

# **INQUIRY-BASED SCIENCE: TWO BEGINNING ELEMENTARY TEACHERS' PRACTICES AND KNOWLEDGE AND BELIEFS**

Lucy Avraamidou [1] Carla Zembal-Saul [2]

[1] Intercollege, Cyprus [2] Pennsylvania State University, USA

*This study examined the nature of two first-year elementary teachers' knowledge and beliefs about science teaching, their practices regarding inquiry-based science and the degree of coherence between each of those practices and knowledge and beliefs. With the use of the constant comparative method and by means of open coding strategies we identified main concepts that became apparent in the data consisting of interviews with the participants and videotaped classroom practices. The findings of this study indicated that both of the participants enacted classroom practices that exemplified certain aspects of scientific inquiry such as engagement in investigations and working with data to answer posed questions, and that those practices were in congruence with their knowledge and beliefs about science teaching.*

## **INTRODUCTION**

Although teaching science as inquiry has been advocated by a number of researchers and reform documents in the world such as the *National Science Education Standards* (NRC, 1996) in North America, the *2000 and Beyond* (Millar & Osborne, 1998) in the UK, and the *National Declaration for Education 2001* (Australian College of Education, 2001) in Australia, the reality is that there are very few specific examples in the literature illustrating scientific inquiry in practice. This study addresses this problem by exploring two teachers' instructional practices and understandings regarding scientific inquiry.

## **PURPOSE AND RESEARCH QUESTIONS**

The purpose of this study is to examine the nature of two first-year elementary teachers' knowledge and beliefs about science teaching, their practices regarding inquiry-based science and the degree of coherence between each of those practices and knowledge and beliefs. The focus of interest and the unit of analysis of this study focuses on the question: *What aspects of two first-year elementary teacher's practices are most consistent with an inquiry-based approach and what knowledge and beliefs serve as a mechanism for facilitating these practices?* More specifically, the research questions that guided this study are:

- What is the nature of beginning teachers' science instruction? To what extent does their science teaching reflect fundamental aspects of inquiry-based science?
- What is the nature of beginning teachers' knowledge and beliefs about

science teaching? To what extent do these knowledge and beliefs appear to influence enactment?

- What factors appear to influence the nature and development of beginning teachers' knowledge and beliefs about science teaching?

The answers to the above questions are significant given their implications about the design of teacher preparation programs as they aim to illustrate *what do elementary teachers need to know and be able to do* in order to support students' meaningful science learning. This study also is important due to its contribution to the research area dealing with the ways in which first-year elementary teachers transform subject-matter knowledge to make it comprehensible to their students. Furthermore, this study is significant because its findings have the potential to improve science teaching. Not only this study reveals inconsistencies between teachers' beliefs and practices but it also illuminates the barriers that first-year teachers face as they attempt to apply these beliefs in practice.

## **DESIGN AND PROCEDURES**

This study has the characteristics of a collective case study (Stake, 1995) as an exploration of multiple cases over time through detailed, in-depth data collection involving multiple sources of information rich in context (Creswell, 1998). Two first-year elementary teachers were purposefully selected to participate in this study for a number of reasons. Jean and Andrea, pseudonyms, were selected because they were considered to be information rich and contrasting cases. Multiple sources of data were used in order to capture Jean's and Andrea's knowledge and practices for science teaching. For each of them data included three audio taped interviews, six videotaped classroom observations, lesson plans, and samples of students' work. Analysis of the videotaped lessons recorded participants' explanations of topics and assignments, their use of metaphors or representations, their reference to student understanding, and their responses to students' questions and comments (Grossman, 1990). The approach to analysis involved categorical aggregation and a search of correspondence and patterns. Data were analyzed by means of open coding strategies consistent with constant comparative analysis. A cross case analysis followed by comparing and contrasting categories retrieved from the data sets in order to generate common themes and patterns.

## **FINDINGS**

### ***Andrea: Engaging in science investigations***

Andrea placed emphasis on: a) supporting students' learning through inquiry-based activities and b) assessing students' learning. In the first lesson about

dinosaurs, Andrea engaged the students in hands-on activities as she asked them to collect information about the foot size of a dinosaur. Logs from our observations provide a typical picture of Andrea's inquiry-based instructional approaches.

In this lesson, the third of the unit, the students received a letter from the paleontologist with information about the size of the length of their dinosaur. This kind of information essentially would help students decide what kind of dinosaur they were dealing with. Andrea provided instructions about how students were going to work in groups to take measurements and explained how they were going to use different tools. The students spent about thirty minutes taking measurements with rulers, legos and other tools and taking notes in their notebooks. When the students were done with the measurements they all gathered in the front of the room and sat in circle on the carpet where Andrea engaged them in a whole-classroom discussion. In the fourth and fifth lessons of the unit the students continued to work through the letter they received from their paleontologist and gather useful information that would help them determine what kind of dinosaur they were dealing with. In the sixth and last lesson of the unit Jean had her students present their findings in the classroom and act as if they were part of the news broadcast on television, and present on a poster that they designed the kind of dinosaur they ended up deciding that they were dealing with.

At this point it is important to notice that the students presented not only their findings about the characteristics of their dinosaur (i.e., it has a long neck and a long tale) but they also described the processes by which they came to know (i.e., we used clues, by doing research in books and making predictions). Assessment was central in Andrea's philosophy of teaching and learning science came out of her preparation interview when she spoke of ways of assessing student learning.

