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Introduction

Teacher Dispositions

The identification of dispositions as a gauge for teacher effectiveness has become a part of many school systems and teacher education programs. Accrediting agencies, such as the National Council for Accreditation of Teacher Education (NCATE) and the Interstate New Teacher Assessment and Support Consortium (INTASC), have been instrumental in emphasizing teacher dispositions' presence in higher education institutions and local schools. NCATE defines dispositions as: "Values, commitments, and professional ethics that influence behaviors toward students, families, colleagues, and communities and affect student learning, motivation, and development as well as the educator's own professional growth" (2006, p. 53). NCATE and INTASC strongly suggest that teachers have certain dispositions to allow for teacher effectiveness (Smith, Knopp, Skarbek, & Rushton, 2005; Thornton, 2006; Koeppen & Davison-Jenkins, 2007). Administrators' view of teacher dispositions is valuable as well. They will need to assess teachers' dispositions to determine the effectiveness of instruction and their attitude towards the teaching profession.

In 1992, INTASC generated specific standards (knowledge, skills, and dispositions) that teachers should have upon beginning the profession. This list of principles and knowledge, skills, and dispositions was designed by twenty-five educators, including teachers and representatives from education agencies. INTASC's dispositions include:

- Understanding of concepts, inquiry, and discipline
- Understanding of child development and learning
- Use of differentiated learning and instruction
- Understanding and use of various instructional strategies to develop critical thinking, problem solving, and performance skills
- Individual and group motivation of students
- Use of verbal, nonverbal, and media communication techniques
- Use of instructional planning based on content, students, community, and curriculum goals
- Use of formal and informal assessment strategies

- Being a reflective practitioner
- Maintenance of healthy relationships with educational constituents for the sake of the student.

These attributes would allow teachers to best prepare their students for those skills needed to function in the 21st century (INTASC, 1992).

Because of NCATE's use of teacher dispositions in accreditation, teacher education programs have utilized them in collegiate courses and for professional development, respectively. NCATE clearly states that teachers should have dispositions of fairness and the belief that all students can learn. Additionally, NCATE strongly suggests that INTASC be referred to for the identification of specific dispositions that beginning teachers should have upon beginning the profession (NCATE, 2006). Since then, a number of studies have been conducted to support INTASC and NCATE in the use and significance of teacher dispositions as factors in teaching effectiveness (Thompson, Ransdell, & Rousseau, 2005; Edwards & Edick, 2006).

The assessment of teacher dispositions within evaluation systems for continued employment falls to school systems and their administration and principals. Teacher dispositions help determine teacher effectiveness in the classroom (Taylor & Wasicsko, 2000). Therefore, principals can use this information to predict and determine effectiveness of teachers. In a study conducted by Thompson, Ransdell, and Rousseau (2005), the researchers decided to observe elementary teachers that were deemed effective by their principals. Effectiveness was determined by students' scores on standardized tests and by principals' own individualized criteria (which was not identified in the study). The dispositions of fourteen elementary teachers were investigated, by comparing their dispositions to the INTASC standards for beginning teachers. Teachers were found to communicate well, but preferred to use direct instruction as opposed to various instructional techniques. The researchers confirmed the thoughts of the principals, in that they also concluded that the teacher participants displayed dispositions of effective teachers (Thompson, Ransdell, & Rousseau, 2005).

Since it has been established that teacher quality and effectiveness is of such importance, it is imperative that teacher dispositions, as well as knowledge and skills, are further studied. Teacher knowledge, skills, and dispositions should also be studied under a narrower focus, by studying them in the various content areas. This study calls for the attention of teacher knowledge, skills, and dispositions in the area of elementary science. By studying and focusing on elementary science teacher knowledge, skills, and dispositions, educators associated with the elementary setting may collaborate and foster teacher effectiveness in science teaching.

Professional Development Schools and Teacher Dispositions

In discussing the need for collaboration on teacher dispositions among elementary schools and colleges and universities, one must consider the importance of The Professional Development School (PDS). The PDS is intended to create working and close relationships between education faculty and local schools. According to NCATE, "Professional developments schools are innovative institutions formed through partnerships between professional education programs and P-12 schools. Their mission is professional preparation of candidates, faculty development, inquiry directed at the improvement of practice, and enhanced student learning" (2001, p.1). Professors and their students are visible in surroundings schools, as research, collaboration, and open communication are key and essential to the success of the PDS. The central purpose is to improve the teaching practice (Darling-Hammond, 2005; Marlow, Kyed, & Connors, 2005; Ridley, Hurwitz, Hackett, & Miller, 2005; Castle, Fox, & Souder, 2006). However, educational constituents' attempt to achieve this purpose or objective has not been unproblematic. Colburn (2003) notes that institutions and schools have different goals with different cultures; this causes difficulty in finding PDS models that effectively display effective teaching, training, professional development, and research. Colburn likens the PDS to a hospital; the PDS unifies teachers, preteachers, and professors, in the way that a hospital brings together doctors, future doctors, and researchers (2003). All participants of the Professional Development School should benefit as a result of taking part (Marlow et al., 2005).

The PDS partnership has shown great promise in improving both student achievement and teaching dispositions. In Bell's (2002) study of a PDS elementary science partnership and the National Science Education Standards (National Research Council, 1996), the researcher hypothesized that the PDS model, tied with the National Science Education Standards, would help to improve science education and elementary science teaching. With an emphasis on teaching science through inquiry, inservice teachers' science beliefs and attitudes were increased as a result of being involved in the PDS. Like preservice teachers, they also showed significant gains in learning when actively engage in inquiry-based teaching (Bell, 2002).

Specifically, this study focuses on the perspectives of practicing teachers, principals, and professors of elementary science education in a Professional Development School arrangement on essential knowledge, skills, and dispositions needed for effective science instruction. The following questions guide the study: (1) How do elementary principals in this local case study view effective knowledge, skills, and dispositions for elementary teachers who teach science? and (2) How do these knowledge, skills, and dispositions differ from what elementary teachers have learned from their university-based learning and what science teacher educators feel are needed for effective elementary science teaching? A discussion of related literature, methods, data analysis, results, followed by implications for further study, will now be discussed.

