Early Childhood Educ J (2009) 36:431–438
DOI 10.1007/s10643-009-0302-7

Utilizing Science Philosophy Statements to Facilitate K-3 Teacher Candidates' Development of Inquiry-based Science Practice

Andrew Gilbert

Published online: 5 February 2009

Abstract This study utilized pre-service teachers' philosophy statements to connect their beliefs for science teaching with inquiry-based constructivist classroom practice. The major findings of this study suggested that before entering the classroom prospective teachers are strongly aligned with inquiry-based, constructivist-based theories, and describe teaching science as a process approach. However, after entering public classrooms the teacher candidates often abandoned those notions of constructivist, inquiry-based science in favor of a more traditional approach to science instruction. This study addresses a method to engage prospective teachers in designing inquiry-based science pedagogy as well as developing their professional pedagogical confidence.

Keywords Early childhood teacher preparation · Science education · Inquiry-based practice

Purpose of the Study

It has been my experience that early childhood teacher candidates often describe that they want to engage students in hands-on, minds-on, inquiry-based, constructivist science where students construct their own understandings of science content. However, there seems to be a major dichotomy between their descriptions of desired practice and the actual lessons they create for their practicum placements. To this end, the particular goal of this study was to investigate how students were able to connect their philosophy of science with their science practice. This required a reflection of experiences in science and what they believed was the most effective approach to teaching science. These philosophy statements became a tool to critique their lesson unit plans to better align with their philosophies. The study investigated the following key questions:

1. How do teacher candidates conceptualize science teaching? To what extent do they describe inquiry as part of their future teaching goals?
2. What difficulties did prospective teachers perceive when trying to enact these philosophies in their practicum placements?
3. Does the utilization of philosophy statements as a reflective tool impact teacher candidates' ability to create and enact inquiry-based pedagogy?

A. Gilbert (✉)
Department of Teaching, Leadership, and Curriculum Studies, Kent State University, 150 Terrace Dr. #404, Kent, OH 44240, USA
e-mail: agilber1@kent.edu

Review of Literature

Inquiry Approaches to Science Teaching and Learning

Many reform efforts and subsequent studies have focused on the development of inquiry-based, constructivist pedagogy as the most effective approach to teaching science (American Association for the Advancement of Science 1990, 1993; Bianchini and Colburn 2000; Kyle 1998; National Research Council 1996; Plevyak 2007; Yerrick et al. 2003). Constructivist approaches to science argue that learning is a result from observing the natural world, scaffolding that information with prior conceptions, and interacting with more capable peers to construct new understandings (Barba 1998; Llewellyn 2002; Stewart and Kluwin 2001). This supports an inquiry-based approach to scientific investigation. The National Research Council (2000) provided five

essential features that are at the core of inquiry-based approaches to science teaching and learning: the learner: (1) engages in scientific questioning, (2) searches for evidence to support ideas, (3) hypothesizes possible explanations based on evidence, (4) connects those explanations to science understanding, and (5) shares findings and explanations with larger classroom community. These features assist students in becoming life-long science learners capable of devising solutions to scientific questions based on evidence and communicating those ideas in a public forum. Accordingly, teachers must constantly question their own strategies and behaviors so as to ensure that they are providing students with meaningful scientific investigations rather than cookbook type activities (Llewellyn 2002).

Inquiry approaches are particularly important in elementary classrooms, where children are developing foundational knowledge on which all future science understanding will be based (Peters and Gega 2002). However, early childhood teacher candidates often struggle to enact school science experiences that are different from the teacher-directed recipe-like science experiences they engaged in during their K-12 years (Plevyak 2007). It is not surprising that student interest in science wanes as they proceed through their elementary years, which has been attributed to "less investigative science practices" employed by their classroom teachers (Watters and Diezmann 2007, p. 351). Wee et al. (2007) further challenged that it is not enough to solely understand inquiry, but teachers must be able to design and implement these types of approaches in effective ways. These authors further argue that, "inquiry presents an inconvenience, or even impediment, to traditional forms of teaching and learning in the science classroom" (p. 65). In a similar vein, Spector et al. (2007) demonstrated that elementary teachers often resist notions of inquiry, in their practice, claiming it gets in the way of the teaching what they "need" to do.

