An Exploration of Pre-service Students' Development in Science Teacher Efficacy and Self Image

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Abstract

This research tested the science-teaching efficacy of 48 pre-service teachers at the beginning and conclusion of a science methods course. The researchers examined the relationship between efficacy and images of science teachers. Students indicated a higher level of personal efficacy at the end of the semester than at the beginning; however, their outcome expectancies did not change. In the images of science teachers, pre-test data indicated that, 33% of the students included no stereotypical traits; whereas, 50% indicated no stereotypical traits at the post test. The more efficacious students rated themselves, the less stereotypical they were in the portrayal of science teachers. Over the semester the relationship between efficacy and the images did not alter for personal efficacy, but the relationship between outcome expectancy and stereotypical images was smaller by the end of the semester suggesting that the course influenced students' personal beliefs about efficacy and images of science teachers.

Keywords: self-efficacy, draw a scientist, science methods

Research clearly supports the finding that teachers who feel efficacious about their role as teachers in promoting student learning are, in fact, more effective teachers. Finson & Beaver (1994); Koballa & Crawley (1985); Riggs & Enochs (1990) and Wilson & Scharmann (1994) demonstrated that elementary teachers with low science efficacy tend to avoid science instruction and teach it sporadically. A passion for facilitating the development of pre-service teachers' science efficacy is pivotal to this research. Children see science everywhere and are always asking questions. Children don't know that their curious questions can be answered through science. But given the emphasis on packaged science (or standards, or district curriculum guides), we are missing a golden opportunity to develop young children's love of science, not to mention their science literacy. Elementary pre-service teachers are likely to receive minimal preparation in science and the teaching of science, so measuring their efficacy development over the final course in their science preparation should reveal something about their confidence, and therefore their effectiveness, as teachers of science in elementary schools.

The goal of the current study was three-fold: first, to measure changes in students' perceptions of efficacy regarding science teaching at the beginning and the end of a term of a science methods course; second, to analyze students' images of themselves and science teachers; and third, to explore the relationships between efficacy and images. One of the primary author's goals is to expand students' views of science and science teachers through a course focused on promoting inquiry and using inquiry teaching styles, as well as, differentiating the study of life sciences, physical science, earth and space science, embedding technology, using process skills, recognizing science from the personal and social perspective, realizing there is a history and nature to science, and then be able to formatively and summative assess science learning. Finally, the ultimate goal is to assist future teachers in internalizing the interconnectedness of all of these categories to weave them together to have a successful classroom. The most widely used measure regarding efficacy and teaching science is the Science Teaching Expectancy Belief Instrument (STEBI), which is based on the theory and practice of efficacy measurement supported by Bandura (2001). Enochs & Riggs (1990) developed two forms. Form "A" for in-service teachers and Form "B" is designed for pre-service teachers. The STEBI has been found to be reliable and valid across several studies (e.g., Bleicher, 2004), and appears to be robust for cross-cultural research (Barros, Labur & Da Silva, 2010; El-Deghaidy, 2006).

The STEBI is comprised of two subscales; personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). Joseph (2010) found that pre-service science teachers had higher levels of efficacy but similar levels of outcome expectancy compared to their non-science counterparts. Hechter (2011) studied preserves teachers and found that the number of postsecondary courses completed and prior school science experience were major factors that improved science teaching efficacy. Scholarship in the area of the perceptions of scientists includes a field focused on drawings of scientists. Based on a tradition of projective tests where individual's drawings or responses of images are supposed to be reflective of internal states and aspirations, Chambers (1983) developed the Draw-A-Scientist-Test (DAST). Drawings are coded for the presence of stereotypic or typical characteristics. For instance, scientists tend to be drawn as crazy-haired, white-lab coated, nerdy Caucasian males with a desire to blow things up. In more recent years, several scholars developed related measures such as the Draw-A-Science-Teacher-Test Checklist (DASTT-C) (Finson, Beaver, & Crammond, 1995).The DASTT-C can be coded for categories-the teacher, the students, and the environment (e.g., Thomas,J., Pedersen,J., & Finson,K.(2001) and has also been coded to indicate "teacher centeredness "and student-centeredness". For the current study, we return to the original intention of an analysis of drawings based on stereotypic traits. Given that the STEBI-B focuses on personal beliefs, we analyzed the DASTTC drawings for the science teacher's personal traits. Of the traits associated with scientists and science teachers, gender has been the most robust finding with males being portrayed much more often than females. However, in a classroom of predominantly female pre-service teachers, it would be expected that the female gender would have dominance, since they are asked to draw themselves as science teachers.