Literature Review

Elementary Science Teacher Knowledge, Skills, and Dispositions

In 2002, the National Science Teachers Association (NSTA) put forth their official statement on effective elementary science teaching. In their statement, inquiry-based instruction and learning is placed at the forefront as part of the daily curriculum. Teachers are also expected to prepare students to be problem-solvers in a society of science and technology. Additionally, NSTA (2003) created a number of standards for candidates preparing to teach K-12 science. These standards were based on previous research and the National Science Education Standards (1996), the framework for teacher preparation in science instruction, and provide guidance in ideal dispositions for effective science teachers. The goal of these standards is for teachers to lead students to becoming scientifically literate, understanding the subject of science and use problem-solving skills when investigating information. NSTA also encourages teacher education programs to use these standards as a foundation for assessing preservice teachers' performance in science instruction (2003).

Pedagogical content knowledge and scientific inquiry are two topics that are associated with the effectiveness of elementary science teaching, and relate to this study. The NSTA's stance is for elementary teachers to be involved in professional development that will build their pedagogical content knowledge for teaching science (2002). Also, from a national perspective, the National Science Education Standards state, that through professional development, future and practicing teachers must be afforded with experiences that help them build their understanding of science content knowledge (National Research Council, 1996). The NSTA simply states that science inquiry must be a daily part of students' schedules (2002). This statement rests on the belief that children learn best when they are guided to use inquiry and process skills in science, as well as being provided with opportunities to explore and investigate. The NSTA (2002) also asserts that students value science instruction when elementary teachers model inquiry-based learning for their students. They suggest that the learning cycle be used to teach exploration and questioning strategies in scientific inquiry (NSTA, 2004).

In relation, INTASC has created a list of standards that include knowledge, skills, and dispositions for beginning K-12 science teachers. The standards provided are different than the previously mentioned standards, in that they are specific to the subject of science. These standards, in INTASC's opinion, will promote scientific inquiry and student learning within science classrooms (2002). The standards include: content knowledge; student learning and development; student diversity; instructional variety; learning environment; communication; curriculum decisions; assessment; reflective practitioners; and community membership (INTASC, 2002). Because of their specificity in nature, the knowledge, skills, and dispositions provided by INTASC were used to analyze this study.

Administrators' Role in the Teaching of Science

This study also takes into consideration perspectives of elementary principals on elementary science teacher knowledge, skills, and dispositions. Teachers have recently repeatedly vocalized the fact that science instruction is limited within their classrooms, due to continued emphasis on reading and mathematics and high stakes testing (Griffith & Scharmann, 2008). There are few studies regarding elementary administrators' positions on science teacher knowledge, skills, and dispositions. However, a few works or studies discuss administrators' role in the delivery of science education (Spillane, Diamond, Walker, Halverson, & Jita; 2001; Lewthwaite, 2004).

When delivering science instruction, elementary teachers often have a feeling of inadequacy in teaching the subject, and often "think of science as a body of knowledge" (Eiss, 1962, p. 171). These feelings of inadequacy cause teachers to be reluctant to teach science, and if administrators can find ways help these teachers, these same teachers can become advocates of science programming within their schools (Eiss, 1962). Eiss also proposes that principals provide professional development in science and appoint a science supervisor or specialist, who could easily be a classroom teacher already employed at the school. Eiss stresses the need for cooperation from administrators to ensure a high-quality elementary science program (1962).

Adding to previous research, the NSTA published a series of handbooks on administrators and elementary science education (1983). The handbooks, entitled "Promoting Science Among Elementary School Principals," sought to provide principals with methods for identifying and maintaining effective elementary science programs within their schools (Mechling & Oliver, 1983). Administrators were provided with a checklist for the purpose of assessing their science program, and as a means for providing goals for administrators to work toward. The authors were innovative in that they focused solely on providing principals with sound advice and methods for successful science education programming.

NSTA also provided guidelines for administrators' role in elementary science education (2002). In their statement of elementary science education, they assert that administrators must become active supporters of science instruction within their schools and become instructional leaders by ensuring that programs are based on national and state standards and examining the programs' success. Administrators must form a support system for science programs, by providing resources for science instruction, noting that excel in science teaching, and promoting science events within the school (NSTA, 2002).

Current studies center on not only elementary science teachers, but also those that work closely with them or those that can affect them (Darling-Hammond & Sato, 2006; Klentschy & Maruca, 2006; Saginor, 2006). These studies echo the sentiments of Mechling and Oliver (1983): Science education reform in the schools is more likely with the support of the building principal. Specifically, Saginor states that the principal as leader must:

[M]anage the culture of change and build professional learning communities; cultivate teacher-leadership; advocate for science to be taught in elementary school to support literacy; provide for proper professional development; understand standards-based science so when he or she knows what to look for when observing a class; [and] have tools to supervise teachers in the best instructional practices for producing enduring learning and deep content in science. (2006, pp. 164-165)

Lewthwaite observed that teachers were uncomfortable with their principal's role in science instruction (2004). Teachers and administrators agreed to work together to improve science programming within their elementary school. Although teachers are ultimately responsible for delivering instruction within their classrooms, principals are held accountable for professional development, mentoring, and ensuring that their teachers meet the high standards that educators often expect from their students (Darling-Hammond & Sato, 2006; Saginor, 2006).

Principals are essential to the success of the elementary school. They bridge the gap between teachers, parents, community members, and higher education institutions. In the area of elementary science teacher knowledge, skills, and dispositions, their role is also vital. Administrators directly and indirectly affect the change or development of teachers' dispositions regarding science instruction, and must frequently make most of the decisions in their schools. These choices can often shape the knowledge, skills, and dispositions of the school's elementary science teachers.

Participants and Context

The participants consisted of eight elementary science teachers and their two principals of a small southeastern school district in close proximity to a land-grant university with a large teacher education college. Two schools (Jefferson Elementary and Rosebud Elementary) represented the participating school district. As mentioned in the previous chapter, these elementary schools were chosen because of the close relationship that was formed between the school system and the university. Science education instructors from a large southeastern university also participated. The science teacher educators that participated were tied to the teachers and principals based on a Professional Development School (PDS) program, in which the professors were often visible within the schools. (For confidentiality purposes, pseudonyms have been used for participants' names and the names of their schools.)