Developing appropriate constructivist practice that combines the social, cognitive, and content related aspects that meet the needs of all students is an exceedingly difficult task (Cobern and Loving 2002; Howes 2002). More research is needed in how to facilitate teachers as they struggle to enact the inquiry-based classroom approaches called for in reforms (Keys and Bryan 2001). Resolving this dichotomy between teacher candidate descriptions of their desired practice and the actual lessons they create represents the focus of this study. Furthermore, this study utilized the assumption that teacher actions are often based on their individual belief systems and better understanding for those beliefs can facilitate the development of innovative science practice (Simmons et al. 1999). This speaks to the importance of reflecting on belief systems within the larger context of actual classroom practice as an essential step in developing inquiry teaching (Luft and Patterson 2002).

This study utilized Howes' (2002) call that researchers concentrate on the strengths beginning teachers possess and use their existing frameworks as a starting point to best demonstrate constructivist approaches. Teacher candidates must undertake reflective processes to better understand their own belief systems and how to fit those beliefs within an inquiry framework (Spector et al. 2007; Wee et al. 2007). Furthermore, this study was informed by Eick's (2002) premise that, "teachers' reflections on the beliefs and values that motivate present action resonate with prior beliefs and values from past personal histories" (p. 355). This study utilized elements of personal histories and how those histories have impacted the type of practice they wished to implement through the creation of science teaching philosophy statements. The reflections and semester-long work with these philosophies provided the impetus for this study.

Methods

This study included 40 total participants enrolled in two separate cohorts of their senior-level early childhood science methods course. All participants were traditional students between the ages of 21–24, female and White. The methods course included a 20 h per week, semester-long, practicum placement in a public K-3 classroom. The philosophy statement process followed a three-phase approach (See Fig. 1). In phase one teacher candidates wrote their philosophy statements based on their science education histories and how they envisioned their future practice. Secondly, teacher candidates reflected on their initial experiences in the field. During phase two, teacher candidates identified a science topic (in collaboration with their practicum teacher) and designed three lessons on that topic. Using these lessons, teacher candidates and the methods instructor determined disconnects between their desired teaching and the activities they created. This facilitated teacher candidates in redesigning their classroom lesson plans. Prospective teachers then taught revised lessons in their field placement. Lastly, prospective teachers reflected on the process and discussed the possibilities and challenges of enacting their philosophies.

Data Collection: Philosophy Statement Process

Philosophy Statements

The philosophy statements were the main feature of the methods classroom and research effort. The prompts for the philosophy statements included:

1. What are your memories of science in your K-12 educational history? Was this experience different from your college science experiences?