A paucity of research exists on the relationship of the STEBI and the DASTT. El-Delghaidy (2006) analyzed 36 pre-service teachers in Egypt using the STEBI and the DASTT across a 14-week term that included a practicum component. El-Deghaidy found that students became more children-centered and less teacher-centered by the end of the terms as evidenced by their drawings for the DASTT. El-Deghaidy also found that students became more efficacious on the STEBI. El-Deghaidy dropped the students one standard deviation below and above the mean on the STEBI subscales and focused on students in the extremes to analyze the correlations between the STEBI subscales (PSTE and STOE) and the DASTT. Students displayed stronger correlations at the conclusion of the semester (in the .5 range) than at the beginning, suggesting that students with stronger efficacy draw science teachers who are more students focused. El-Deghaidy's study provides preliminary data on the relationship between the DASTT and the STEBI. The current study builds on El-Deghaidy's work using a U.S. sample and focuses on the stereotypical portrayal of science teacher personal characteristics rather than the distinction between teacher and student centeredness. We expected that students would increase in their level of self-efficacy regarding teaching science as a result of a course on science methods. Additionally, it was expected that students' drawing of "science teachers" would become less stereotypical and less abstracted to an image and more Approachable and personalized to their own image. Finally, it was expected that there would be a negative correlation between the STEBI and stereotypical depictions of science teachers - that is, students with strong Efficacy will be less likely to portray science teachers as stereotypical.

Method

Participants

Forty-eight students (43 female, 5 male, age range 20-23) early childhood through middle childhood pre-service teachers were assessed. Complete data were available on 38 students. The students were drawn from three sections of a course titled Teaching General Science Methods EC/MC, MC/EA (early childhood/middle childhood, middle childhood/early adolescent certification range). The students were assessed during the first week and last week of a 14-week semester. The course is one of four methods courses required for certification of early childhood elementary and middle level preserves teachers. Only one of the students in the group had identified "science" as a content interest (science minor) for being a middle school teacher. Except for this one student, the students' scientific coursework at the college level were two 4-credit science courses (one life science and one from any of the following sciences - physics, chemistry, physical science, or astronomy). These courses are normally used to "weed out" science majors rather than for promoting the learning of science for future classroom teaching, thus the pre-service teachers background in science content is minimal. All of the students were in their final semester of course work prior to student teaching.

Materials and Procedure

The focus of the course Teaching General Science Methods EC/MC, MC/EA is to provide differentiated strategies for the study of life sciences, physical science, earth and space science, the embedding of technology, using process skills, recognizing science from the personal and social perspective, and to understanding that there is a history and nature to science. Traditionally students in the course start the semester associating science teaching with the science content categories rather than the more global goals of the eight National Science Education Standards (NSES, 1996) associated with the course (Table 1). The assessment of science involves formative and summative assessment of knowledge, skills and dispositions. Finally, the course embeds the 10 Wisconsin teacher education standards. After providing informed consent to allow their responses to be included in a research study students completed two primary measures on two separate course days.

Table 1 National Science Education Content Standards

Categories	Description
Unifying concepts and processes in science	Unifying concepts and processes include: systems, order, and organization; evidence, models, and explanation; change, constancy, and measurement; evolution and equilibrium; and form and function.
Science as inquiry	Engaging students in inquiry helps students develop: understanding of scientific concepts; an appreciation for "how we know" what we know in science; understanding of the nature of science; skills necessary to become independent inquires about the natural world; and the dispositions to sue the skills, abilities, and attitudes associated with science.
Physical science, Life science, and Earth and space science	The standards for physical science, life science, and earth and space science space science describe the subject matter of science using three widely accepted divisions of the domain of science. Science subject matter focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.
Science and technology	The science and technology standards establish connections between the natural and designed worlds and provide students with opportunities to develop decision-making abilities. They are not standards for technology education; rather, these standards emphasize abilities associated with the process of design and fundamental understandings about the enterprise of science and its various linkages with technology.
Science in personal and social perspective	An important purpose of science education is to give students a means to understand and act on personal and social issues. The science in personal and social perspectives standards help students develop decision-making skills. Understandings associated with these concepts give students a foundation on which to base decisions they will face as citizens.
Science in personal and social perspective	In learning science, students need to understand that science reflects its history and is an ongoing, changing enterprise. The standards for the history and nature of science recommend the use of history in school science programs to clarify different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.

