Using a Guided Inquiry and Modeling Instructional Framework (EIMA) to Support Pre-Service K-8 Science Teaching
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Abstract

This paper presents results from a study investigating the effect of a guided inquiry and modeling instructional framework and accompanying science methods instruction on pre-service elementary teacher’s science pedagogy skills and teaching orientations. Analysis of pre-service teacher’s pre-post tests, classroom artifacts, peer interviews, and lesson plans throughout the semester, indicates the framework successfully built on student teachers’ prior instructional ideas, and that the majority of students learned and used the framework in their lesson plans and teaching. Most importantly, the framework and accompanying instruction enabled two thirds of the class to move their teaching orientations away from discovery or didactic approaches towards conceptual change, inquiry, and guided inquiry approaches. Additionally, analysis of pre-post test differences indicates a significant increase in post-test lesson plans that focused on engaging students in scientific inquiry and modeling.

Objective

This paper presents results from a semester-long study with pre-service teachers in an elementary science methods class which investigated how experiencing, learning about, and using a guided inquiry and modeling instructional framework impacted pre-service teachers’ pedagogical skills and their orientations towards science teaching. The guided inquiry and modeling framework used in this study, EIMA, is a learning and teaching framework adopted from the BSCS 5 E’s instructional model (Bybee, 1997) that encourages teachers to engage students in guided scientific inquiry with a focus on creating, using, and revising models.

Prospective elementary teachers are often bombarded with knowledge and skills that they must learn in a brief period of time to become effective practicing teachers. An informal survey of elementary methods textbooks indicates that such textbooks (and one-semester courses) are often filled with topics ranging from studying how children learn science, to learning about state and national standards, to creating good assessments, to addressing diverse learners. In addition, reform-based science teaching requires teachers to master complex knowledge and skills about such aspects as teaching for understanding, using scientific inquiry, fostering scientific habits of mind, and incorporating technology. Reform-based science teaching is even more challenging because most teachers have neither experienced nor seen such instruction, nor do they have the subject-matter knowledge to support such advanced practices.

How can new teachers learn significant reform-based science teaching skills and develop an underlying orientation that is commensurate with reform-based teaching within a one-semester course? It was the aim of this study to develop, use, and research the EIMA guided inquiry and modeling instructional framework that along with relevant
instruction could help student teachers experience, learn about, and teach reform-based science instruction. The EIMA framework was designed as a cognitive tool to help student teachers remember and address important components of reform-oriented science while planning and conducting their science lessons. These components include teaching conceptual content, teaching science through inquiry with a focus on creating and revising scientific models, and using educational technology within a community of learners. The tool was meant to be flexible and adaptable enough for application to future teaching contexts.

What is the EIMA guided inquiry and modeling instructional framework? EIMA stands for (1) engaging students in the topic and eliciting their prior ideas, (2) helping students investigate the topic, phenomena, or ideas, (3) helping students create models that explain their ideas or evidence, and comparing and reconciling those ideas with the scientific explanations, and (4) asking students to apply those explanations to novel situations. EIMA teaching also emphasizes creating a community of learners and using the tools of science through technology. EIMA is different from other learning and teaching cycles (Bybee, 1997, Magnuson & Palincsar, 2002) because of its explicit focus on creating, revising, and applying models as the culmination of inquiry. As such, EIMA sets the stage for technology use such as computer models and simulations that have become a focal point in modern science and engineering. In addition, EIMA uses the term ‘investigate’ rather than the 5E term ‘explore’ to connote an inquiry-specific (rather than discovery) science teaching orientation. Lastly, EIMA incorporates an emphasis on communities of learners by stressing the importance of scientific discourse and practices using the tools of science.

The EIMA framework was used in the context of a classroom intervention designed to motivate and help elementary student teachers understand and use EIMA while helping them develop a science teaching orientation that was commensurate with EIMA and reform-based teaching. Components of the instruction included (1) thinking about what is science and why should we teach it, (2) studying and thinking about how students learn science, (3) studying and thinking about what students should be learning, and (4) understanding and evaluating models of teaching (didactic, discovery, conceptual change, guided inquiry, and communities of learners). True to the EIMA instructional model, student teachers also created their own version of a teaching framework before being introduced to EIMA, and discussed benefits and drawbacks to using the various frameworks. In addition, student teachers experienced EIMA as a framework for two sets of science investigations in the class (light and shadows, and electricity over 4-6 class periods), and they practiced using EIMA within two sets of lesson plans towards the end of the semester.

**Theoretical Framework**

This research is grounded in the cognitive psychology teacher education research that views teacher knowledge as encompassing pedagogical knowledge, pedagogical content knowledge, and content knowledge (Shulman, 1987). As such, we use the term science teaching orientations to include the set of teacher beliefs and knowledge that guides
teachers’ goals and methods for teaching science (Grossman, 1991). It has been widely shown that teachers hold strong orientations and beliefs about teaching before they enter the classroom. In order to enable student teachers to teach reform-oriented science, and in order to help them develop their skills and practices for reform-based teaching, these prior teaching orientations need to be addressed, reflected on, and challenged (Gess-Newsome, 1999; Friedrichsen & Dana, 2003).

In this study, we worked towards helping student teachers refine their pedagogical content knowledge and related teaching orientations through the use of the EIMA framework and related instruction. Prior research (Bybee, 1997; Lawson, 1995) indicates that learning frameworks and cycles can be highly beneficial for helping teachers attend to the important components of patterns, explanations, and applications.