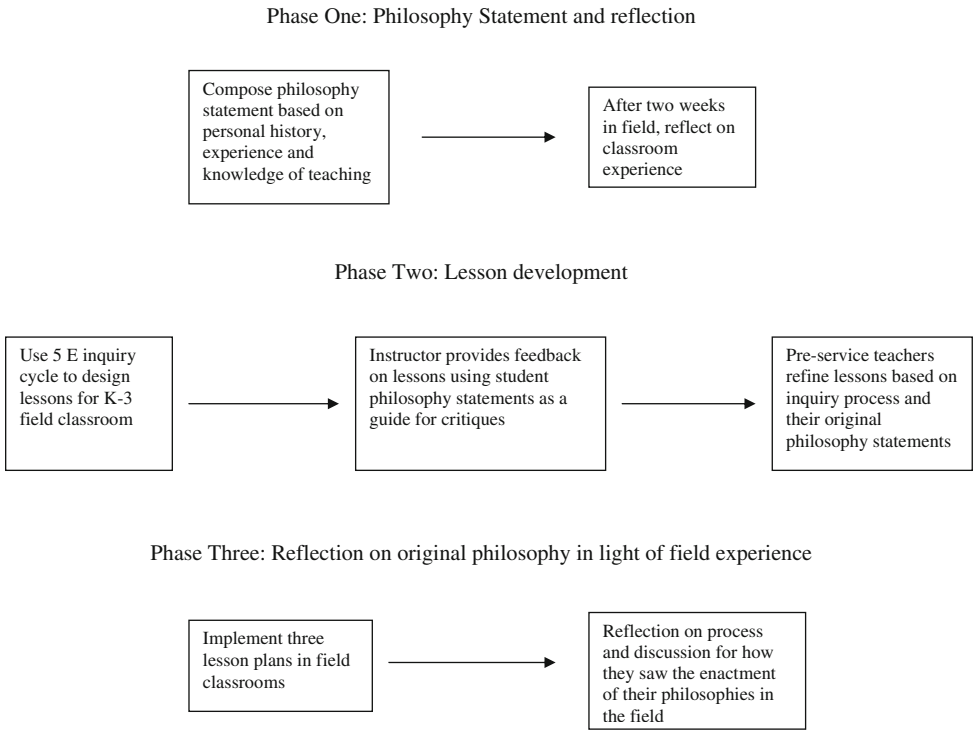

Fig. 1 The philosophy statement process

2. How do you feel science should be taught in schools? Why do you feel this is important?
3. How will science look in your future classroom? How will you enact these kinds of approaches?

I utilized these philosophies over the semester and felt they made an appropriate tool to facilitate teacher candidates' emergent inquiry teaching. The philosophy statements were designed under the premise that articulating personal belief systems and prior science learning experiences are an appropriate avenue to understanding future teaching practice (Eick 2002; Plevyak 2007).

Lesson Planning

The pre-service teacher lessons were designed using Llewellyn's (2002) "5 E" (Engage, Explore, Explain, Elaborate and Evaluate) inquiry cycle as a framework for creating meaningful student-centered approaches. The lessons also needed to incorporate higher-level thinking and questioning skills in accordance with Bloom's taxonomy. Furthermore, prospective teachers were expected to align these lesson ideas with state standards for both content and science process skills.

Reflections

A key component of the lesson planning approach was to utilize teacher candidate reflections at various stages throughout the semester. After 2 weeks in the field classroom, students reflected on their observations and any possible obstacles they envisioned in carrying out ideas stated in their philosophy statements. A second layer of critical reflection took place after completing their lesson plans. Students needed to analyze their pedagogical approaches utilized in their lessons and compare those ideas to those espoused in their original philosophies. Lastly, students wrote reflective addendums to their philosophy statements at the close of the course. This served to document student thoughts over the duration of the course in terms of inquiry teaching.

Data Analysis

The use of multiple sets of data allowed for triangulation in an effort to establish credibility of the research interpretations (Patton 1990). All data sets were subjected to multiple complete readings of the text in an effort to generate a preliminary list of possible coding categories (Miles and Huberman 1994). These initial categories where then subjected to constant comparison and analysis with differing sets of data in an effort to develop a working set of emergent themes as described by Strauss and Corbin (1998). In some cases categories were collapsed with others, while occasionally entirely new categories would emerge. This provided a mechanism to reduce large amounts of data into more manageable categories across similar themes.

The analysis of these categories provided insight for how prospective teachers understood inquiry teaching,

struggled to enact their ideas and how they applied inquiry concepts into their teaching. The subsequent themes that emerged were *notions of inquiry, constructivism as chaos, standards and assessment, and evolving professional confidence*. These themes were applied to the particular research questions of the study to build the interpretations in the following section.

Findings and Discussion

Research Question #1: How Do Teacher Candidates Conceptualize Science Teaching? To What Extent Do They Describe Inquiry as Part of Their Future Teaching Goals?

One of the most interesting aspects of prospective teachers' philosophy statements was the remarkable similarity in how they described their previous science experiences and the types of pedagogy they wished to employ. Many gave accounts of their school science experiences that consisted of reading science related material and answering questions in a textbook. Roughly 60% of participants articulated that they were uneasy with science content and felt that learning science in this manner was ineffective because they spent most of their time bored and/or confused. The following are typical excerpts from philosophy statements depicting their previous science experiences:

> Most of the lessons I received in science were based primarily on readings from a textbook and worksheets…I was never fully engaged and I could not apply anything I had learned to a real world context. (Marie)
>
> I can recall reading lots of textbooks and doing lots of worksheets in elementary school. (Elle)
>
> All of my memories of science are unpleasant ones. I always seemed to dread science class. I often found activities boring and I never had a teacher explain to me the importance of the material. (Alice)

It has been my experience when working with early childhood majors that this is a common theme among my students. This is the experience from which they build their notions of science practice.

