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Improving Elementary School Teacher' Self-Efficacy towards Teaching Science

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Abstract

The central purpose of this article is to explore elementary school teachers' self-efficacy towards teaching science. Interviews with teachers reveal that elementary school teachers do not usually have degrees in science and often see science as a subject that is hard academically to learn and to teach. Included in this article is a model for professional development to improve elementary school teachers' self-efficacy to teach science. The goal is to break the cycle of poor science education in elementary schools thus increasing young students' ability and motivation to excel in science.

Keywords: Elementary Education, Science Education, Teacher Learning, Teacher Self-efficacy, Professional Development

Profile

Meet Alice, an elementary school teacher. An outstanding student, and liberal arts major, she went on to earn her Masters' degree and teaching credential. Alice has always wanted to teach elementary school. She is bright, focused, excited, and eager to introduce her students to literature, arts, and music. Alice believes that she will be an excellent reading teacher and a good math teacher. To be better prepared to teach math, Alice has worked to supplement her math education. Alice does not feel confident in her ability to teach science; this is partly a result of her own science education history. Before 3rd grade, she had no science education at all. Then in 3rd, 4th, and 5th grades a specialist who came to her classroom, about four times a year taught some "fun" science classes. She took Biology 1 and Chemistry 1 in high school to fulfill her science requirements. To fulfill the science requirement in college, she took Astronomy an easy science course at her university.

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The labs were great, as the classes took place in the campus planetarium on Friday nights. Alice is typical of current Elementary School Teachers who themselves have a limited science education. For many students in the US, science has not been included in the elementary school curriculum in any substantive way for many years. Teachers and teaching candidates report that they do not feel prepared to teach science. For them, “Science is scary to teach.” The central purpose of this article is to explore elementary school teachers’ (EST) selfefficacy towards teaching science. Included is a model for professional development to help EST improve their self-efficacy to teach science. The goal is to break the cycle of poor science education in elementary schools and increase young students’ motivation to learn science.

1. Context

Alice’s science education is not an anomaly. For many ESTs teaching science is a daunting task (Kazempour, 2014; Lumpe, Czerniak, Haney, & Beltyukava, 2012). In a 2012 National Survey of Science and Mathematics Education: Status of Elementary School Science, elementary school teachers were asked to rate their content preparedness to teach three subjects: Mathematics, Language Arts, and Science. EST report that they feel 81% prepared to teach language arts and 77% ready to teach math while only 40% report that they feel prepared to teach science (Trygstad, 2013). Furthermore, when Trumper (2003) asked 645 preservice elementary teachers about multiple astronomy topics, the overall correct response rate was only 36%. This research suggests that ESTs do not have the content knowledge that they believe they need to teach science (Davis, Petish, & Smithy, 2006; Fulp, 2002). ESTs also often have misconceptions about science (Asoko, 2002), and many depend on the science textbooks having correct information (Davis et al., 2006).

1.1 Teachers’ Beliefs

Teachers’ beliefs develop over a broad range of life experiences, including their education. This belief system directly affects how teachers understand their subject matter content and their self-efficacy toward teaching it (Madden & Weibe, 2015). Like anyone, teachers will avoid tasks and situations that they believe exceed their capabilities. If they have no experience learning science and they lack the confidence to teach science, they tend to avoid it to elude feelings of incompetence. Most elementary school teachers are in the same boat as Alice. Only 50% of elementary school teachers have completed the minimum number of science courses recommended for teaching candidates (Fulp, 2002, Trygstad, 2013). This problem perpetuates a negative cycle of poor science education.

