentors share their expertise in a specific discipline by teaching a mentee about that discipline in the form of prescribed roles such as teacher, coach, trainer, protector, sponsor, leader, or motivator (Debolt, 1992). Jonson (2002) notes that the teacher-mentor plays a vital and unique part in the development and training of someone new to the profession by providing support and collegiality, and alleviating the isolation of being in a classroom.

According to role theory, the interactions (spoken and unspoken) within the mentor/mentee dyad are to some extent dictated by their respective roles and are to be interpreted in these terms. This study moves beyond the concept of role theory and is based on a poststructuralist framework that explores a concept of "positioning" in terms of the mentor-mentee dyad according to Davies and Harre (2000). Subject positioning as a concept allows us to capture the moment-by-moment, fluid, and dynamic aspects of people in interaction with each other. Within this framework, the science mentor and teacher candidate are viewed as bringing their "lived" histories to this dyad and all interactions within it. For example, they bring their perceptions regarding the topic of science as well as multiple aspects of their identities, including gender, race, and status within their communities. The science mentor and teacher candidate each take up multiple subject position(s) within their interactions that involve images and metaphors of how each person is to act and respond within this particular context. When they both take up a subject position, they perceive the world from the vantage point of that position. Thus, each "individual emerges through the processes of social interaction, not as a relatively fixed end product, but as one who is constituted and reconstituted through the various discursive practices in which they participate" (Davies & Harre, 2000, p.

89). Understanding these positionings and their impact upon identity is important to consider in determining whether a science professor acting as a mentor for a teacher candidate can strengthen the preservice teacher's knowledge in science.

Procedures for the Science Mentor/Teacher Candidate Dyads

Traditionally, a university supervisor supports and guides the teacher candidate and the classroom teacher with whom the teacher candidate is placed. She or he articulates university requirements regarding student teaching in addition to observing and evaluating teacher candidates. This study involved the addition of a science mentor directed to assist the teacher candidate with the design and implementation of a one to two week science unit.

During the first week of an eight-week student teaching placement, the teacher candidate and classroom teacher decide on a science topic as part of a unit that the teacher candidate will design and implement during the second half of his or her placement. Once the science topic is selected, a science mentor, who has expertise on this topic, is assigned to the teacher candidate. The teacher candidate arranges for the science mentor to meet at his or her classroom. During this meeting, the science mentor receives further information about the direction of the unit as well as some of the characteristics of the students (e.g., ability level, ethnicity, socio-economic level, special needs). With this information, the science mentor provides assistance with the unit. At least one more contact between the science mentor and teacher candidate is arranged in order for the science mentor to review the teacher candidate's unit for accuracy of content and to give final suggestions before implementation.

Science Inquiry

One of the current directions in science preservice education is to focus more on pedagogy of scientific inquiry. The first content standard in the *National Science Education Standards* (*NSES*) (National Research Council [NRC], 1996), "Science as Inquiry," outlines abilities appropriate for all K-12 grade clusters. In grades K-4, students should be able to obtain competency in this standard by achieving the following at the end of 4th grade: (1) ask questions that can be answered with scientific knowledge; (2) plan and conduct a simple investigation; (3) employ simple equipment and tools to gather data and extend the senses; (4) use data to construct a reasonable explanation; and (5) communicate investigations and explanations. This content standard represents a decrease in the *NSES*'s emphasis on facts and an increased emphasis on major ideas.

Science inquiry offers interesting and important explanations about the natural world that lead to an understanding about various phenomena. Teaching science through an inquiry method models how scientists construct their knowledge, or essentially learn new things. Children enter classrooms with their own understandings of biological and physical phenomena. This preexisting knowledge is a powerful influence on the learning process, and teaching for conceptual change requires approaches that identify current student conceptions, introduces science concepts that are plausible, and provides numerous opportunities to apply these new ideas in a familiar context (Bybee, 2002). An inquiry-based approach to learning helps students see relevant uses of knowledge that allows them to make sense of what they are learning and their scientific understanding of the world (Bransford, Brown, & Cocking, 1999). The *NSES* calls for providing opportunities for teachers "to learn and use the skills of research to generalize new knowledge about school science and the teaching and learning of science" (NRC, 1996, p. 68).