STEBI-B

The STEBI-B is a 23-item measure with a response set ranging from 1-5 (strongly disagree to strongly agree) and coded such that high numbers indicate a high efficacy. The STEBI-B reflects two subscales. The Personal Efficacy subscale (PSTE) items reflect beliefs about respondents' ability to successfully perform. A sample item from the personal efficacy subscale reads "Even if I try very hard, I will not teach science as well as I will most subjects." Outcome Expectancy subscale (STOE) reflects respondents' beliefs about the likelihood of the behavior leading to a specific outcome. A sample item from the outcome expectancy subscale reads, "The low science achievement of some students cannot generally be blamed on their teachers." Reliability coefficients for the subscales at the pre and post administrations for this sample, were in the .7 range. The correlations between the PSTE and STOE subscales at both the pre and post test times were non significant and ranged from .02- to .10.

DASTT

The DASTT measure is a version of the "Draw a Scientist" Test where instead of drawing a scientist, students draw a "science teacher," that was to be themselves as science teachers. In addition, researchers have utilized a version of the measure where students draw a "science teacher teaching" (DASTT) (Finson & Beaver, 1995). At the first administration time, students were asked to "draw a science teacher." At the second administration, students were asked to "draw a science teacher" and prompted to have the picture reflect "what the science teacher was doing" and "what the children were doing." Students had access to paper, pencils, pens, markers, and crayons. For the analyses associated with the current project, only teacher personal traits were considered.

Based on the work of Chambers (1983) and Mason, Kahle, and Gardner (1991), a rater coded the drawings for the presence/non presence of each of the following stereotypic scientist/science teacher characteristics listed in Table 2 (hereafter referred to as DASTT-P; draw a science teacher task - personal).

Table 2. Stereotypic Scientist/Science Teacher Characteristics

Coded Number	**Characteristic**
1	Male portrayed
2	Caucasian portrayed
3	Glasses present (separate from protective eye gear)
4	Hair - bald or "wacky" hair (hair standing straight up)
5	Clothing - "wacky" (such as tie-dyed shirts or mismatched or unkemp clothing)

Results

This study endeavored to explore three hypotheses. First, that student would increase in their level of self-efficacy regarding teaching science as a result of a course on science methods. As hypothesized and shown in Table 3, students indicated a higher level of personal efficacy at the end of the semester than at the beginning (paired t (37) = 8.0, p = .001), whereas the outcome expectancy showed a non-significant change in the hypothesized direction (paired t (37) = 2,8, p = .07).

Table 3. Science Teaching Efficacy Pre and Post Scores

STEBI Subscales	Pre-Test	Post-Test
Personal Efficacy (PSTE)	42.08 (SD = 3.7)	47.21 (SD = 4.2)
Outcome Expectancy (STOE)	37.84 (SD = 4.5)	39.18 (SD = 4.0)

Second, that students' drawings of the personal characteristics of "science teachers" would become less stereotypical over the semester. As hypothesized and shown in Table 4, students drew science teachers with fewer stereotypic personal characteristics at the end of the semester than at the beginning (paired t (37) = 2,9 p = .005).

Table 4. Draw a Science Teacher Personal Attributes Score Pre and Post Scores

	Pre-Test	**Post-Test**
DASTT-P	**1.28 (SD = 1.3)**	**.85 (SD = 1.2)**

Table 5 provides the raw number counts for each of the major categories at the pre and post administrations to provide a more quantitative perspective on the data. In addition, Figures 1 and 2 show the pre and post drawings from a student who showed a high level of stereotypic imagery at the pre administration but a low level at the post administration. At the pre-test time 33% of the students included no stereotypic traits; whereas, 50% indicated no stereotypic traits at the post-test.