1.2 Science Education in the United States

In order to understand the depth of this problem, it is necessary to consider the story of science education for students in the US. When children reach upper elementary grades and encounter science content as part of the required curriculum, they report that science is more arduous than other school subjects (Cleaves, 2005). When children enter middle and high school without a foundation in science, it may be too late to begin to develop the habits of mind that spark scientific curiosity and facility. Over the last 25 years, there has been a sharp decrease in the number of students choosing careers in science-related fields. Kindling young children's' interest in science is essential if we are to develop a larger pool of scientists able to compete globally. In 1980, approximately 34% of the bachelor's degrees awarded in the United States were in science and engineering; by 2000, that number had dropped to 17% (National Science Foundation, 2004). Interviews with college Science Engineering, Technology, and Mathematics (STEM) majors reveal that most of them (78%) developed their interest in STEM-related fields in high school, and 21% reported that they made the decision before high school. STEM in high school or earlier—and one in five (21%) said they made their decisions in the middle school or earlier (Blank, 2012).

2. Literature

Mastering subject-specific science content often seems overwhelming for ESTs to even consider. Unlike middle and high school science teachers, who are expected to have a specialization in one area of science (biology, physics, etc.) ESTs are expected to be science generalists. Teachers, to successfully teach science will have to increase their self-efficacy science; increasing their knowledge about science content and pedagogy. It is only then that teacher's can positively impacting student-learning outcomes (Loucks-Horsley, Hewson, Love, & Stiles, 2010; National Research Council, 2012).

2.1 Self-Efficacy

Teachers' beliefs about their capability to teach a subject are critical to what and how they teach (Bhattacharya, Volk & Lumpe, 2009; Kazempour, 2013; Trygstad, 2014), in addition to how much time and energy they will put into curriculum planning and implementation (Duffee & Aikenhead, 1992). Self-efficacy beliefs are beliefs (accurate or not) about one's competencies and one's ability to exercise these competencies in certain domains and situations (Bandura, 1997). Within self–efficacy beliefs are selfevaluations and judgments of one's performance capabilities for a particular task (Bandura, 1997). Self-efficacy involves inferences that are influenced by prior beliefs and experiences.

Teachers' self-efficacy affects their behaviors in the classroom and their choice of instructional activities (Stipek, 2001). This belief system directly affects how teachers understand their subject matter content and their self-efficacy about teaching it (Simpkins, Davis-Kean, & Eccles, 2006; Van Driel, Beijaard, & Verloop, 2001) If a teacher's self-efficacy is low for teaching science and they feel that they have inadequate knowledge of science content, it is going to impact their motivation to teach it. In California, ESTs are expected to incorporate science into their general education classrooms based on the California State Science Standards using McGraw-Hill science textbooks. Even with this resource, the reality is that most ESTs do not feel prepared to teach science, and many omit it from the curriculum or include it as an isolated activity disconnected from other subjects the children are learning (Kazempour, 2014). Processes for increasing self-efficacy must include reflection on one's current abilities and practices. One aspect of this is working with other teachers in a community to explore web-based and community science resources, co-creating and envisioning new approaches and strategies for teaching science, and increasing opportunities in the classroom for students to make connections between scientific concepts and practices.

2.2 Science Self-Efficacy

Teaching science in elementary school is a daunting task for many ESTs (Kazempour, 2014). The feeling of being unprepared is related to EST self-efficacy beliefs about teaching science and inadequate knowledge of science content. ESTs are expected to incorporate science into their general education classrooms based on the California State Science Standards using McGraw-Hill science textbooks. Even with this resource, the reality is that most ESTs do not feel prepared to teach science, and many omit it from the curriculum or include it as an isolated activity disconnected from other subjects the children are learning (Kazempour, 2014).

In a 2012, National Survey of Science and Mathematics Education: Status of Elementary School Science elementary school teachers were asked to rate their content preparedness to teach three subjects: mathematics, reading/language arts, and science. EST report that they feel 81% prepared to teach language arts and 77% prepared to teach math, and only 40% prepared to teach science (Trygstad, 2013). When Trumper (2003) asked 645 preservice elementary teachers' about multiple astronomy topics, the overall correct response rate was only 36%. EST generally do not have the content knowledge that they need to teach science (Fulp, 2002, Davis, Petish, & Smithy, 2006). EST often have misconceptions about science and many believe that old science textbooks have correct information (Davis et al, 2006).