Despite these experiences, nearly 80% of the participants articulated how they wished to carry out some form of inquiry-based/constructivist approach so as not to repeat the pedagogy that they experienced as a student. This became an important avenue for students to reflect on the goals laid out by the teacher education program while simultaneously sorting through their own understandings for how to best teach science to young children. Furthermore, the science methods course was designed to incorporate inquiry through multiple experiences, modeling, readings, videotaped examples of exemplary practice, and feedback on classroom teaching. The following examples are a representative sample for the common science classroom pedagogical goals of these prospective teachers:

> I see my classroom as a place to discover and learn, a place where students are thinking and questioning ideas. (Jessica)
>
> The science experiences I will introduce my students to, need to be meaningful and connected to real life situations, and not just 'lessons' planned from a textbook or worksheet…Along with this, I feel that it is essential that I continuously support and provide opportunities for my students to explore and make scientific discoveries independently. (Marie)

They envisioned challenging their students to "explore and investigate" and helping them to think and question scientific understandings. This is the essence of scientific literacy as called for by the *National Science Education Standards* (National Research Council 1996).

These teacher candidates had an understanding for constructivist approaches to teaching as a result of the years within our teacher preparation program and their completion of pre-school student teaching prior to this course. However, these notions of inquiry-based science teaching quickly evaporated once they entered the primary practicum classroom.

Research Question #2: What Difficulties Did Prospective Teachers Perceive When Trying to Enact These Philosophies in Their Practicum Placements?

Nearly all of my students articulated wanting to teach from a constructivist framework in their introductory philosophy statements at the beginning of the year. Yet, these notions quickly dissolved after students entered their practicum classrooms where they began teaching lessons on their own in a public school context. The idea of control emerged as being more important than learning content. The atmospheres of "thinking and questioning ideas" were replaced by fears of constructivism as "chaos." The following excerpts came from prospective teachers' reflections on their initial experience in their practicum classrooms.

> What it boils down to is: I am afraid of chaos and disrespect. I do agree the constructivist approach is most effective in learning; I also know that these methods will not be employed throughout the children's lives and they must be prepared for what the future holds. (Janice)
>
> I feel that in many ways, too much control is given to children… Unfortunately, high school, college, and

> the career worlds do not operate under constructivist ideals. They are very much run with rules and structure, both of which I feel children need and thrive on. (Jessica)

Interestingly, both of these students first mentioned issues of control. They equated allowing students the chance to pursue scientific questions using their own thinking will result in "chaos." This paints a picture of students running around screaming with no regard for the specific academic questions posed by the lesson activity. Martin (2003) argues that behavioral issues in constructivist classrooms are minimal compared to traditional classrooms because students are not bored and are treated with dignity; children see their ideas being valued and have the power to pursue their interests.

Another interesting aspect of these responses is how students felt allowing children to experience constructivist approaches would not prepare them for the structure of future classrooms. They saw their role as one where they needed to prepare students to sit and process information individually because that will be expected of them in high school and college classrooms. There exists a few possibilities for why prospective teachers felt so strongly about these issues: (1) They could not conceptualize that teaching students to actively engage with content was beneficial for children, (2) They understand the importance of inquiry on science learning but felt future preparation was more essential, (3) Prospective teachers felt that inquiry-based teaching was too daunting to enact, and (4) Teacher candidates felt inquiry methods could possibly hinder children later in life. They did not question whether the structure of schools should change; rather they rationalized that they needed to prepare their young children to submit to teaching that does not interest them.

Another form of resistance that emerged was related to enacting and aligning science teaching with state and national standards. Interestingly, in their philosophies some students viewed the standards as a support mechanism for their inquiry-based views of science teaching and discussed them with enthusiasm. The following example, taken from Marty's philosophy statement, demonstrates this idea:

> The National Science Education Standards state, 'Learning science is something that students do, not something that is done to them.' Educational experiences will be much more meaningful to the children if they are given the opportunity to participate in science.