Teachers

Eight elementary science teachers from two separate elementary schools participated in the study. Teachers taught grades three through five. Five teachers took part in the study from Jefferson Elementary, and three teachers participated from Rosebud Elementary (See Table 5). These teachers were selected with the understanding that science was being taught on a regular basis. All teachers have self-contained classrooms; they teach and are responsible for the same students for the entire day. Jefferson Elementary teachers have been in the profession from one to eleven years. Rosebud Elementary teachers have taught seven to twelve years.

Table 5 – Teacher Participants. This table represents teacher participant descriptive data.

Teacher	School	Grade Level Taught	Number of Years Teaching Science
B. Elsner	Jefferson Elementary	3rd	1
R. Davis	Jefferson Elementary	5th	11
L. Karwoski	Jefferson Elementary	4th	2
D. Gardner	Jefferson Elementary	3rd	2
M. Malone	Jefferson Elementary	3rd	4
T. McDowell	Rosebud Elementary	5th	11
J. Holston	Rosebud Elementary	5th	12
A. Douglas	Rosebud Elementary	4th	7

Principals

The schools in this school system are unique in that they only have head principals, and no assistant principals. Dr. Chappell, the principal of Rosebud Elementary, taught fourth grade science for six years before becoming an administrator, and was in his eighth year of being a principal at the time of the study. He taught science twice a day, in addition to teaching math and history each day. The principal of Jefferson Elementary, Mr. Daniels, taught science and reading for two years within a departmentalized, middle school setting. He has been a principal for five years. While teaching science, he equated his teaching effectiveness to whether students had a clear understanding of the purpose of the activity being conducted.

Science Teacher Educators

The professors, Dr. Miller and Dr. Scott, are the sole faculty members that teach science education courses to elementary science majors at the university. Dr. Miller began teaching secondary science methods courses (for seven years) before moving on to teaching elementary science methods courses for three years. He taught for approximately ten years, in middle and high school settings, before becoming a science teacher educator. Dr. Scott has taught elementary science methods courses for six years. Before becoming a science teacher educator, she taught fifth grade science for four years and taught elementary students through the National Aeronautics and Space Administration (NASA).

Relationship of Participants

The schools and college in this study interact with each other on a consistent basis, based on their PDS-type relationship. The schools are both used for elementary intern placements from the college, as well as laboratory placements during methods courses. The schools, Jefferson Elementary and Rosebud Elementary, are both considered intermediate schools since their grade levels range from three to five. Each teacher instructs students in self-contained classrooms, and science is taught on a daily basis, although some admit to not being to always teach it daily. The amount set aside for science instruction ranges from 30 to 45 minutes long. Teachers conduct lessons according to their state's course of study, including materials funded by the Alabama Math, Science, and Technology Initiative (AMSTI). AMSTI (2009) utilizes research- and inquiry-based curriculum designed to improve mathematics and science instruction. Kits are the basis of the curriculum, such as the Full Option Science System™ (FOSS) and Science and Technology for Children™ (STC) programs. After principals agree to enroll their school in the AMSTI program, teachers and administrators attend training. Teachers receive an additional 120 contact hours before completion; administrators' training is less than that of teachers, and the amount of training they receive is not specified. The AMSTI program also requires participating schools to work closely with a neighboring college or university (2009).

Methods

Data Sources

After gaining consent from participants, the researcher conducted individual or focus group interviews to collect data regarding elementary science teacher attitudes and opinions of elementary science teacher dispositions. Individual face-to-face interviews were conducted for the principals and science teacher educators. The researcher chose to conduct focus group interviews with the elementary science teacher participants. Utilizing focus groups can help to incite emotions and spontaneity about the topic at hand (Kvale, 1996). A list of guiding interview questions was utilized for each interview (See Appendix). The participants answered questions relating to their science teaching experience, the length of time dedicated to science instruction, and beliefs about ideal elementary science teacher dispositions.

A number of artifacts were collected as well. According to Schwandt, "An artifact is an object that carries meaning about the culture of its creators and users. Understanding and interpreting the composition, historical circumstances, function, purpose, and so on of artifacts are central to the study of material culture" (2007, p. 9). Elementary science teachers were also asked to submit lesson plans to supplement the study. Each teacher was asked to choose and submit a lesson that represented their most effective science lesson. Science teacher educators were asked to submit syllabi for their science elementary methods courses. These items were used to provide triangulation for their thoughts and perspectives of elementary science teacher dispositions (Schwandt, 2007). A personal researcher journal was also kept, by the researcher, to record thoughts and ideas related to implementation of the study. The journal provided a means of personal observations and realizations made during the researcher's journey, as she conducted interviews and transcribed and analyzed data. According to Lichtman, a journal helps one self-reflect on his/her thinking and motivation, which affects is affected by research interests (2006).

Data Analysis

The data collected were analyzed across participating schools, and the university, as a multi-site study, and part of a larger case study on elementary science teacher dispositions (Cresswell, 2007; Lichtman, 2006). Cases included teachers and the principals of each school. Individual cases were studied within a bounded system of the local university-teacher education program. Therefore, each school is considered an individual case, along with its relationship with the university, and then studied across cases in comparison to the other elementary school (Creswell, 2007).

One audio-taped focus group interview was conducted with the teachers at each school. This resulted in two total focus group interviews. The researcher also conducted individual audio-taped interviews with each principal and science teacher educator. All interviews (individual or focus group) were transcribed and analyzed in a text document, using the research questions previously stated (Kvale, 1996). The researcher looked for patterns in responses as they related to elementary science teacher knowledge, skills, and dispositions and participants' attitudes and beliefs towards science instruction, and coded these in categories. For example, after reading participants' responses that related to materials and delivery of instruction, having a lack of resources and hands-on science were two topics that stood out immediately to the researcher, and became the titles of categories for participants' responses.

Responses were coded based on commonalities that were then noted as emerging themes. The noted themes became evident during the initial and second coding processes. For example, themes of hands-on science, inquiry, exploration, and discovery emerged as educators discussed the best approaches to teaching science. Themes were recorded in a text document using word processing software. These themes were compared and contrasted as they became evident to the researcher (Coffey & Atkinson, 1996; Creswell, 2007; Schwandt, 2007). In the within-case analysis, commonalities were noted within each school or case (e.g., Jefferson Elementary vs. Rosebud Elementary). Next, in utilizing a cross-case study analysis, commonalities were noted by looking at both schools, or across cases (e.g., Jefferson Elementary and Rosebud Elementary) (Creswell, 2007). Topics and dispositions identified by teachers and science teacher educators were also compared to their corresponding artifacts (lesson plans or syllabi), to corroborate participants' responses.

