Does Intention Matter? Assessing the Science Teaching Efficacy Beliefs of Pre-service Teachers as Compared to the General Student Population

Jann Joseph
Grand Valley State University

Abstract

Teachers' sense of efficacy, that is, the extent to which they believe that their efforts affect student learning, is a significant indicator of effective teachers. Efficacy has two dimensions: self-efficacy and outcome expectancy. The research tests the hypotheses that there is no difference in the science teaching efficacy of science majors who planned to teach and science majors who did not and, non-science majors who planned to teach and non-majors who did not. The data were also analyzed to compare the science teaching efficacy of science majors and non-science majors in the general student population and of males and females. Among all pre-service teachers, science majors had a significantly higher Personal Science Teaching Efficacy (PSTE) but their Science Teaching Outcome Expectancy (STOE) was not significantly different from their non-science counterparts. In a comparison of science majors the pre-service teachers had a lower STOE than their peers who did not intend to teach. Pre-service non-science majors did not have a significantly different PSTE or STOE from the general population, demonstrating that completing a teaching minor and intending to be become elementary teachers did not positively impact their science teaching efficacy.

Correspondence concerning this manuscript should be addressed to Jann Joseph,_Integrated Science Program, Grand Valley State University, Allendale MI 49401 USA. Email: josephj@gvsu.edu

Introduction

Self-efficacy as a predictor of behavior is grounded in Albert Bandura's (1977) work in the theory of social learning. He hypothesized that efficacy has two dimensions: self-efficacy and outcome expectancy. Bandura described self-efficacy as the belief that a person could do something to produce a specific outcome, and outcome expectancy as "a person's estimate that a given behavior will lead to certain outcomes" (p. 79). Bandura (1977, 1981, 1982, 1989a & b) theorizes that over time, individuals are able to anticipate their behavior in a specific situation. Cause and effect based on accumulated experiences will change individuals' beliefs about how they will cope in a specific situation in the future. Self-efficacy beliefs are "not simply inert predictors of future behavior." According to Bandura (1989a, p. 731), individuals with more efficacious beliefs, "make things happen."

A person with high self-efficacy is confident about a specific task and that may influence his/her behavior. This includes effort, persistence, the ability to learn, and, ultimately performance and achievement (Bandura, 1977, 1982, 1989a; Schunk, 1989a & b: Zimmerman, Bandura, & Martinez-Pons, 1992). When Bandura's theory of social learning is applied to elementary science teaching, one can infer that if teachers have low science teaching efficacy they are likely to avoid teaching science. Conversely, if teachers have confidence in their science teaching ability, science will be taught. Riggs and Enochs (1990) developed a science teaching self-efficacy instrument for pre-service teachers. This instrument measures both of Bandura's constructs of efficacy: *self-efficacy* or individuals' "judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" and o*utcome expectancy* or individuals' judgments or beliefs regarding the contingency between a person's behavior and the anticipated outcome" (Bandura, 1986, p. 391).

Teachers' sense of efficacy (i.e., the extent of their belief that their efforts affect student learning) has been shown to be a significant indicator of effective teachers. Several researchers (Finson & Beaver, 1994; Koballa & Crawley, 1985; Riggs & Enochs, 1990; Wilson & Scharmann, 1994) have demonstrated that elementary teachers with low science efficacy tend to avoid science instruction, teach it sporadically, or give it inadequate time.

Pedagogical preparation and content knowledge are linked to science teaching efficacy. But science educators need to have a clearer understanding of their combined and individual impacts on science teacher preparation and specifically teaching efficacy. One would expect an effective teacher to have well-structured pedagogical and content knowledge and consequently, a higher sense of teaching efficacy.

Purpose of the Study

This study adds a new dimension to the literature on pre-service science teaching efficacy. Pre-service teachers' beliefs have been largely compared among peers, in specific contexts and socializations like methods courses where changes in efficacy were tracked before and after interventions (Liang & Gabel, 2005; Mulholland, Dorman, & Odgers, 2004; Palmer, 2006; Tosun, 2000; Young & Kellogg,1993). But we have limited knowledge about how these interventions separate teacher candidates from the general college student population. Do teacher education programs including coursework and experiences like teacher assisting and volunteering in classrooms elevate teacher candidates' science teaching efficacy above that of the average college student?