2.3 Improving Self-Efficacy

Teacher learning is understood as a process of participation, practice and collaboration on teaching methods (Borko, 2004; Guskey & Yoon, 2009). Collaborative learning communities (CLC) provide teachers the time, space and scaffolding to reflect on their own thinking, to assess student thinking, and to engage in discourse that emerges from the work in the classroom (Kabasakalian, 2007). To improve self-efficacy teachers will have to have the time and space to collaborate and reflect. One hundred years ago, John Dewey (1916) recommended that teachers learn processes for how to think deeply about their own and others' ideas and practices.

One challenge to developing selfefficacy is creating an environment in which teachers can develop what Dewey describes as "an attitude of mind which actively welcomes suggestions and relevant information from all sides" (Dewey, 1916, p. 175). This ability to consider new points of view and conflicting information is the sign of a good reflector. When provided with space for active learning and reflection, teachers can articulate their views, challenge those of others, and come to better understandings of themselves (Kabasakalian, 2007; Loucks- Horsley & Matsumoto, 2010). For PD to be perceived as useful by teachers, it must positively impact their work in the classroom with students and provide the time and space to develop, teach, and reflect on lessons in collaboration with other teachers (Loucks-Horsley & Matsumoto, 2010).

The structure of schools does not typically support collaboration among teachers. Teacher learning is best understood as a process of participation, practice and cooperation among participants (Borko, 2004). The PD needs to provide teachers the time, space and scaffolding to reflect on their thinking, to assess student thinking, and to engage in discourse that emerges from the work in the classroom (Kabasakalian, 2007). The research on effective PD is unambiguous about the importance of organized, structured and purposeful time for teacher development.

3. Interviews with Teachers

To explore how teachers' science education affects their self-efficacy to teach science, I spoke to pre-service, teachers, credentialed teachers and a Science Education Specialist. All participants were asked about their science education self-efficacy. The science curriculum specialist was also asked about her experiences with helping elementary school teachers learn to become better science teachers.

Twelve teachers were interviewed. Six pre-service teachers were completing their Masters' degree their teaching credential and six were currently working as elementary school teachers.

3.1 Pre-Service Teachers

The six teachers who were completing their education participated in a focus group about teaching science. The first question followed the Fulp (2002) model, asking them to rank the top three subjects that they felt most prepared with one being the highest level. Four of the participants responded- 1) Literacy, 2) Math, 3) Social Studies and two replied 1) Literacy, 2) Math, 3) Science. The conversation continued to explore the differences in how they ranked science. The two pre-service teachers who ranked science third had science classes in their undergraduate education. They enjoyed studying science in college and felt competent to teach it.

The four who rated social studies third, and left science out, were humanities majors and lacked any science education since high school. Follow-up questions asked about their plans for to teaching science. Five responded that they knew that the schools used a standard textbook that could follow and that was their plan. They all concurred that they were glad that they were not teaching 5th grade since that is when students in the state take a mandated science test. The one participant who said she would bring in outside sources beyond the textbook had the most science experience including some college level science classes. The final follow-up question asked how they would go about learning more science content to be better prepared. All six responded that they would use the Internet and mentioned the NASA, and National Geographic websites with which they were familiar.

3.2 Credentialed Teachers

All of the credential teachers interviewed were attending a school district sponsored STEM teaching conference; therefore, it is possible that they had some interest in becoming more proficient in teaching science, or it is possible that they were there only to receive continuing education credits for attending the conference. Of the six teachers that I interviewed, two said that they were attending the conference because their interest in science developed in elementary school. A fourthgrade teacher remembered a portable planetarium brought to the school and having lessons on astronomy including learning that there was a star named Beetlejuice; this stuck with him and piqued his interest in star gazing. He wanted to inspire his own students' interest in science. Another teacher was a pre-med undergraduate student. Having decided to become an elementary school teacher, she continued her interest in science.