This view of student learning is very similar to directions in early childhood education that support a constructivist, interactive perspective of learning that is more than telling and one that fosters children's natural curiosity. According to the National Association of the Education of Young Children, one of the principles of child development and learning that inform developmentally appropriate practices states, "Children are active learners, drawing on direct physical and social experience as well as culturally transmitted knowledge to construct their own understandings of the world around them" (Bredekamp & Copple, 1997, p. 13). In this context, children are encouraged to form their own hypotheses and keep trying them out through social interaction, physical manipulation, and their own thought processes by observing what happens, reflecting on their findings, asking questions, and formulating answers. Teaching science through inquiry, as reflected in the *NSES* (NRC, 1996), can be a challenging proposition to a teacher candidate who has never personally been faced with inquiry-based learning strategies in previous coursework or life experiences.

The Study

Context and Participants

The study was conducted at a public university located in the southeastern part of the United States. The university was founded as a normal school for teacher training and now graduates approximately 400 students per year. The university is situated in a suburban community of over 45,000 that is close to a major metropolitan area, attracting students from rural, suburban, and urban communities.

A total of 16 teacher candidates participated in the science mentoring program during the spring semester of 2003. All the teacher candidates were female; 14 were Caucasian, and two were African-American. Fourteen teacher candidates in the study were seeking preK-4 certification, and two teacher candidates were seeking K-8 certification with a K-4 notation. These participants typified the university's teacher education program.

Seven science professors, who had preK-12 teaching experience in the disciplines of biology, chemistry, physics, and astronomy, served as mentors. They assumed this responsibility in addition to their regular courseloads and received a nominal monetary compensation for their participation. Six of the seven mentors taught a content course specifically for elementary education majors receiving K-8 certification. This course involves integrating inquiry-based teaching within the classroom context. The early childhood (preK-4 certification) preservice teachers were not required to take this course. Thus, none of the mentors had any of the teacher candidates as students in their courses. Each mentor was assigned one to four teacher candidates, depending on factors such as the mentor's availability, unit topic, and driving distance from the university to school placements.

The science mentoring study is part of a larger project, the Renaissance Partnership Project, a Title II-funded initiative to improve the quality of graduates and teachers in local partner schools by focusing attention on preK-12 student learning. The university participating in this study is one of eleven teacher preparation institutions in ten states contributing to this five-year Title II project. The focus of the Renaissance Partnership Project involves the Teacher Work Sample Methodology, which is a process that enables a teacher candidate to demonstrate his or her abilities to plan, implement, and evaluate a standards-based unit of instruction for a specific class of students and to facilitate learning for all students.

One of the project objectives is to design a collaborative effort among a teacher educator, science faculty, and school practitioner to support teacher candidates in their design and implementation of a Teacher Work Sample (TWS). The following research questions framed the study:

1. a. What were the interactions and perceptions between the teacher candidates and their science mentors within the context of science teaching in kindergarten through 4th-grade classrooms?

   b. What was the relationship between the number of science mentor contacts and final TWS score?

2. What are the strengths and weaknesses of teacher candidates in the design and implementation of a standards-based science unit in preK-4th grade settings?

   (As a consequence of scheduling defaults, approximately one-third of the teacher candidates did not have mentors. Therefore, one additional question was addressed.)

3. What were the differences between teacher candidates who had mentors and teacher candidates without mentors?

Methodology and Data

All the teacher candidates designed and implemented a one- to two-week science standards-based unit within the context of a written TWS that included the following key processes: (1) Contextual Factors, (2) Standard-Based Learning Goals, (3) Performance-Based Assessment Plan, (4) Design for Instruction, (5) Instructional Decisionmaking, (6) Analysis of Student Learning, and (7) Reflection and Self-Evaluation. To evaluate the effectiveness of the dyads, teacher candidates and science mentors separately completed an open questionnaire form that focused on the number and types of contacts between each, contributions the science mentors made to the units from both the teacher candidate and science mentor's perspective, and suggestions for improving the mentoring relationships. A focus group interview was conducted with the science mentors to gather more descriptive data about their mentor/mentee relationships (Morgan, 1998). In-person or phone interviews were also conducted with teacher candidates, science mentors, classroom teachers, and university supervisors.