Since attitudes and behaviors are related, then non-science majors who plan to become teachers should have a significantly higher sense of self-efficacy related to teaching science than non-science majors who do not plan to teach. That is, the teacher preparation program should be affecting teacher candidates' science efficacy whether they are science majors or not. Supporting evidence for the teacher preparation program would include data demonstrating that science majors who do *not* plan to teach have no significantly higher efficacy than pre-service non-science majors.

This study was designed to provide additional insight into the effect of science coursework and teacher certification preparation on pre-service elementary teachers' science self-efficacy. In addition to a brief analysis of the impact of age and gender, it addresses three hypotheses as follows:

Hypothesis One

There is no significant difference in personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) between two groups of pre-service teachers: science majors and non-science majors. Since both groups took the same elementary teaching minor and required experiences, this hypothesis explores the effect of science coursework on science teaching efficacy.

Hypothesis Two

There is no significant difference in PSTE and STOE between a group of science majors who plan to teach and science majors who do not. This hypothesis tests the effect of the elementary teaching minor and the required pre-service teacher experiences since the science coursework is similar.

Hypothesis Three

There is no significant difference in PSTE and STOE between a group of non-science majors who plan to teach and non-science majors who do not. This hypothesis tests the effect of the elementary teaching minor and the required pre-service teacher experiences.

Background and Location for the Study

A Midwestern university in the United States with a teacher education program that graduates approximately 375 students annually was the setting for this study. At this university, students complete a content major and an elementary teaching minor before being accepted in the teacher certification program. The 20-22 credit elementary teaching minor includes two methods courses each in Mathematics, English, and Reading. Students also take two of four Art, Music, Physical Education or Theatre teaching methods courses for elementary teachers. The social studies and science courses in the minor are not designed especially for teachers but are also part of the university's general education requirements. Thus, it is not unusual for a pre-service teacher to graduate with only two science classes, only one of which must include a laboratory. Before completion of the minor and admission to the professional certificate program, all pre-service teachers must also complete 25 hours of volunteering with K-8 students.

A total of 490 students (pre-service teachers and general enrollment students) participated in university's Internal Review Board approved study. Their backgrounds were as follows:

- All pre-service teachers had completed a state-approved content major, a 20-credit distributed elementary teaching minor, and were enrolled in the teacher certification program.

- The science majors who planned to teach had completed a 39-41 credit group science major, with at least three courses taught by science education faculty who modeled discipline-specific methods in their courses.

- The science majors who did *not* plan to teach were enrolled in one of several science programs offered at the university.

- The non-science students' majors, whether they planned to teach or not, ranged across the arts, social sciences, and humanities, but they had all completed at least two general education college science courses.

Method

The Science Teacher Efficacy Belief Instrument (STEBI-B), as developed and tested by Enochs and Riggs (1990), was administered to the 490 participating students. While the instrument was specifically developed for pre-service teachers, students who had no immediate plans to teach were asked to reflect on the role of an elementary teacher and consider themselves as one as they completed the questionnaire. Enoch (personal communication, January 8, 2009) confirmed that the instrument's validity is not in question if careful instructions are provided to students who are not pre-service teachers.

STEBI-B includes 23 Likert-scaled statements relating to personal beliefs about teaching science. Response categories are "strongly agree," "agree," "uncertain," "disagree," and "strongly disagree." The STEBI-B measures two sub-scales (PSTE and STOE, mentioned previously) related to Bandura's (1977) theory of self-efficacy and applied to teaching by Gibson and Dembo (1984). The questionnaire also elicits demographic data, including gender, age, and number of high school and college science credits completed.

Pre-service teacher participants were enrolled in a seminar in the teacher education program and were in the middle of their practicum. General population students completed the survey while enrolled in a general education science course for science majors and non-majors.

In all, four groups of undergraduate students were asked to complete the STEBI-B instrument:

- Group 1 contained 262 non-science pre-service teachers.

- Group 2 consisted of 109 non-science majors who did not plan to teach.

- Group 3 included 88 science pre-service teachers.

- Group 4 consisted of 31 science majors who did not plan to teach.

The survey was completed by 109 males and 381 females. Students' responses were tabulated in Excel® and analyzed using SPSS® software as outlined in Enochs and Riggs (1990). The data were split along demographic lines and the variables outlined in the research hypotheses. Independent t-tests were conducted to determine significant differences between group means.