When I asked her if she could recall when she became interested or what motivated her interests in science, nothing particular came to mind- it had always been an interest of hers. Two teachers that I spoke to reported that they were "anxious" about teaching science and were attending the PD to get some ideas and support. They were very forthcoming about their lack of science education and fear of having to teach a subject in which they had no experience, let alone expertise. One teacher I spoke to was married to an engineer and felt as though science was "just part of her life." Although she had not been a good science student herself, in life "outside of the classroom", she saw an enthusiasm for science and its practical applications and wanted to convey this to children.

3.3 K-12, Science Educational Specialist

Ms. R is the Science Education Specialist is a science coach for a University Lab School affiliated with a State University The conversation took place over the phone. Ms. R started her career as a high school chemistry teacher and a lifelong interest in the field of science. In the last few years, she had the opportunity to supervise Science labs for K-8 students. Ms. R's views echoed those of the teachers. According to Ms. R's experience, the type of person that becomes an EST doesn't usually have degrees in science and often see science as a subject that is hard academically and takes a "genius" to teach. In her view, their self-efficacy in science stems from the fact that it was not taught well when they were in school. "When they are forced to teach it, their first response it "no way." Following the idea of poor self – efficacy Ms. R finds that "Teaching science makes EST feel inadequate and insecure. The PD that teachers get typically focuses on language arts or math, but rarely in science. Even if they come to teaching feeling weak in one of those topics, they gain expertise, through the PD that the school/district provides. Since there are few resources devoted to supported science PD, this typically does not happen in science. Therefore, even if teachers are willing or value it, they have no idea where to start." Ms. R's focus in her work is in helping ESTs integrate science into the curriculum "[teachers] can integrate it. Students can read a story about science and write about that; they can create a graph with science data when they are learning graphs in mathematics. The possibilities are limitless."

4. Professional development to increase science self-efficacy

In this section, a research-based PD model is proposed to in increase EST self efficacy to teach science. This PD is different from other science PD in that it begins with the NGSS Seven Cross Cutting Concepts rather than science content.

The reason for this is that embedded in these concepts are learning objectives and teaching methods that EST already incorporate in their teaching. It is a way for EST to start with “what they know.”

4.1. Professional development and learning

The connection between professional development (PD) and student learning is complex. There are three elements that research suggests provide productive connections between teacher learning and student learning: 1) An extended time for PD that is well organized, structured and purposeful; 2) A focus on content and pedagogy (Loukes- Horsely & Mastumoto, 2010), and 3; opportunities to explore and adopt a variety of practices. When teachers themselves understand that becoming proficient science teachers is a progression of learning and doing, they will be able to meet better the needs of their students (Loucks-Horsely et al, 2010). Successful PD includes both increased time span and contact hours positively. Teachers will have the time to make connections between their experiences, content knowledge, and student learning (Garet et al., 2001, Loukes-Horsley, 2010).

4.2 Self reflection in professional development

The content of the PD will include a reflection component in which teachers will explore their science education history and feelings of self-efficacy around teaching science, examining the NGSS Seven Cross-Cutting concepts and how they can be implemented in the classroom, assessing and using web-based resources for EST to teach science. Exploring and discussing one's areas of low self-efficacy is not easy. EST may be reticent to expose what they see as a deficiency in their teaching. One way to help scaffold this is providing them with a shared language. In 1990, Riggs and Enoch developed an instrument for assessing teacher’s self-efficacy beliefs for teaching science (STEBI). The STEBI provides EST with a vocabulary for discussing feelings of selfefficacy around teaching science.