TWSs were evaluated with the Science Inquiry Rubric (Table 1), which was designed and based on the *NSES* (NRC, 1996) and the National Council of the Accreditation for Teacher Education (NCATE) (2002) guidelines. The purpose of the Science Inquiry Rubric was to determine the depth of science standards-based instruction and the degree of scientific inquiry that was incorporated in each TWS. The 17-item Science Inquiry Rubric measured four categories of abilities and one overall rating for unit design:

I. Developing abilities necessary to engage in scientific inquiry

II. Developing investigative skills

III. Developing data gathering, analysis, and communicative skills

IV. Developing understandings about scientific inquiry

Overall Rating for Unit Design – In the rubric design, NCATE standard rankings of unacceptable, acceptable, and target were assigned numerical scores to provide a range of values for analysis. The numeric ranks do not correlate to traditional grading assignments but are representative of low (1), high (10), and midrange (5) values. Each TWS was assigned a numerical value for each of the 17 subcategory items listed with the following Likert-type scale: Unacceptable = 1 – 4.9, Acceptable = 5 – 9.9, and Target = 10. Prior to its use in this study, the rubric was piloted and independently coded to identify relevant items. In order to ensure validity of the instrument, one professor of curriculum and instruction and two professors of science education reviewed the rubric. Revisions were made in order to place strong emphasis on scientific inquiry and lessen the focus on curriculum design. In addition to piloting the rubric, the TWSs were individually coded by two other researchers to establish inter-rater reliability (Cronbach's alpha coefficient of .88).

Findings

The study began with 16 teacher candidates who were each assigned to a science mentor at the beginning of their student teaching placement. Five of these teacher candidates didn't have any assistance from mentors due to unforeseen scheduling problems. Thus, the first research question focused on the interactions of 11 mentor/mentee relationships and the relationship between the number of contacts and the Science Inquiry final score on the TWS. Nonparametric analysis (Spearman Rank Order Correlation) was selected due to the small sample size, which determined that there was a medium, positive correlation between the number of contacts and the Science Inquiry final score on the TWS [$r = .37$, $n = 11$, $p < .05$]. The number of contacts between the 11 dyads ranged from 2 to 15 with an average of five contacts occurring between the dyads and a final Science Inquiry mean score of 87.6 (170 was the highest possible score). These contacts involved both in-person contacts (e.g., meetings at the teacher candidate's classroom placement, the mentor's office, and the mentor's home) and non in-person contacts (e.g., e-mail and phone). The science mentors visited their teacher candidates' classroom in 9 out of the 11 dyads. A school visit was not encouraged in one dyad where the teacher candidate was placed more than a 45-minute drive from campus, and another dyad decided a school visit was not necessary to assist with the science unit. All the dyads, except for one, reported the mentors' school visits to the classroom very helpful. Several of the teacher candidates expressed pleasure that their mentors made additional classroom visits to observe the implementation of their science units.

Ten of the eleven dyads perceived the science mentors as contributing positively to the design and implementation of the teacher candidates' science units. The science unit topics of the teacher candidates included Animals and Their Habitats, Plants, Weather/Seasons, Wood, Space, Solids/Liquids, Insects, the Human Body/Nutrition, and Earth/Rocks. According to both the mentors and teacher candidates, the mentors reviewed general ideas and/or lesson plans pertaining to the teacher candidates' science units and provided assistance in several ways. First, mentors assisted the teacher candidates in applying specific state and national standards and corresponding developmentally appropriate learning goals. Second, mentors explained and modeled hands-on activities related to the science units. Third, many teacher candidates had little or inaccurate knowledge about their unit content. Mentors helped dispel myths held by the teacher candidates by clarifying and integrating these concepts within the curriculum. Fourth, mentors provided resources as well as access to other professionals who could further assist the teacher candidates with their units. The quote below from a teacher candidate's questionnaire highlights the mentors' contributions to the science mentor/teacher candidate dyads:

> *She was very, very helpful! She allowed me to borrow materials so that my lesson would be hands-on. She also even took the time to contact another professor to see if I could borrow an insect collection from him, which turned out successful. She let me borrow books to help my lesson planning and we met every day during my unit to make sure I had all of the materials and information that I needed to make the lesson successful for the next day.*

The second research question evaluated the strengths and weaknesses of teacher candidates in the design and implementation of a standards-based science unit in preK-4th grade settings. To determine how all the teacher candidates compared with each other, all 16 of the TWSs were included for analysis and scores were derived from the Scientific Inquiry Rubric. The scores of each teacher candidate's TWS from the Science Inquiry Rubric is reported according to the sum of points and ranges of a Likert-type scale: Unacceptable = 1 – 4.9, Acceptable = 5 – 9.9, and Target = 10 with the highest possible total score of 170 points. Half of the TWS scores (this includes all of the 17 Science Inquiry Rubric items) were in the unacceptable range (59-84 total points), and half were in the acceptable range (92-135 total points). The highest TWS score converted to percentile was 80% and the lowest was 34%.