Later in the semester, when reflecting on her practicum, Marty remarks how the same standards have created a source of difficulty for her in the classroom, "With pressures of proficiencies, standards, and testing looming overhead, there is not much time to dedicate to science." This makes a particular challenge for teacher educators. How do we convince prospective teachers that standards and the approach to scientific literacy, called for by reforms, are possible within the constraints of the classroom? Marty was able to completely distance herself from her ideas about meaningful educational experiences after only a few weeks in her practicum classroom.

Importantly, there were several students who shared similar experiences and ideas that resonated with Marty's experience. Many of the students felt that it was nearly an impossible task to teach through a constructivist worldview while still achieving the goals within standards documents. The following example highlighted the disconnection that Nicole perceived between her teaching goals (discussed in her philosophy) and the reality of the classroom.

> I want to teach science through many hands-on projects that make the students come up with their own hypotheses that they can test and re-test to see the results of. I want my students to realize the value of asking a question and having the tools to investigate and answer the question.

Her reflections later highlighted her frustration at her inability to carry out these approaches:

> I would like to know how to accomplish constructivist ideals, while trying to maintain standards placed upon me by the district, state, as well as the set-up and amount of materials at my disposal, or lack thereof.

These students are making abundantly clear what they need and desire from their teacher education program. These types of juxtapositions were common with nearly all of the students enrolled in my course during the study.

I offer that the practicum experience draws out the ways in which prospective teachers envision the gaps within their educational practice and the type of teacher they wish to be. It would be simple enough to argue that their initial philosophies were written merely to please a professor and their reflections better represent their true notions of teaching. This may well be the case with a few of my students who described school simply as a place where students learned to follow structures and rules. However, many students did not want to let go of their original ideas and were disappointed that they seemed to struggle in the context of the actual classroom as highlighted in the following section. This provided a powerful opportunity to utilize their philosophy statements as a guiding tool in the creation of classroom science approaches that would be consistent with their visions of teaching.

Research Question #3: Does the Utilization of Philosophy Statements as a Reflective Tool Impact Teacher Candidates' Ability to Create and Enact Inquiry-based Pedagogy?

In order to investigate this final question, I had students re-read their original philosophy statements and compare their classroom goals with the lessons they designed for their practicum placement. Consequently, they revised their classroom lessons to better match their philosophy statements. After revision, the students taught the lessons in their practicum classroom and provided a final reflective statement on their classroom teaching. This process provided students with a mechanism to develop their own ideas for science teaching. The following section highlights some of the struggles and successes faced by students during this process.

There were several students (eight total) who felt that the overall structure of schools was too restrictive for them to carve out any inquiry approaches. These worries were focused mainly on control, time, and standards. Janice's final reflection demonstrated her continuing worry (see prior statements) about the issues of control in the classroom, "Educators could have the most creative constructivist ideas, but if they cannot control the class, those ideas will be very ineffective." Jessica's concern for preparing students for the reality of life (see prior statements) resonated all the way through the entire experience, "Sometimes inquiry seemed a little too idealistic considering the increasing pressure standardized tests are putting on educators." The philosophy process seemed to have little effect on 20% of the students who had the most negative views of inquiry from the beginning. However, if teacher candidates entered the course with more positive notions of inquiry the philosophy statement process provided a vehicle to develop confidence and challenge them to enact their beliefs.

There were numerous examples of students developing their notions of inquiry and demonstrating increased confidence in their ability to enact those ideas. Angelina demonstrates this aspect of a burgeoning professional identity.

> My thinking has changed about using textbooks in the classroom. I always felt textbooks were necessary for students to guide them while discussing and doing different activities in the classroom. After developing my lessons and observing other science lessons, I discovered that I no longer have a strong feeling for textbooks in the classroom…Instead, I provided the students with seed booklets that encouraged them to record and draw their thoughts. I used standards as my guide for planning the lesson and targeted certain concepts within the standards that I needed to cover…

Angelina's developing confidence allowed her to step away from her reliance on textbooks. This provided her with a platform to create lessons more aligned with inquiry teaching. She no longer envisioned the text as guiding the students rather she placed that responsibility squarely on the teacher and learner. Furthermore, given this freedom she did not envision the standards as a limiting factor, but one that provides some direction to the goals she has for her students.