4.3 Science Inquiry

This PD focuses on science inquiry process that is based on the NGSS and explores the relationship between science process skills and teaching and learning a conceptual understanding of these processes. In all of the PD, the emphasis will center on the Seven Crosscutting Science Concepts (NGSS, 2013) that foster the development of conceptual connections within and across science disciplines (See Table 1, Appendix A). The rationale for starting with these process standards is that they effectually overlap with the curriculum that is already familiar with EST teachers.

For example, the first cross-cutting concept is *patterns*. When you ask EST's about teaching patterns, they have knowledge and experience teaching this topic. They include patterns in math and literature as part of the existing curriculum. Once this is understood, then thinking about patterns in science is less daunting. The second cross-cutting concept is *cause and effect*. EST's understand cause and effect regarding social behavior, and in literature. Again, this can help them to form a bridge between the science concepts and their previous knowledge that is central to developing their self-efficacy.

4.4 Web-based Resources

Another aspect of the content is learning to use the myriad of web-based information for EST to use in teaching science. Edutopia alone has ten links for teachers to science education websites for teachers to view and use. From the Smithsonian's website that provides videos of scientists talking about their work (http://www.smithsonianeducation.org/scientist/index.html) to the National Science Foundation's website that provides classroom resources (http://www.nsf.gov/news/classroom/) to PhET, a site that provides free, developmentally appropriate science simulations, the internet provides almost unlimited resources for teachers that incorporate science knowledge and student learning objectives.

4.5 Partnerships

Teachers argue that they have much better things to do than to sit in a room all day and hear about something they will not use in their classrooms. One way to change this perception is to partner with community resources for science education PD. These partnerships offer teachers the opportunity move out of the school and interact with science specialists in their community. Conducting a science education PD in collaboration with a community science center is not as difficult as it may seem. There are over 300 science centers in the United States located in both large cities and small towns, from Augusta, Maine to Boseman, Montana (Association of Science-Technology Centers, 2016). The staff at these centers tends to be delighted to host teachers and to collaborate with them to improve science education. In this collaboration, the goal is to increase teachers' self-efficacy. Community Science centers provide them support.

4.6 Assessment

There are a few assessments that will work for PD on teacher self-efficacy about teaching science; the Science Teaching Efficacy Belief Instrument (STEBI; Riggs & Enochs, 1990) is an excellent instrument.

The STEBI is a one-page, 23-item five-point Likert scale instrument. It has been widely used and has been determined to be a valid and reliable instrument (Chronbach Alpha =.90) to investigate in-service elementary teachers' efficacy in science education (Lumpe, Czerniak, Haney, & Bletyukova, 2012). Another instrument for assessing self-efficacy is the Teacher Efficacy Evaluation Form from Guskey, 2012 (cite). This 21 item, Likert scale questionnaire developed by Guskey & Passaro (1994), assesses two dimensions of self-efficacy: internal and external.

5. Conclusion

True learning belongs to the learner. When knowledge is integrated, it is owned. The research on teachers' pedagogical content knowledge is clear about the need for teachers acquiring new and lasting knowledge. This is particularly important for teaching science. PD for EST's teaching science needs to be deep, ongoing, and cost effective. When teachers understand that becoming proficient science teachers is a progression of learning and doing, they will be able to better meet the needs of their students (Loucks-Horsely et al., 2010). Elementary school teachers' self-efficacy around teaching science is central to improving science learning for their students. Part of improving teachers' self-efficacy is creating a space in which they can learn together in an environment that respects their previous life experience. Since factual science knowledge is not fixed, the skills, attitudes, and knowledge that teachers develop can become integrated into an ongoing educational process and support their continued professional development. 16

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Appendix A

Table 1: The Seven Cross-Cutting Core Concepts

1. Patterns	Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. Cause and Effect	Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. Scale, Proportion, and Quantity.	In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. Systems and System Models	Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering. EST all teach about the senses, or about transportation, about interactions and how they work together.
5. Energy and Matter:	Flows, cycles, and conservation Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. Structure and Function	The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. Stability and Change	For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.