Interestingly, during this overall process, the researcher noticed that principals were responding differently than teacher and science teacher educator participants, in many instances. As emerging themes became evident, the researcher created a table or matrix to help interpret and provide a visual representation of these findings (Yin, 2003). The matrix noted the responses that principals gave, in comparison with the teachers and science teacher educators, to the questions asked during the individual and focus interviews. This particular chapter discusses principals' responses, in contrast with the other educators, and what was noticed after the original study was conducted. The results represent those responses and differences that were most evident to the researcher. Evidence of participants' thoughts and ideas are provided through excerpts from interviews, along with interpretations made by the researcher.

Results

The elementary teachers and science teacher educators were in agreement on what was most important for the knowledge, skills, and dispositions of elementary science teachers. However, the principals did not vocalize many of the same knowledge, skills, or dispositions as the other two groups of educators. Principals responded differently to the questions being asked in the study, although all participants were asked the same or similar questions at the time of their interviews. Table 6 shows the themes emergent in this study on the interview questions asked for principals, elementary teachers, and science teacher educators. The table was created to provide a visual representation of the findings that emerged in the study. Teacher and science teacher educator responses are labeled together, since they're responses were similar in nature.

Table 6 – Emergent themes from interview questions. This table displays the themes emergent from principals and other participants on key interview questions.

Interview Question Being Addressed	Principals' Responses	Teachers and Science Teacher Educators' Responses
Self-Evaluation ofTeacher Effectiveness	• Enjoyment • Refined Practice	• Content Knowledge
Value of TeachingScience	• Experiments • Hands-on Science	• Real-Life Applications • Student Connections
Best Approach to Teaching Science	• Hands-on Science	• Scientific Inquiry • Exploration/Discovery
Lesson Planning		

	• Lack of Resources	• Planning for Instruction

Delivery of Instruction versus Content Learning

One of the interview questions asked principals if they felt as if they were effective when they taught science, while elementary teachers and science teacher educators were asked if they thought that they were effective in their current positions. The two principals responded differently than the other educators, and responded differently when compared to each other as well, although their responses related to delivery of instruction. Mr. Daniels equated his teaching effectiveness to being able to improve his delivery of instruction from year to year, and being able to conduct experiments with his students. On the other hand, Dr. Chappell shared that he thought that he was effective because he was able to enjoy the material as he delivered science instruction. He also stated that he was ineffective at times, due to not having the proper resources to be effective while teaching science.

Pretty much…ah…I think I was okay! I was always willing to improve from different experiments that we had done from one year to the next year, and looking at ways at trying to reach the students to make sure that they were having a clear understanding of the purpose of the different experiments and why we were doing them. [Daniels, Principal, Jefferson]

I think that I would say yes I was [effective], but it's *because* of the fact that I enjoyed it so much. You know science, and *especially*…you know, in areas like the weather and the earth and that kind of stuff. Um…but then again, I'm saying probably not because of what I just said about the limitations of…of resources. But, because I enjoyed it so much though, I…I would lean more towards the yes side. [Chappell, Principal, Rosebud]

In contrast, teachers and science teacher educators mentioned the need for content knowledge for teacher effectiveness. Content knowledge was noted by both groups of educators as a necessity for effectiveness in teaching elementary science.

I learned this year with my kids. I was like…I was learning things this year in science that I don't know that I've ever…I probably was taught at one time, but I don't remember it so, this year I was like, "Oh ok!..Yeah!" You know, "I'm learning something with y'all!" [Douglas, Teacher, Rosebud]

Professors provided support for content knowledge in their syllabi for their science methods courses. Dr. Scott's course description stated that preservice students would be introduced to content that would be needed to teach in their own classrooms. In Dr. Miller's syllabus, the course description states that the course:

Was designed to assist prospective teachers in developing the confidence and

competence needed to begin teaching science as a hands-on, process approach in elementary classrooms. This competence involves a basic level of understanding of the subject matter and the inquiry nature of 'doing' and learning science…

Of the course objectives, one states that students will be able to develop competency and an enjoyment of science instruction as a result of being in the course. Dr. Miller also utilized reflective journals in the course, so that students could make the necessary connections with what was being learned as they taught and observed in the cooperating teachers' classrooms.

Hands-On Science versus Connections to Life and Academic Success

Participants were also asked what they valued about teaching science as a subject. When principals responded, they both stated that they enjoyed administering hands-on science instruction, or teaching science using experiments. They also added that the textbook should be used as a supplementary resource. Interestingly, Dr. Chappell again mentions the lack of resources having a negative effect on science instruction.

I liked the fact of having…hosting experiments and having like a hands-on science in the classroom along with the textbook as a reference. [Daniels, Principal, Jefferson]

Well, I enjoyed it! Now, the only thing was, there were limitations because, we were kind of…we were very much limited to the textbook, which I don't think is good…So, on those few rare occasions where we could actually do some kind of experiment or something like that…*those* were the ones that I really valued and the ones I think that the students valued as well! Where they were able to actually do something and see something and experience something, but just being tied to the book though made it difficult. [Chappell, Principal, Rosebud]

On the other hand, elementary teachers and science teacher educators responded differently than the principals, but similar to each other. Being able to relate science to everyday life and providing a foundation for further study was mentioned as a skill needed for elementary science teachers. The following excerpt is representative of teachers' and elementary science teacher educators' response being asked what they value about teaching science as a subject. Dr. Scott states:

One of the things that I value is that I understand, and I want my students to understand that yes science is a content class, but it also offers so many other things in helping you deal with real-life situations and real-life application. There's problem-solving. You know we have to problem-solve and do things every day, and one of the statements I make to *my* class is that, "We're *all* scientists." Because every day we make observations, we do investigations, we experiment, we collect like data…So that's really important to me, to be able to use science as a vehicle for being able to operate in the everyday world. [Scott, Professor]

In regard to applying instruction to everyday life for students, teachers and science teacher educators were aware of the need for this skill for elementary science teachers. Teachers recognized that many of their students need to understand the importance and reasoning behind learning about science. The teachers made connections in their instruction to address these needs, and also wanted to provide a foundation for higher grade levels. In her submission of "Lifeboats Investigation" as one her most effective lesson plans, Ms. McDowell, of Rosebud Elementary, stated that she originally chose the lesson because it prepared them for higher-level sciences. Ms. Holston, also of Rosebud Elementary, enjoyed her lesson on observing microscopic worlds because it provided a closer look into students' worlds. Ms. Davis, of Jefferson Elementary added, "I value it because in fifth grade, the kids are starting to understand that they can take this into the future that their jobs in the future will have, will be related to what they are doing now." In the collegiate setting, Dr. Miller notes that throughout the semester, preservice teachers would gain practice teaching and learning in an everyday atmosphere.