This philosophy statement process can be best exemplified by tracing one student's journey and highlighting the impact that this approach had on pedagogical thought and eventual classroom approach. Alice began the semester stating: "I hope to develop a teaching style that allows for the students to be able to feel free to explore and investigate ideas that spur their inquiry within a structured environment." This was followed after a few weeks in her field class, where she remarked on a class reflection: "There is just not enough time to carry out inquiry in my field classroom…the schedule is too tight to cover everything." Like other prospective teachers, Alice distanced herself from her own ideas for engaging children after only a few weeks in her practicum classroom. She argued there was just too much to "cover." Her classroom lesson plans reflected her new ideas for the lack of time to engage students in more meaningful inquiry approaches. Despite using a 5 E inquiry lesson plan format, her lesson ideas utilized standard behavioral techniques. She began by asking students if they knew what machines did (Engagement) and followed this with a worksheet from a textbook series (Exploration) that depicted some basic features of simple machines and lectured the students concerning those aspects (Explanation). The lesson ended with reading a section from a non-fiction book concerning simple machines (Elaboration) and correcting the worksheet (Evaluation).

Her own words (from her philosophy) became an effective reminder to not lose sight for the type of teaching she wished to enact. Students were provided with photocopies of their philosophies and asked to critique their lessons based on the ideas they originally wrote at the beginning of the course. After critiquing lessons, students and I worked in small teams to redesign lessons more aligned with the goals outlined at the outset of the course. Alice's new lesson incorporated more inquiry approaches, which resonated more clearly with her goals for teaching. She presented a challenge to students asking how to lift a brick without touching it (Engagement) and then students designed machines to carry out this challenge (Exploration). Students then presented their ideas and analysis to

the class (Explanation). Students brainstormed improvements and modifications for their machines (Elaboration) and lastly wrote out their findings for the modification process (Evaluation). This revised lesson clearly aligns with the National Research Council (2000) five features of inquiry teaching and met Alice's original teaching goals.

Reflecting, working together, revising lesson ideas and reconnecting with her original philosophy enabled Alice to muster sufficient courage to attempt this inquiry-based lesson in her practicum classroom. In Alice's final reflection on the course and her field placement she made the following remark: "I'm so happy with my lesson…the students were so excited and engaged. My teacher loved the simple machines and actually suggested to take pictures to document all the 'wonderful' projects." I utilized Alice's story because it was the best example for the effectiveness of the philosophy statement approach. What is most satisfying from Alice's case was the reaction of the cooperating teacher. She valued Alice's effort and planning and provided her with another layer of confidence by celebrating the work achieved by Alice and the students.

Conclusion

This study represents my efforts to facilitate beginning teachers' construction of inquiry-based science pedagogy. This was done utilizing teacher candidates' philosophies to better understand how students wanted to approach science instruction. Students often moved from wanting to teach from a constructivist viewpoint (at the beginning of the semester) toward a more traditional approach after entering their practicum classroom. Many students equated constructivism with "chaos" and felt that it was impossible to achieve science reform standards if they used a constructivist approach in the classroom.

The philosophy statements provided powerful opportunities to facilitate the development of teacher candidates' beginning practice by demonstrating disconnections between their theoretical beliefs and their actions in the classroom. I have found that using the students' own words was an effective tool of persuasion when students began to utilize excuses for why they could not develop inquiry-based practice. This lowered resistance to teaching steeped in constructivist, inquiry-based approaches and more importantly provided students with a reminder for the type of teacher they wished to be. In addition, this study demonstrated that students needed help in understanding how to incorporate structure (classroom/behavioral) into constructivist-based lessons while simultaneously aligning those approaches with state and district standards. It is also important for teacher educators to understand that practicum placements can quickly undo their notions of inquiry-based practice. In these instances, philosophy statements provided powerful guidance to help students stay focused on the kind of science teachers they wished to become.