Results

Effect of Gender and Age

Table 1 show that there was no significant difference in the personal science teaching efficacy (PSTE) and the science teaching outcome expectancy (STOE) between males and females in the combined population of 490 students. This pattern is similar when the non-science pre-service teachers are isolated. However, the male science pre-service teachers had significantly higher STOE scores than their female peers.

Table 1
Comparison of all Students by Gender

Gender	N	Mean	Std. Dev.	Sig.
		All Students		
PSTE				
Male	109	41.33	5.45	
Female	381	41.88	4.98	.396
STOE				
Male	109	36.17	4.52	
Female	381	35.87	4.61	.540
		Non-science Pre-service Teachers		
PSTE				
Male	67	40.67	4.52	
Female	195	40.23	4.50	.492
STOE				
Male	67	34.65	4.49	
Female	195	35.23	4.74	.376
		Science Pre-service Teachers		
PSTE				
Male	23	39.30		
Female	86	40.13	.546	.546
STOE				
Male	23	*38.26*		
Female	86	35.51	.001	.001*

Students older than 27 years of age have a significantly higher PSTE score than their younger peers. The effect of age is also consistent for non-science majors who plan to teach, F(1,260); p=.04, .05. Based on the data shown in Table 2, age, which is linked to life experiences, can have an effect on science teaching self-efficacy.

Table 2
Comparison of all Students by Age (Over 27 vs Under 27)

Age	N	Mean	Std. Dev.	Sig.
PSTE				
Over 27	208	*42.79**	5.16	
Under 27	282	40.93	4.90	.000*
STOE				
Over 27	208	*37.05**	4.42	
Under 27	282	35.11	4.54	.000*

*Statistically significant

Effect of the Elementary Teaching Minor

Among all pre-service teachers (i.e., those who had completed the elementary teaching minor), science majors had a significantly higher PSTE, but their STOE was not significantly different from that of their non-science counterparts. However, as outlined in Table 3, there was no significant difference between science majors who planned to teach and those who did not. The elementary teaching minor had no effect on the PSTE scale of science majors, but there was a significant difference in their STOE. In fact, science majors who planned to teach had lower STOE scores than their peers who did not. The elementary teaching minor also had no effect on the PSTE of the non-science pre-service teachers. However, they had significantly lower STOE scores than their non-teaching peers.

Table 3
Comparing Students by Major and Elementary Teaching Minor

	N	Mean	Std. Dev.	Sig.
		All Pre-service Teachers		
PSTE				
Science	88	*46.42*	3.77	
Non-science	262	40.96	4.72	.000*
STOE				
Science	88	37.11	4.59	
Non-science	262	35.52	4.75	.762
		Science Majors		
PSTE				
Pre-service	88	46.42	3.77	
No minor	31	46.25	2.88	.805
STOE				
Pre-service	88	37.11	4.59	
No minor	31	39.29	3.63	.010

	N	Mean	Std. Dev.	Sig.
		Non-science Majors		
PSTE				
Pre-service	262	40.96	4.79	
No minor	109	39.96	4.50	.480
STOE				
Pre-service	262	35.08	4.75	
No minor	109	*38.09*	4.67	.035*

Effect of College Science Credits

Science majors, whether planning to teach or not, had significantly higher PSTE and STOE scores than their peers majoring in non-science disciplines (Table 4).

Table 4
Comparison of all Students by Major

Major	N	Mean	Std. Dev.	Sig.
PSTE				
Science	119	*46.37*	3.55	
Non-science	371	40.23	4.58	.000*
STOE				
Science	119	*37.68*	4.45	
Non-science	371	35.38	4.49	.000*

To further illuminate the effect of college science credits, an analysis of all 490 students (Table 5), showed that those who had taken more than 12 credits of college science demonstrated a significantly higher PSTE. Only one of the science majors had taken less than 12 college science credits, so this sub-group could not be separated. When the 371 non-science majors were compared, there was no significant difference between those who had taken more than 20 credits of science and those who had taken less. For all non-science majors, even completing more than 20 credits of coursework did not significantly increase their PSTE score. Further, at the 12-credit cutoff there was a significant difference in their PSTE, but not their STOE.