Simply Hands-On versus Inquiry and Discovery

Teachers utilize various methods to dispense learning within their classrooms. In terms of instruction, teachers and science teacher educators referred to inquiry-based instruction and using exploration and discovery in their teacher methods. Principals, on the other hand, simply emphasized a hands-on approach to help reinforce learning in a way different from simply traditional teaching methods.

Hands-on Science

When asked how students learn best, both principals participating in the study responded differently than their counterparts. However, they responded similarly to each other. Instead of referring to inquiry, discovery, or exploration in teaching as an elementary science skill or dispositions they discussed the importance hands-on science within classrooms.

My beliefs is that students should be at least introduced to the opportunity of learning science in a different manner…to where it's either hands-on or having enough resources in the classroom to where it addresses some of the things that they're interested in, as far as their prior…or prior knowledge about different objectives that they have to cover each year at each grade level. [Daniels, Principal, Jefferson]

[To] me they learn it when they're actually doing it. So, I mean it keeps coming back to that same thing over and over, and that is the theme of actually being able to *do* some things with their hands and not just sit there with the textbook and look at a few pictures. You know that…that's *good* and has its place, but…you know if they can actually be doing something, they'll get a whole lot more out of it. And it sticks with them, too. [Chappell, Principal, Rosebud]

Hands-on science is preferred instead of textbook-related activities. Mr. Daniels also makes mention of the need for resources and alludes to science instruction being effective when students' prior knowledge is activated. They responded differently, when compared to the other participants, to being asked how students learn science best.

Inquiry

The following response includes an answer representative of teachers and science teacher educators being questioned about perspectives of the best teaching methods for science and how students learn science best.

My approach is to first build my background knowledge of what I'm teaching and then to think of a way to introduce the topic at hand that gets my students using the scientific process or method. I think of an activity in which they are able to build inquiry upon and then I introduced the vocabulary and or facts. [Elsner, Teacher, Jefferson]

The use of inquiry-based teaching can also be categorized under instructional variety as a fundamental elementary science teacher disposition. The teachers and education faculty discussed inquiry as the best, or one of the best, approaches to teaching effectiveness. In her lesson plan on matter, Ms. Elsner's students took part in observations and questioning practices. She stated that she created and chose this particular lesson plan because it allowed students to participate in scientific inquiry. In the course syllabus for the elementary science methods course, Dr. Scott simply asserts that the students will explore inquiry-based planning and teaching practices. Course periods were devoted to discussing the meaning of inquiry, inquiry process skills, and inquiry-related assessment. Dr. Miller required preservice students to use resources that tie inquiry to children's literature. Students learned about the nature of doing science as it relates to inquiry, and modeling and practicing inquiry-based teaching. It is also interesting to note that inquiry is the only topic or disposition mentioned here that is not mentioned by teachers from both schools; only teachers from Jefferson Elementary and the science teacher educators discuss inquiry in science.

Exploration and Discovery

In addition to inquiry-based learning, science teacher educators and teachers of the study agree that students should take part in exploration and discovery to reach their highest learning potential. Again, the following excerpt is a teacher response to how students learn science best.

I think they learn through like, actually discovering. Like, you can't tell a child that if you plant a seed it's gonna grow some roots, and then it's gonna grow into a plant with a flower, and then the process starts…[Growing a plant] might take a month…but over time, they're going to remember and retain information more because they actually saw it and used it…I think they learn better by actually discovering…So I think allowing them to take some responsibility and learn on their own helps them actually see it. [Karwoski, Teacher, Jefferson]

Ms. Karwoski, of Jefferson Elementary, submitted a lesson plan on animals and how their characteristics help them adapt to their environment. In her reasoning behind choosing the lesson plan, she stated that she chose the lesson because students could discover science instead of simply being taught science. Dr. Scott has time set aside in the course to discuss discovery learning's impact on students. Dr. Miller, a science teacher educator, predicted that elementary teachers would mention dispositional qualities related to exploration, hands-on science, and investigations. Interestingly, his response was a mixture between teacher and administrator responses.

Resources for Teaching versus Lesson Planning

In discussing planning, organization, and preparation for science teaching, both principals note that having a lack of resources can negatively impact lesson planning and science instruction in the elementary classroom. In the following responses, administrators state how they think teachers will respond to being asked what dispositions are needed to be effective.

The fact of having adequate resources to be able to host the different types of hands-on science experiments in a regular classroom and making sure you have enough for all the students that are within that classroom. [Daniels, Principal, Jefferson]

I think most of them would probably say the same thing. It's just that it goes back, though, to so many times having limitations on your resources. And of course you know, now next year they're saying that it's not going to be…we're going to be real short on funds. Well, that's going to be tough! Because, you know, you don't really expect your teachers to go out and spend his or her money on all of these supplies, even though I know some do! But…but I think when it gets down to it though, I think that most of them would have that same feeling that I do that it's best to not be limited to that textbook. [Chappell, Principal, Rosebud]

Dr. Chappell also predicts that teachers will state that being limited to the textbook for instructional practice will limit them in terms of effectiveness, and includes funding as well as materials in terms of resources for science programming.

Lastly, teachers and education faculty stated that elementary science teachers must set time aside to plan, organize, and prepare for lesson planning in order for science teaching to be effective. Ms. Karwoski admitted that she has learned from not taking time to plan head for science lessons.