This approach was not effective with students who entered my class with strong aversions to inquiry teaching. If prospective teachers felt inquiry teaching was impossible from the beginning, there was little change in that thinking. Although by continually having to reflect on their positions, my hope is that this process will plant a seed for trying some aspect of inquiry in the future. More research is needed to better understand how to impact the prospective teachers who are most resistant to inquiry ideas. However, the majority of my students entered the course with honest questions concerning how to enact inquiry teaching. This represented the most beneficial aspects of the study. These students demonstrated growth and complexity in their thinking about the inquiry science process. Furthermore, there were multiple cases of teacher candidates developing a greater degree of confidence in both designing and carrying out inquiry approaches. It is my contention that this increased confidence will provide much needed courage when they enter their future classrooms. The challenge facing them will include time constraints, scripted teaching programs, testing, etc., but if prospective teachers have not developed methods to defend and conceptualize their ideas they will be quick to abandon that professional identity. The philosophy statement approach has provided them with multiple opportunities to locate and internalize their own professional beliefs.

References

American Association for the Advancement of Science. (1990). *Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. Washington, DC: New York: Oxford University Press.

Barba, R. (1998). *Science in the multicultural classroom*. Needham Heights, MA: Allyn and Bacon.

Bianchini, J., & Colburn, A. (2000). Teaching the nature of science through inquiry to prospective elementary teachers: A tale of two researchers. *Journal of Research in Science Teaching, 37*, 177–209. doi:10.1002/(SICI)1098-2736(200002)37:2<177::AID-TEA6>3.0.CO;2-Y.

Cobern, W., & Loving, C. (2002). Investigation of preservice elementary teachers' thinking about science. *Journal of Research in Science Teaching, 39*, 1016–1031. doi:10.1002/tea.10052.

Eick, C. (2002). Studying career teachers' personal histories: A methodology for understanding intrinsic reasons for career choice and retention. *Research in Science Education, 32*, 353–372. doi:10.1023/A:1020866111670.

Howes, E. (2002). Learning to teach science for all in the elementary grades: What do preservice teachers bring? *Journal of Research in Science Teaching, 39*, 845–869. doi:10.1002/tea.10049.

Keys, C., & Bryan, L. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38*, 631–645. doi:10.1002/tea.1023.

Kyle, W. (1998). Viewing science in a different light: Making meaning of the science education goal "science for all". *Journal of Research in Science Teaching, 35*, 835–836. doi:10.1002/(SICI)1098-2736(199810)35:8<835::AID-TEA1>3.0.CO;2-V.

Llewellyn, D. (2002). *Inquire within: Implementing inquiry-based science standards*. Thousand Oaks, CA: Corwin Press.

Luft, J., & Patterson, N. (2002). Bridging the gap: Supporting beginning teachers. *Journal of Science Teacher Education, 13*, 267–282. doi:10.1023/A:1022518815872.

Martin, D. (2003). *Elementary science methods: A constructivist approach*. Belmont, CA: Wadsworth Publishers.

Miles, M., & Huberman, M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks: Sage Publications.

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

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage Publications, Inc.

Peters, J., & Gega, P. (2002). *How to teach elementary science*. Columbus, OH: Merrill Prentice Hall.

Plevyak, L. (2007). What do pre-service teachers learn in an inquiry-based science methods course? *Journal of Elementary Science Education, 19*, 1–14.

Simmons, P., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., et al. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*, 930–954. doi:10.1002/(SICI)1098-2736(199910)36:8<930::AID-TEA3>3.0.CO;2-N.

Spector, B., Burkett, R., & Leard, C. (2007). Mitigating resistance to teaching science through Inquiry: Studying self. *Journal of Science Teacher Education, 18*, 185–208. doi:10.1007/s10972-006-9035-2.

Stewart, D. A., & Kluwin, T. N. (2001). *Teaching deaf and hard of hearing students: Content, strategies, and curriculum*. Boston, MA: Allyn and Bacon.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

Watters, J., & Diezmann, C. (2007). Multimedia resources to bridge the praxis gap: Modeling practice in elementary science education. *Journal of Science Teacher Education, 18*, 349–376. doi:10.1007/s10972-007-9051-x.

Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: Insights and challenges in professional development. *Journal of Science Teacher Education, 18*, 63–90. doi:10.1007/s10972-006-9031-6.

Yerrick, R., Doster, E., Nugent, J., Parke, H., & Crawley, F. (2003). Social Interaction and the use of analogy: An analysis of preservice teachers' talk during Physics inquiry lessons. *Journal of Research in Science Teaching, 40*, 443–463. doi:10.1002/tea.10084.