A breakdown of the Scientific Inquiry Rubric (Table 1) in accordance with the five ability categories of science inquiry found that the teacher candidates were strongest in Category I, "Developing abilities necessary to engage in scientific inquiry," in which all received a Target rating (10) on item 1 for identifying appropriate state or national standards for their unit and an Acceptable (8.0) average for the entire category. Category I did have one item rated Unacceptable (item 4 had 4.3), unit activities encouraging student questions. The other ability categories had sporadic Acceptable ratings with subcategory items. For example, under Category II, "Developing investigative skills," two subcategory items, 5 and 9, were rated Acceptable. These subcategory items encouraged student observation and information gathering based on those observations, and encouraged technological literacy skills. Under the other two ability categories—(III) "Developing data gathering, analysis, and communication skills" and (IV) "Developing understandings about scientific inquiry"—each had one Acceptable subcategory, item 14, learning tasks that engaged students in data gathering, and item 15, requires some opportunities for investigation and explanations based on observations.

The three other ability categories (II, III, IV) and overall unit design (V) showed an Unacceptable rating (4 to 4.6) average for the 16 TWSs. The lowest ratings by subcategory item were on those tasks that involved students planning their own investigations, the utilization and interpretation of data, and student collaboration and communication. For example, under Category IV, "Developing understandings about scientific inquiry," subcategory item 16, "Unit lessons are consistently designed to assist students in building communication skills in order to engage in self and peer evaluations," was rated a very low Unacceptable value of 2. In Category II, "Developing investigative skills," subcategory item 6, "Content and learning tasks include multiple opportunities for students to plan and conduct a simple investigation," rated an Unacceptable 3.1 average.

Table 1. Science Inquiry Rubric

	Mean Item Score	Non Mentor *n* = 5	Mentor *n* = 11
I. Developing abilities necessary to engage in scientific inquiry	8.0	8.0	7.9
1. Unit content is developmentally appropriate for targeted age/grade level.	10	10	10
2. All content is accurate.	8.8	9.0	8.6
3. All content reflects state and national standards.	8.8	9.0	8.6
4. All unit activities are consistently designed to encourage student questions about objects, organisms, and events in the environment.	4.3	4.2	4.4
II. Developing investigative skills	4.6	3.6	5
5. Multiple learning tasks encourage students to utilize observations and seek information based on their own observations.	5.7	5.0	6.0
6. Content and learning tasks include multiple opportunities for students to plan and conduct a simple investigation.	3.1	1.8	3.6
7. Unit activities require students to utilize several basic instruments/tools (ruler, magnifiers, scales, etc.) for science learning.	3.7	1.8	4.6
8. Evidence of multiple opportunities for students to develop science process skills (example: observe, measure, cut, connect, switch, pour, hold, tie, hook, etc.).	4.6	3.4	5.2
9. Unit allows for multiple opportunities for students to develop technological literacy skills such as using computers and calculators.	6.1	6.2	6.0
III. Developing data gathering, analysis, and communication skills	4.6	3.4	4.3
10. Learning tasks consistently engage students in data gathering.	3.8	2.6	4.4
11. Content, unit objectives, and learning goals are designed in a systematic manner that enables students to utilize data to construct reasonable explanations.	3.3	1.8	3.9
12. Learning tasks engage students in a high degree of collaboration.	3.4	5.2	2.6
13. Unit design provides multiple opportunities for students to communicate investigations and construct explanations based on simple data.	3.8	2.6	4.3
14. Unit design incorporates investigations that include multiple opportunities for students to describe objects, events, and/or organisms.	5.9	5.0	6.4
IV. Developing understandings about scientific inquiry	4.0	4.2	4.7
15. Unit design requires multiple opportunities for students to classify, experiment, use instruments, and develop explanations based on observations.	5.0	4.2	5.5
16. Unit lessons are consistently designed to assist students in building communication skills in order to engage in self and peer evaluations.	2.0	2.6	1.7
V. Overall Unit Design	4.6		
17. Overall unit design incorporates targeted areas and encourages the development of inquiry skills and student-centered science learning.	4.6	4.2	4.7

Scale: Unacceptable: 1 – 4.9, Acceptable: 5 – 9.9, and Target: 10
(Permission to reproduce or adapt this rubric is obtained by notifying one of the authors: Dorothy V. Craig, Kim Sadler, or Laurie Katz.)