I think you have to plan ahead, which is really hard for me a lot of times because we do

have so many other things going on that it's like, oh, I have this great idea, but [I] haven't planned it so it doesn't turn out exactly like I would have wanted it to…so I feel like you have to be able to plan in advance and try things before your students try them. [Karwoski, Teacher, Jefferson]

Dr. Miller, a science teacher educator, adds that elementary science teachers must be able to plan ahead of time what should be taught.

There has to be some sense of a system or organization inside that person that enables them to plan and prepare and lay out what needs to be taught…especially as a new teacher. If you can't do that, it's *rare* that you're going to be able to wing it without experience as a brand new teacher. So I think that's important. [Miller, Professor]

In his syllabus, Dr. Miller notes that preservice students will learn how to plan effectively for science instruction. Time is provided in the course to prepare for their co-teaching assignments. Two lesson plans are submitted in the course. Dr. Scott ties in technology with lesson planning in her elementary science methods course. Time is also given, within the course, for learning how to plan and manage science instruction within the elementary classrooms. Three lesson plans are submitted before ending the course.

Discussion

Participants of the study responded to questions addressing: self-evaluation of teacher effectiveness; the value of teaching science as a subject; how students learn science best; and lesson planning. Principals responded differently than teachers and science teacher educators, when questioned. They identified the need for experiments and hands-on science, with the textbook as a supplementary resource, as significant in elementary science instruction. They also mentioned that a lack of resources or funding negatively affects lesson planning and limits teaching effectiveness. Although principals taught science more than or equal to some of the teachers, teachers and science teacher educators responded differently.

On the other hand, elementary science teachers and science education faculty identified different teacher knowledge, skills, and dispositions for effective science teaching. These included: content knowledge; real life applications/student connections; inquiry; exploration and discovery in learning; and the ability to effectively plan for science instruction. All of these teacher topics relate to INTASC's standards (knowledge, skills, and dispositions) for beginning science teachers (2002). The INTASC standards are: content; student learning and development; and instructional variety. The findings identified by principals, teachers, and science teacher educators will now be discussed.

Adequate resources contribute to teachers being able to teach science effectively, and administrators must support teachers by providing materials and equipment for science instruction (Mechling & Oliver, 1983b; Lewthwaite, 2004). Principals equated their teaching effectiveness on being able to improve their teaching practices and on their availability of resources within the classroom. This may be attributed to science teachers historically not having an adequate amount of resources, which may have been the situation at the time that these administrators taught, compared to what current teachers have to teach science. Like the teachers in Lewthwaite’s study, teachers in this case study did not identify a lack of resources as a contribution to their ineffectiveness (2004). This fact can easily be related to teachers being adequately provided with resources through AMSTI, therefore leading to a greater focus on planning and increasing content knowledge to teach with these materials. According to NSTA (2002), teachers and science teacher educators identify content knowledge as an essential skill or dispositional quality for an effective elementary science teacher. In addition to INTASC’s (2002) insistence on content knowledge, NSTA, in its official statement on elementary science teaching, notes that teachers must constantly engage in professional development to increase science content and skills in teaching (2002). Teachers’ admittance to a need for increased science content knowledge suggests that teachers adhere to previous literature’s assertion that there must be continuous professional development to meet this need (Jarvis & Pell, 2004; Klein, 2005). In support of previous literature, teachers also increased their content knowledge as a result of teaching inquiry-based lessons (Bell, 2002).

In terms of what is valued in teaching science as a subject, principals again mentioned the importance of hands-on science instruction. This support’s Nabor’s study in which principals stated that they were in support of hands-on science within their schools (1999). Principals also stated that textbooks should be used as a supplementary resource. Teachers and science teacher educators, however, discussed the importance of providing real-life applications of science for their students. They realized that they must ensure that they provide the foundation for future learning in the subject of science. Thus, students will be prepared for the scientific and technological world that NSTA speaks of in its official statement of elementary science education (2002).

For administrators, the importance of hands-on science within the elementary classroom is vital. Principals believed that hands-on science was the best method for teaching science. Again, this data supports previous research that states that principals encourage and prefer hands-on science within the elementary science classroom (Nabors, 1999). NSTA also advocates that elementary preservice and inservice teachers be involved in hands-on activities during teacher preparation and professional development (2002). Knowledge of scientific inquiry, inquiry-based approaches, and exploration were stated by teachers and professors as essential skills or dispositions for effective elementary science teachers. The National Science Education Standards notes that students must be involved in activities where they are allowed to inquire (National Research Council, 1996; National Academy of Sciences, 2000). In order for this to take place, teachers must understand the concept of inquiry themselves. Teacher and science teacher educator participants also stated that student exploration was a significant part of effective instruction. Further, NSTA maintains that teachers must be able to model inquiry skills for their students, and that students learn best when they are involved in inquiry and exploration (2002). Principals mentioned the use of hands-on science as an instructional method. However, inquiry-based learning has been determined as being more effective for scientific learning

(National Research Council, 1996; NSTA, 2002). The statements of differences in approaches, (e.g. hands-on science versus inquiry, exploration, and discovery) may be attributed to the education terminology used at the time each educator was or is in the classroom, combined with keeping abreast of current research and contemporary practices related to elementary science instruction. The researcher proposes that teachers and science teacher educators remain current through professional development and research, practices that may be less common, but desirable, for principals also (Saginor, 2006).

Lastly, principals, teacher participants and professors discussed the significance of planning, preparation, and organization, and their role in science teaching effectiveness. Principals stated that they thought that a lack of resources would be identified by elementary teachers as a hindrance to lesson planning. Consequently, NSTA states that administrators can contribute to this aspect by ensuring that teachers have the proper materials and resources for science programming (2002), which is also supported by previous literature on science teaching (Lewthwaite, 2004; Saginor, 2006). This suggests that principals can directly influence teachers' ability to plan, prepare, and organize for instruction. In opposition, elementary teachers and science teacher educators stated that effective science teachers have the ability to plan and organize for their lessons. Since AMSTI provided resources for science teaching, teachers' concerns were shifted towards managing their time in terms of lesson planning. Lack of resources was no longer a major issue in lesson planning.