Table 5
Comparison of all Students by Number of Science Credits Completed

Science Credits	N	Mean	Std. Dev.	Sig.
		All Students		
PSTE				
More than 12	258	*43.43*	5.02	
Less than 12	232	39.82	4.46	.000*
STOE				
More than 12	258	*36.46*	4.63	
Less than 12	232	35.35	4.47	.008*

Science Credits	N	Mean	Std. Dev.	Sig.
		Non-Science Majors		
PSTE				
More than 20 credits	41	41.26	4.70	
Less that 20 credits	330	40.10	4.56	.140
STOE				
More than 20 credits	41	34.65	4.56	
Less than 20 credits	330	35.46	4.48	.288
PSTE				
More than 12 credits	140	*40.92*	4.70	
Less than 12 credits	231	39.81	4.74	.026*
STOE				
More than 12 credits	140	35.40	4.52	
Less than 12 credits	231	35.36	4.48	.928

Of the 262 non-science majors who completed the elementary teaching minor, 167 had taken fewer than 12 credits of science. There was a significant difference in PSTE between this group and their peers (Table 6). However, there was no difference in their STOE scores. Science coursework seemed to be a significant variable in determining science teaching efficacy, but only when students took more than 12 credits of science.

Table 6
Comparison of Non-science Pre-service Teachers by Number of Science Credits Completed

Non-Science Majors	N	Mean	Std. Dev.	Sig.
PSTE				
More than 20 credits	29	41.44	4.69	
Less that 20 credits	233	40.20	4.47	.186
STOE				
More than 20 credits	29	34.37	4.86	
Less that 20 credits	233	35.17	4.65	.412
PSTE				
More than 12 credits	95	*41.11*	4.53	
Less than 12 credits	167	39.90	4.44	.038*
STOE				
More than 12 credits	95	35.31	4.68	
Less than 12 credits	167	34.95	4.68	.547

Discussion

In this study, male pre-service science teachers had significantly higher science teaching outcome expectancy scores (STOE) than their female peers. This result is consistent with that of Jones and Levin (1994) who also reported that males demonstrated a significantly higher positive attitude to teaching science than females. These data do not provide evidence that males have more mastery over science content than females, only that male pre-service science teachers' outcome expectancy is significantly higher than that of their female peers and male non-science majors. If so, this may propagate a vicious cycle of producing female students who are less comfortable with science because they see few social models. This result is particularly notable because an overwhelming majority of elementary school teachers, including the participants in this study, are female non-science majors.

Age, which can intuitively be linked to increased exposure to social models, was also a factor in determining science teaching efficacy among these participants. Older students had a significantly higher PSTE but lower STOE. Perhaps their life experiences contributed to lower expectations of a teacher's ability to make a difference in the classroom. However, there was no clear indication that these experiences were linked to the teacher preparation program or experience in classrooms, as has been suggested by Ashton and Webb (1986).

When all students were compared, pre-service teachers had higher PSTE scores, but lower STOE scores, than their non-teaching peers. When all science majors were compared, there was no significant difference in PSTE scores, but pre-service teachers had significantly lower STOE values. This pattern was similar among non-science majors. Those who planned to teach had a significantly lower STOE than their peers with no teaching intent who did not complete the elementary teaching minor. This result may be due to the coursework, volunteer experiences with K-8 students, and/or other experiences in the professional certification program and the elementary teaching minor. Social experiences in their teacher training program may be lowering their expectations of themselves as teachers.

Cantrell, Young, and Moore (2003) suggest that teacher training programs that include science lesson planning, assisting with events such as Science Olympiad, and micro-teaching experiences in a supportive environment should have a positive effect on science teaching efficacy. However, these experiences are part of the science majors' pre-service training program at this university. The results of this study suggest that they did not have a significant influence. These results are consistent with Desouza, Boone, and Yilmaz (2003), who also observed that teachers with a science degree have higher teaching efficacy. But their extensive study of 300 teachers also indicates that those with more experience had lower outcome expectancy. Researchers such as Jones and Levin (1994) report similar results about declining efficacy with increased teaching exposure, including evidence that pre-service teachers can show higher science teaching efficacy than in-service teachers.