The third research question compared the scores from the Scientific Inquiry Rubric of the teacher candidates' TWSs who had a science mentor with those teacher candidates who had no assistance from a science mentor. Due to small sample size (n = 16), the Mann-Whitney U Test was selected to determine differences between mentor and nonmentor TWS final score. Findings from nonparametric analysis of the final score did not support a higher-quality product that involved a mentoring relationship versus a teacher candidate who was not assigned a mentor. There is no statistically significant difference in the final TWS mean scores of the nonmentored (78.6 points of 170 possible) versus mentored (90.3 points of 170 possible) student teacher candidates (z value = -.341, with a significance level of p = .733); however, in two item subcategories mentored scores show an Acceptable average score of 5.2 (compared to a nonmentored Unacceptable score of 3.4) for item 8, "Evidence of multiple opportunities for students to develop science process skills," and an Acceptable average score of 5.5 (versus a nonmentored Unacceptable score of 4.2) for item 15, "Unit design requires multiple opportunities for students to classify, experiment, use instruments, and develop explanations based on observations." In contrast, nonmentored TWS Science Inquiry Rubric scores for item 12, "Learning tasks engage students in a high degree of collaboration" is higher than mentored TWS scores with an Acceptable rating of 5.2, compared to the Unacceptable, 2.6 rating for mentored TWS. Summary information for each ability category is shown in Table 1.

Discussion

The scores from the TWSs did not support a higher-quality product when a mentoring relationship was involved versus a teacher candidate who was not assigned a mentor. In lieu of these findings, 10 of the 11 teacher candidates did perceive the science professors as contributing positively to the design and implementation of their science units. It is important to realize that the mentoring program is only a small part of a teacher candidate's preparation for teaching science in the early grades. These findings will be discussed in the context of the mentor/teacher-candidate dyads and preservice teacher preparation.

Teacher Candidate/Science Mentor Interactions

Even though the science professors were well-qualified to act as mentors, their lack of impact may have resulted from how the mentors and mentees positioned themselves relative to the other in developing a standards-based science unit. For example, a mentor or mentee who positions the other in a traditional professor/student relationship will have difficulties developing trust and respect, which are critical to an effective relationship within this new context. The hierarchical position of the professor may hinder the teacher candidate from sharing concerns or asking questions about the science unit with the science mentor for fear of being judged negatively. For example, the science professor may think his position as mentor is to grade the lesson plans. Thus, if the mentee didn't have any lesson plans, there would be no assistance (i.e., no grading) with the science unit. Those professors who were able to reposition themselves were able to be helpful in alternative ways such as assisting with resources and instruction. The nonhierarchical positioning we were trying to create might have been deconstructed by positionings within the role of "professor," which may be shaped and assumed by both the mentor and teacher candidate according to other professor responsibilities within the university setting. Davies and Harre (2000) state that participants may be unaware of their assumptions or of their images when interpreting information in a particular context. For example, teacher candidates may hold assumptions about the nature of science as a discipline with high status, consisting of esoteric information and traditionally for males only. Teacher candidates who hold any of these assumptions (aware or unaware) may find it difficult to implement a science standard unit with a mentor.

The timing of the science mentor/teacher candidate dyads may have been a factor in challenging these assumptions and others held by the participants. In this study, teacher candidates were assigned to mentors at the beginning of their first placement. They usually conduct their unit plan between the fourth and seventh weeks of this placement. In some of these situations, by the time the teacher candidate met with her mentor, she had already received assistance from her classroom teacher and didn't perceive the need for the mentor. Furthermore, the mentor found it difficult to provide assistance in a situation where the teacher candidate had already designed her unit and perhaps wasn't willing to make many changes. Thus, there seemed to be a need for an extended time frame that allowed for mentoring interactions to evolve and for trust to be developed (Kochan, 2002) as well as time for participants to benefit from the resources that each person brings to the relationship (Martin, 2002).