Implications

The findings from this study found that principals have differing views from elementary science teachers and science teacher educators. The findings contribute to current literature that stress the administrator's role in effective elementary science programming (Lewthwaite, 2004). These views were identified and discussed, and can influence science reform and inform science education policy in these school cases in a number of ways.

The gaps in findings between principals and the teachers and science teacher educators in this study do not suggest that one group is less knowledgeable than the other in relation to elementary science programming and views of teacher self-evaluation, the value of science teaching, the best approach to teaching science, and lesson planning in science. Neither do their responses deny the importance of science being taught in the elementary schools involved. However, they do suggest that participants responded differently to the questions being asked. Principals focused on tools and strategies for making science possible and more enjoyable for students, while teachers and science teacher educators focused on academic goals and goals for scientific literacy.

The findings from this study do imply that the necessary amount of communication may not take place in regard to elementary science programming at the participating schools. Science teacher educators are able to disseminate valuable information related to effective science teaching to preservice teachers, as well as inservice teachers, when visiting within schools. Teachers and science teacher educators within this PDS system must openly communicate with principals about what is needed to ensure maximum effectiveness in science programming (Petto, Patrick, & Kessel, 2005). There must be constant sharing of knowledge between all participants from Jefferson Elementary, Rosebud Elementary, and the local university (Fullan, 2002). In this study, hands-on science was frequently discussed by principals, while inquiry teaching was deemed significant by teachers and science teacher educators. Elementary science reform will also call for open discourse among teachers, principals, and science teacher educators about certain terms or areas in science that may be unfamiliar to administrators: discuss the meaning of hands-on science and inquiry, how these words look within the elementary classroom, their differences, and effectiveness (National Academy of Sciences; 2000; van Zee, 2006). Participants of this study may also discuss, for confirmation and comprehension (if necessary), how to change hands-on science lessons into those that are inquiry-based (Huber & Moore, 2001). The researcher also suggests that there be a true science liaison to improve communication practices between teachers, principals, and science teacher educators within the study, and to serve as a true leader of science (Eiss, 1962; Spillane et al, 2001). This liaison can easily be a classroom teacher or an already existing specialist for AMSTI at each school participating in the program.

Additionally, administrators must continue to realize and maintain the importance of science programming within their schools, and guarantee that teachers receive professional development in science instruction (Mechling & Oliver, 1983b). To address the seemed disconnection between principals and their counterparts (teachers and science teacher educators), principals must take part in science professional development courses that are intended for *their* development in elementary science programming. In this particular PDS relationship, science teacher educators, with the assistance of teachers, may be tapped to work closely with principals to administer professional development that is relevant to principals' needs in relation to elementary science programming, including information on content knowledge and effective teaching approaches (Mechling & Oliver, 1983b). Acquisition of this new knowledge will help to improve communication with all involved in the PDS relationship, and also improve collaboration. Through collaboration, which is the focus of the PDS model, all educators involved will move towards effective elementary science programming, which will ultimately result in science literacy for all students.

References

Akerson, V. L. & McDuffie, A. R. (2006). The elementary science teacher as researcher.

In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 259-274). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Alabama Math, Science, and Technology Initiative (AMSTI). (2009). Retrieved May 7,

2010 from http://www.amsti.org/About/GeneralInfo/tabid/78/Default.aspx.

Appleton, K. (2006). Science pedagogical content knowledge and elementary school

teachers. In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 31-54). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Bell, G. L. (2002, January). *Elementary science teaching enhancement through a*

Professional Development Schools model. Paper presented at the meeting of the

Association for the Education of Teachers in Science, Charlotte, North Carolina.

Bransford, M. S. & Donovan, J. D. (Eds.). (2005). *How students learn: Science in the classroom.* Washington, D.C.: The National Academies Press.

Castle, S., Fox, R. K., & Souder, K. O. (2006). Do Professional Development Schools (PDSs) make a difference? A comparative study of PDS and non-PDS teacher candidates. *Journal of Teacher Education, 57*(1), 65-80.

Cattell, R. B. (1931). The assessment of teaching ability. *The British Journal of Educational Psychology, 1*(1), 48-72.

Colburn, A. (2003). The lingo of learning: 88 education terms every science teacher should know. Arlington, Virginia: NSTA Press.

Darling-Hammond, L. (2005). *Professional development schools: Schools for developing a profession.* New York, New York: Teachers College Press.

Darling-Hammond, L. & Sato, M. (2006). Keeping good science teachers: What science Leaders can do. In J. Rhoton & P. Shane (Eds.), *Teaching science in the 21st century* (pp. 177-196). Arlington, Virginia: NSTA Press.

Edwards, S. & Edick, N. (2006). Dispositions matter: Findings for at-risk teacher candidates. *The Teacher Educator, 42*(1), 1-14.

Eiss, A. F. (1962). The role of the administrator in elementary school science. *Science Education, 46*(2), 170-171.

Fullan, M. (2002, May). The change leader. *Educational Leadership, 59*(8), 16-20.

Griffith, G. & Scharmann, L. (2008). Initial impacts of No Child Left Behind on elementary science education. *Journal of Elementary Science Education, 20*(3), 35-48.

Hillman, S. J., Rothermel, D. & Scarano, G. H. (2006). The assessment of preservice teachers' dispositions. *The Teacher Educator, 41*(4), 234-250.

Howes, E. V. (2008). Educative experiences and early childhood science education: A Deweyan perspective on learning to observe. *Teaching and Teacher Education,* *24*(3), 536-549.

Interstate New Teacher and Assessment and Support Consortium (INTASC). (1992).

Model standards for beginning teacher licensing, assessment, and development: A resource for state dialogue. Retrieved June 29, 2008 from http://www.ccsso.org/ content/pdfs/corestrd.pdf.

Interstate New Teacher and Assessment and Support Consortium (INTASC) Science

Standards Drafting Committee. (2002). *Model standards in science for beginning*

teaching licensing and development: A resource for state dialogue. Retrieved

March 30, 2008, from http://www.ccsso.org/publications/index.cfm.

Jarvis, T & Pell, A. (2004). Primary teachers' changing attitudes and cognition during a

two-year science in-service programme and their effect on pupils. *International Journal of Science Education, 26*(14), 1787-1811.