Table 5. Stereotypic Scientist/Science Teacher Characteristics Raw Data

	Pre-Test	Post-Test
1. Male portrayed	11	8
2. Caucasian portrayed	6	3
3. Glasses present	15	10
4. Hair - bald or "wacky" hair	11	9
5. Clothing - "wacky"	18	10

Figure 1. Pre-Drawing

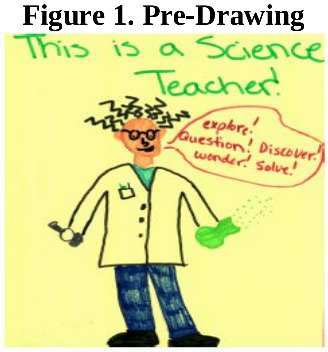

Figure 2. Post-Drawing

Finally, it was hypothesized that there would be a negative correlation between the STEBI and stereotypical depictions of science teachers (Table 6) -that is, students with strong efficacy will be less likely to portray science Teachers as stereotypical. Personal efficacy showed a small significant negative correlation with the DAST-P at both the pre and post administration times. However, the correlation was significant at the pre-test and no significant at the post test for outcome expectancy. Both the STEBI and DAST scales showed change from pre post; however, the relationship between the scales changed during the school term.

Table 6. Negative Correlation

Post-Test	Pre-Test
Science teacher personal traits and personal efficacy subscale	-.32* - .36*
Science teacher personal traits and outcome expectancy subscale	-.30*.14

* p < .05

Discussion

As indicated earlier, there is sparse research on the relationship between the STEBI and the DASTT. Our findings mirror El-Deghaidy's (2006) results. However, El-Deghaidy coded the DASTT for student or teacher centeredness, whereas this research focused on stereotypic traits. An analysis of the data confirmed that pre-service students indicated a higher level of personal efficacy at the end of the semester than at the beginning; however, their outcome expectancies did not change. Secondly, students' images of science teachers became less stereotypical over the semester. In terms of the relationship between efficacy and images, the more personally efficacious students portrayed science teachers less stereotypical than the less personally efficacious students. Over the semester the relationship between efficacy and the images did not alter for personal efficacy, but the relationship between outcome expectancy and stereotypical images was smaller by the end of the semester suggesting that the course influenced students' personal beliefs about efficacy and images of science teachers more than it altered their beliefs about the outcomes of teaching science. The findings from the current study suggest that students feel more efficacious but experience no change in their views of the ultimate outcome.

The implications of this are they felt better about their ability to learn science, but not about their ability to teach it. The lack of a relationship between personal and outcome efficacy is troubling for the long-term implications of studying efficacy and its impact on new teachers because of the concern for future U.S. students in the area of science.

Implications

Three long term implications for pre-service teachers are evident in the research: 1) they might feel more comfortable about science, however, if they do not believe they are competent with teaching science then they may avoid teaching science in their future classrooms; 2) they will be more text driven (teacher centered) rather than student centered in the pursuit of science; and 3) they will perpetuate the way they were taught science.

These implications suggest a closer look and possible revision of science content courses for elementary teaching majors is in order. Also, a more hands-on standard based focus should be explored.

Future Considerations

If students have a strong content background in the various sciences, they will truly be able to concentrate on the various teaching strategies and methodologies used in teaching science. The Framework of the Next Generation Science Standards "describes a vision of what it means to be proficient in science.…

This vision views science as both a body of knowledge and an evidence-based, model and theory building enterprise that continually extends, refines, and revises knowledge" Practices, crosscutting concepts, and disciplinary core ideas will combine to form three dimensions of each standard (Next Generation Science Standards, http://www.nextgenscience.org/threedimensions). This vision, when completed, will be the foundation of future research in the teaching of science. There are multiple reasons for science education and science teacher education research: building theory: understanding social cultural contexts; responding to state curriculum and assessment committees; and addressing local and global issues (Kamen, 2011). Future research should further explore factors that may affect outcome efficacy and should track changes in teachers' science efficacy as they transition from pre-service teachers to in-service teachers.

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