It's so important for me to some way kind of assess what they learned or did not learn and this provides it. And I do my own assessment when I do conversations with the whole class. After the lesson we'll talk, the next day we'll talk before the lesson; but the journal that is designed by the unit, that provides good opportunities too because they do so much writing there and this provides a good opportunity for me because some of the words that they use, their ideas, some kids just put things that we talked about together which good and some kids come off with something that is totally different which shows me that "okay, you definitely have an idea and you are taking it to the next level" and that's very prominent part of this unit, assessment and that's helpful for me and everything that I believe that I should be doing. (Andrea, Preparation interview)

Andrea's knowledge and beliefs of the role of assessment in teaching found their way in practice as it became apparent through data analyses, which illustrates a coherence between her practices and knowledge and beliefs. In summarizing our findings regarding Andrea's practices and knowledge and beliefs about science teaching we assert that she enacted classroom practices that exemplified certain aspects of scientific inquiry such as engagement in

investigations and working with data to answer posed questions, and that those practices were in coherence with her knowledge and beliefs about science teaching. However, a missing component of scientific inquiry in Andrea's practices was the fact that she did not engage students in critiquing results of investigations and constructed claims. Such an understanding also was absent from her set of knowledge and beliefs. Another aspect of scientific inquiry that was absent from Andrea's practices and knowledge and beliefs set was the discourse of scientific inquiry. An examination of her learning experiences led us to hypothesize that Andrea's knowledge and beliefs about the discourse of science were not developed because she had no learning experiences explicitly associated with supporting the development of such knowledge and beliefs. Andrea's main source of knowledge and beliefs appeared to be her preparation program - PDS - and she articulated no critical experiences during her schooling.

### ***Jean: Toward evidence and explanation***

The aspects of teaching that Jean placed emphasis were a) engaging students in inquiry-based investigations, and b) writing in science in terms of claims and evidence. When investigating the properties of *Oobleck*, a lesson that was almost typical of Jean's practices, the students were asked to collect evidence based on observations and tests in order to answer the question of whether *Oobleck*, a substance made of water, cornstarch and food coloring, was a liquid or a solid.

First, the students in groups spent five minutes recording their predictions and made some casual observations without touching *Oobleck*, and then Jean asked them to do some formal observations through tests that would help them figure out whether *Oobleck* was a solid or a liquid. In doing so, the students were asked to fill out a worksheet titled: 'A crazy colloid: Observation record sheet' which had a table with four columns: Test, Observation, Liquid, Solid, where the students had to describe the kind of test they performed, their observations, and indicate whether *Oobleck* acted as a liquid or a solid given the test. At the end of the worksheet there appeared a question: *Is this colloid a liquid or a solid? Write a paragraph that supports your claim.* The students brainstormed their ideas about some possible tests first and they then worked in their groups to carry out those tests. At the end of the lesson Jean asked all the groups to share their observations about the behavior that *Oobleck* exhibited under each test. She then asked them to write a paragraph, in the form of claim-evidence to argue about whether *Oobleck* was a solid or a liquid and use evidence gathered from the differed tests they carried out to support their claims. (Researcher's logs of classroom observations)

As this lesson reveals, Jean was able to create an open-inquiry learning environment as she had the students design investigations, collect evidence to answer scientific questions and construct claims and communicate those claims to others in the form of claim and evidence. Jean emphasized the importance of writing in science mostly because it is a different style of writing that emphasizes the use of claims and evidence.

I think it's good for them to having to write about what they learn in science... because I think it's important to express what they know and I think it's a different kind of writing than writing something for language arts you do not always have to back yourself up in language and arts you can just say whatever because you think it was but in this I am really trying to have them make a claim and then support it so I just want them to express orally or on paper or whatever what they know with that kind of format. (Jean, Preparation interview)

Not only was Jean's belief that it is important to write in terms of claims articulated through her philosophy, but it was also demonstrated in her practices, which provides evidence of the coherence between her practices and her knowledge and beliefs. In summarizing our findings regarding Jean's practices and knowledge and beliefs about science teaching we assert that she enacted classroom practices that exemplified certain aspects of scientific inquiry such as designing investigations to answer posed questions, collecting and analyzing data, interpreting data to form evidence, and constructing and communicating evidence-based claims. These practices were in coherence with Jean's set of knowledge and beliefs of science teaching as those became evidenced in her interviews. Unlike Andrea, Jean valued the nature of the discourse of science – an understanding that was implemented in her practices as well. Such knowledge can be traced back in a specially-designed course (i.e., *Using Technology to Enhance Science Learning*) she took as part of her university coursework and which placed emphasis on the construction and communication of evidence-based claims.

## **Conclusions:**

In this study we have shown that it is possible to come across innovative instructional practices at the elementary school classroom but that they are likely to be found in particular contexts. We do not claim that either Jean or Andrea had reached the level of competency of experienced elementary science teacher as indicated in the literature (Brickhouse, 1990). Nonetheless, there is no doubt that these two first-year elementary teachers demonstrated exemplary instructional practices that were informed and guided by robust understandings of science teaching and learning. The findings of our study suggest that the school context appeared to be supportive in helping Jean and Andrea apply their innovative personal philosophies of teaching and learning in practice, which reveals the significance of the PDS context. In closing, this type of study adds to the literature of teachers' practices, knowledge and beliefs, within the domain of research, practice and policy by providing two concrete models of reform-oriented instructional practices and by illustrating the pathway by which they came to know.

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