Johnson, L. E. & Reiman, A. J. (2007). Beginning teacher disposition: Examining the

moral/ethical domain. *Teaching and Teacher Education, 23*(5), 676-687.

Klein, B. S. (2005). Application of the guidelines for effective elementary science teacher

inservice education. *Journal of Elementary Science Education, 17*(2), 57-72.

Klentschy, M. P. & Maruca, P. M. (2006). The administrator's role in supporting science

and literacy in classrooms. In R. Douglas, M. P. Klentschy, & K. Worth (Eds.),

Linking science and literacy in the K-8 classroom (pp. 407-426). Arlington, Virginia: NSTA Press.

Koeppen, K. E. & Davison-Jenkins, J. (2007). *Teacher Dispositions: Envisioning their*

role in education. Lanham, Maryland: Rowman & Littlefield Education.

Lewthwaite, B. (2004). "Are you saying I'm to blame?" Exploring the influence of a

principal on elementary science delivery. *Research in Science Education, 34*(2),

137-152.

Marlow, M. P., Kyed, S., & Connors, S. (2005). Collegiality, collaboration and *Kuleana*:

Complexity in a Professional Development School. *Education, 125*(4), 557-568.

Mechling, K. R. & Oliver, D. L. (1983a). *Science teaches basic skills. Handbook I.*

Project for promoting science among elementary school principals. Washington,

D. C.: National Science Teachers Association.

Mechling, K. R. & Oliver, D. L. (1983b). *The principal's role in elementary school science. Handbook II. Project for promoting science among elementary school principals.* Washington, D. C.: National Science Teachers Association.

Mechling, K. R. & Oliver, D. L. (1983c). *Characteristics of a good elementary science program. Handbook III, part A: Principal's checklist of characteristics. Project for promoting science among elementary school principals.* Washington, D. C.: National Science Teachers Association.

Mechling, K. R. & Oliver, D. L. (1983d). *Characteristics of a good elementary science program. Handbook III, part B: Elaboration of the principal's checklist of characteristics. Project for promoting science among elementary school principals.* Washington, D. C.: National Science Teachers Association.

Mechling, K. R. & Oliver, D. L. (1983e). *What research says about elementary school science. Handbook IV. Project for promoting science among elementary school principals.* Washington, D. C.: National Science Teachers Association.

Minger, M. A. & Simpson, P. (2006). The impact of a standards-based science course for preservice elementary teachers on teacher attitudes toward science teaching. *Journal of Elementary Science Education, 18*(2), 49-60.

Mulholland J. & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science. *Journal of Research in Science Teaching, 42*(7), 767-790.

Mullin, D. (2003). *Developing a framework for the assessment of teacher candidate dispositions.* Retrieved from ERIC on October 17, 2008 from http://eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1b/48/45.pdf

Nabors, M. L. (1999). "Principals" for hands-on science. *Education, 119*(4), 744-746.

National Academy of Sciences. (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning.* Washington, D.C.: National Academy Press.

National Council for Accreditation of Teacher Education. (2001). *Standards for Professional Development Schools.* Retrieved February 11, 2010 from http://www.ncate.org/documents/pdsStandards.pdf.

National Council for Accreditation of Teacher Education (NCATE). (2006). *Professional standards: Accreditation of schools, colleges, and departments of education.* Retrieved October 12, 2007, from http://www.ncate.org/documents/standards/ unit_stnds_2006.pdf.

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

National Science Teachers Association (NSTA). (2002). *NSTA position statement: Elementary school science.* Retrieved March 31, 2008, from http://www.nsta.org/about/positions/elementary.aspx.

National Science Teachers Association (NSTA). (2003). *Standards for science teacher preparation.* Retrieved March 31, 2008 from http://www.nsta.org/pdfs/ NSTAstandards2003.pdf.

National Science Teachers Association (NSTA). (2004). *NSTA position statement: Scientific inquiry.* Retrieved May 13, 2010 from http://www.nsta.org/about/ positions/inquiry.aspx.

Petto, A. J., Patrick, M., & Kessel, R. (2005). Emphasizing inquiry, collaboration, and leadership in K-12 professional development. In R. Yager (Ed.), *Exemplary science: Best practices in professional development* (pp.147-160). Arlington, Virginia: NSTA Press.

Ridley, D. S., Hurwitz, S., Hackett, M. R. D., & Miller, K. K. (2005). Comparing PDS and campus-based preservice teacher preparation. Is PDS-based preparation really better? *Journal of Teacher Education, 56*(1), 46-56.

Saginor, N. (2006). The principal as leader of change. In J. Rhoton & P. Shane (Eds.), *Teaching science in the 21st century* (pp. 163-176). Arlington, Virginia: NSTA Press.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Smith, R. L., Knopp, T. Y., Skarbek, D., & Rushton, S. (2005). Dispositions and teacher beliefs: A heuristic to inform efforts toward improving educational outcomes. In R. L. Smith, D. Skarbek, & J. Hurst (Eds.), *The passion of teaching: Dispositions in the schools* (pp. 211-222). Lanham, Maryland: Scarecrow Education.

Spillane, J. P., Diamond, J. B., Walker, L. J., Halverson, R., & Jita, L. (2001). Urban school leadership for elementary science instruction: Identifying and activating resources in an undervalued school subject. *Journal of Research in Science Teaching, 38*(8), 918-940.

Taylor, R. L. & Wasicsko, M. M. (2000). *The dispositions to teach.* Paper presented at the annual meeting of the Southern Region Association of Teacher Educators (SRATE) Conference, Lexington, KY. Retrieved May 21, 2010 from http://nku.edu/~education/educatordispositions/resources/The_Dispositons_to_Teach.pdf.

Thompson, S., Ransdell, M., & Rousseau, C. (2005, September). Effective teachers in urban school settings: Linking teacher disposition and student performance on standardized tests. *Journal of Authentic Learning, 2*(1), 22-36.

Thornton, H. (2006). Dispositions in action: Do dispositions make a difference in practice? *Teacher Education Quarterly, 33*(2), 53-68.

van Zee, E. H. (2006). Teaching “science teaching” through inquiry. In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 239-257). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Yilmaz-Tuzun, O. (2008). Preservice elementary teachers’ beliefs about science teaching. *Journal of Science Teacher Education, 19*(2), 183-204.