Preservice Teacher Preparation in Science

The teacher candidates' science units demonstrated their strengths and weaknesses towards achieving a command of their subject matter within the preK-4 benchmarks. Most students, with or without mentors, were generally strong in identifying state and national science standards for their units; however, they seemed to have difficulty integrating these standards into their units in a manner that fostered scientific inquiry. Teacher candidates were particularly low in four areas of the Science Inquiry Rubric: (1) Learning tasks encourage students to utilize observations and seek information based on their own observations, (2) Learning tasks engage students in data gathering, (3) Learning tasks provide opportunities for students to communicate investigations and construct explanations based on simple data, and (4) Design of the unit lessons assists students in building communications skills in order to engage in peer or self-evaluation. Further analysis of the science units found that all of the science units involved hands-on activities as part of the learning tasks; however, these activities differed according to the type of materials or items used and the manner in which they were implemented within the unit. Activities that involved "real" objects better addressed inquiry benchmarks. For example, activities that involved a living plant fostered an inquiry approach where students were able to chart their observations on a graph recording growth based on amount of light and water. Conversely, activities that involved making a drawing of a plant on paper prevented this type of inquiry process. Another difference related to how student knowledge was perceived. Many units developed products that were created in a manner in which students communicated their knowledge primarily from assessments in the form of a "correct answer" response versus any data that they actually collected. For example, a teacher candidate who implemented a unit on wood displayed different types of wood from computer or video/laser disk pictures. Products included making a book about a particular type of tree. Then, students were assessed regarding their knowledge of wood through written responses. A more scientific inquiry lesson would entail using actual pieces of wood for students to explore the unique characteristics of wood and communicate their findings with each other. Their knowledge might be assessed by describing differences in types of wood through charting characteristics such as growth rings, color, and texture.

Recommendations

The following are recommendations for strengthening preservice early childhood teacher education programs in order to prepare teachers to develop and implement standards-based science lessons:

1. Develop partnerships between early childhood education faculty and science content faculty. Previous to this study, the teacher candidates had minimal understanding as to the nature of scientific inquiry within standards-based science units. Furthermore, they were unable to apply their knowledge from previous science classes. The science-mentoring project created a dialogue for both disciplines to begin redesigning their curriculum to strengthen the teaching of science to early childhood preservice teachers.

2. Expand the timing of the science mentor/teacher candidate assignments. Assigning science mentors to teacher candidates during the last part of their preservice teacher education program is an insufficient amount of time to change assumptions about science or to strengthen science content and pedagogy. Kochan (2002) describes successful mentor/mentee relationships to include both participants committing to making the relationship work, caring about each other, and being comfortable working with each other. Assigning mentors for longer periods of time with their teacher candidates will strengthen these relationships. Examples include assigning mentors when teacher candidates begin taking science prerequisite certification courses and continuing with these mentors through a practicum or student teaching placement. A field experience component in a teacher preparation program provides a context for the mentors to directly assist the teacher candidates in transferring theory into practice.

3. Further identify other competent individuals who will serve as mentors. Individuals who have K-12 teaching experience and a strong background in science include graduate students majoring in science, inservice teachers, and retired science teachers. Science professors are vital resources to preservice teachers, but their backgrounds don't always include K-12 teacher education experiences and their responsibilities limit the number of students they can assist during a specified period of time.

4. Further integrate a scientific inquiry approach throughout an early childhood preservice teacher education program. This study demonstrated that teacher candidates appear to have knowledge of the importance of hands-on activities in standards-based science lessons, but lack the understanding of the use of materials and how to integrate these materials within hands-on activities that incorporate an inquiry approach. Teaching with inquiry is not a model that most of us have seen ourselves; this requires a complete paradigm shift from a focus on "teacher talk" to "student think." Many teacher education programs integrate a scientific inquiry approach only in science methods courses. Developmentally appropriate concepts are important, but greater emphasis should be placed

on an inquiry approach throughout the curriculum. Expanding the scientific inquiry approach through all of the early childhood certification courses will strengthen the teacher candidate's understanding and implementation of this approach within the early childhood classroom.

5. Further analyze the interactions between science mentors and teacher candidates. This study began laying the framework to analyze mentor/mentee interactions in terms of how science mentors and teacher candidates position themselves within their relationships versus their prescribed roles. Strengthening these relationships involves further research into the dialogue between science mentors and early childhood education teacher candidates to better understand the many positions that are created through these dyads.

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