Method and Data Sources

In order to determine how the EIMA instructional framework and accompanying science methods instruction affected student teachers’ pedagogical skills and orientations, we conducted this study in a one-semester pre-service elementary science methods class at a large midwestern university. The first author was the instructor for the class of twenty-five students, and the second author was a participant observer. We used several data sources to address our research questions including a written pre-post test, classroom artifacts, transcripts of peer interviews (Friedrichsen & Dana, 2003), weekly writing responses, and student teachers’ lesson plans.

We evaluated the change and quality of student teachers’ skills in teaching reform-oriented science by analyzing pre-post test lesson plans, classroom artifacts, and lesson plans generated at the end of the semester. In particular, we looked for evidence of student teacher understanding and use of EIMA, and we analyzed the structure and purpose of the lessons within the lesson plans. For example, did the lessons involve an inquiry approach in which students investigated a question, collected information or data, and analyzed those data to come up with some sort of explanation or model?

Similarly, we evaluated the change in student teacher’s science orientations through analysis of pre/post tests responses, through self-reports on the post test, through peer interviews conducted towards the end of the semester about teaching orientations, and through student teacher lesson plans. In particular, we looked for evidence of what student teachers thought was important to teach and how. For example, were student teachers mainly concerned about engaging students in hands-on activities without a clear purpose(an activity-based approach) or on presenting factually correct information (didactic approach)? Alternatively, did they focus on engaging students in a scientific question while guiding students within their investigations and explanations (a guided inquiry approach)? We derived our coding rubrics of the nine science teaching orientations from the prior work of Magnuson, Krajcik, & Borko (1999).

Results
Analysis of classroom artifacts indicates that use of EIMA effectively built on, expanded, and challenged students’ prior ideas of science teaching. In particular, before introducing EIMA, student teachers created their own frameworks that included aspects such as: eliciting students’ prior ideas, engaging students in hands-on/minds-on activities, and engaging students in exploring and reflecting on their ideas. Nonetheless, it took time for student teachers to understand some aspects of EIMA. In particular, they did not understand the nature and purpose of models and modeling, and they did not understand that EIMA was designed to apply to a sequence of lessons rather than to a single lesson. Analysis of mid-semester outlines of lesson plans indicates that all but one group had difficulty determining how to address the model section of EIMA.

Evidence from the end of the semester lesson plans indicates that student teachers used and adapted EIMA for their envisioned science teaching. While nearly all students addressed EIMA in one set of formal lesson plans for the course, they varied in their fidelity to EIMA within the final, more open-ended lesson plan assignment. Analysis of student teachers’ work indicates that two of the twenty-five student teachers specifically used EIMA as the framework for their lessons, while most students adapted EIMA to an ‘engage, investigate, and discuss explanations’ instructional framework. Overall, this adaptation is a fairly close interpretation of EIMA, and a productive inquiry framework for addressing reform-oriented science teaching. The majority of student teachers’ lesson plans (twenty-two of twenty-five) involved inquiry-based student investigations, explorations or problem solving. Twelve student teachers designed lesson plans that engaged students in creating or using models.

Analysis of lesson plans within the post-tests also indicates that student teachers learned to incorporate and design lessons around scientific inquiry. When the semester started, four of twenty-three student teachers designed science lessons that included investigations or experimentation. Post-test analysis indicates that by the end of the semester, fourteen of twenty-four student teachers designed lesson plans that engaged students in inquiry or experimentation.

Did EIMA and the accompanying methods instruction impact student teacher’s orientations about science teaching? Yes. Analysis of several sources of data indicates that students moved away from didactic and discovery orientations and towards inquiry, guided inquiry, and conceptual change orientations of science teaching.

Self-reported data from the posttest show that sixteen of twenty-four student teachers categorized themselves as having a guided-inquiry approach to teaching science teaching, three as having an activity-driven or discovery approach, and five as having a conceptual change approach; by comparison, data show that at the beginning of the course, only one identified with a guided-inquiry approach, 13 with an activity-driven or discovery approach, and two with a conceptual change approach. In describing the change in her teaching orientation, one student teacher wrote in her post-test, “Coming into this class, I felt science was more of basic subject. You have your facts, you present them, understand them and that is it. Now, I can see how important it is to investigate the problems, I can see that providing explanations is necessary.” Another student described her change in
orientation by stating, “I used to put a huge focus on ‘hands on’ as I enjoy doing this aspect of science. I now see there needs to be more than just activities, and inquiry includes investigating, drawing conclusions, and assessing the validity – all important parts of science learning.”

How reliable are the self-reports? In-depth analysis of multiple sources of data from six focus students (chosen to represent varied ability level and varied attitudes towards the class), indicates that three of the six students were fairly consistent in expressing their teaching orientations within their lesson-plans, pre-test questions, and peer-interviews. Two other student teachers were moderately consistent, and one was completely inconsistent.

Discussion and Educational Significance

What is significant about these results? Changes in student teachers’ pedagogy skills and orientations are often extremely difficult to foster, and change in these areas is critical for reform-oriented science teaching. Tools and methods that encourage such change deserve our attention. It is also important to note that the pre-service teachers who experienced this intervention reviewed the course very positively and felt that the course had met their needs for learning how to teach science.

Nonetheless, future work and analysis of EIMA is warranted. For example, more information is needed to determine how such changed occurred and whether these results are reproducible. In particular, how do the particular components and emphases of EIMA work to foster change compared to other kinds of instructional frameworks? Finally, methods instruction needs additional refinement as student teachers require a stronger understanding of the nature and purpose of models, and they need additional practice evaluating their lesson plans (and teaching) with respect to EIMA.

References