Benbow (1993) suggested that mastery of content and pedagogy may only be loosely linked to a sense of teaching efficacy. However, the results of this study suggest that science teaching efficacy is directly linked to science content. Science majors with no teaching intent, when asked to momentarily consider themselves as teachers, demonstrated no significant difference in their science teaching efficacy than those who were pursuing teaching careers.

The pre-service teachers in this study had completed a teaching minor and also a minimum of 20 credits of teacher certification coursework, including child psychology and classroom management. Yet these experiences had no effect on their PSTE scores, and a negative effect on their STOE values. Consequently, these data support Wenner's (2001) suggestion that subject matter knowledge appears to be a significant factor in teacher efficacy, and that confidence in teaching ability is linked to knowledge of facts, skills, and subject matter concepts.

When non-science pre-service teachers were separated from the general population of non-science majors, the data showed there was a significant difference in PSTE scores between students who had taken 12 credits of science and those who had taken between 12-20 credits. Although students did not complete the same science courses, the data suggest that the lower limit of 12 credits is sufficient for generalizations about the PSTE scale. This is supported by similar findings by Jones & Levin (1994). However, a difference of 12 to 20 credits or more did not have an effect on the STOE scale; this provided another source of data to support the idea of science coursework influencing the PSTE scale and social experiences influencing the STOE scale.

Jones and Levin (1994) demonstrated a strong correlation between the number of science courses and science efficacy (i.e., three or more courses are linked to the individual teacher giving a higher priority to science instruction). This result is consistent with our observation that science majors who did not plan to teach had significantly higher PSTE scores than pre-service teachers who were non-science majors. It also demonstrates that the data set and the results are consistent with established research.

Implications and Conclusions

Perceived self-efficacy encompasses people's beliefs about their capacity to produce designated levels of performance that exercise influence over events affecting their lives. Beliefs contained in self-efficacy determine how people feel, think, motivate themselves, and behave. A person with high science teaching efficacy will be likely to approach teaching science with confidence, rather than viewing it as a threat or giving up quickly when faced with a difficult situation. Limited content and pedagogical content knowledge and low efficacy have been linked to teachers avoiding science in the classroom. When they do teach science, it is usually within their comfort zone where they feel they can control the classroom. This, in turn, can limit student engagement (Appleton, 2007). Although not always obvious or easily defined, teachers' attitudes and beliefs influence the sum total of their actions in the classroom. This includes lesson planning and delivery, assessment strategies, and interactions with students and parents (Jones & Carter, 2007).

If science educators consider the key sources of efficacy: mastery experiences, vicarious experiences provided by social models, social persuasion, and emotional states (Bandura, 1997), what are the implications of this study? First, it appears that, except for males, the outcome expectancy of pre-service teachers who are majoring in science are no higher than those of their peers who were asked to imagine themselves as a future teacher as they completed the instrument. Since the majority of participants were female, the lack of social models in K-12 and college could account for this observation. The data suggest that at least this teacher training program does not provide science pre-service teachers with opportunities that change their outlook on science teaching beyond that of their non-teaching peers. Any additional experiences possibly even had a negative effect on the outcome expectancy scale of the belief instrument.

Second, non-science pre-service teachers did not exhibit significantly different expectations about their ability to teach science in elementary schools than their peers who had no intention of teaching. The findings of this study suggest that these non-science majors may not be ready to assume responsibility for their students' learning in science.

The results provide evidence that, while generally the pre-service teachers were willing to take more responsibility for students' learning in science, the non-science majors were not yet identifying themselves as teachers who would be successful teaching science in K-8 classrooms. The data suggest that service learning, volunteer experience, and science education courses have little influence on science majors and non-majors. Additional research on the quantity and quality of these experiences, and their effect on science teaching efficacy, will expand the literature. Science teacher educators will benefit from further qualitative and quantitative research on the socialization of pre-service teachers before and during their teacher preparation programs and the subsequent impact in teaching efficacy and teaching practice.

To improve the science teaching efficacy of pre-service elementary teachers at this institution, teacher educators must provide effective experiences above and beyond those offered to the general population of students. Specifically, science majors must be held accountable for the same content as their non-teaching peers, but must also be exposed to the nature of teaching science in social environments that builds confidence for teaching. Non-science majors require similar content courses as their science major peers, although, how much will be enough is still open for discussion. This study suggests a minimum 12 credits is necessary. Finally, teacher educators must model good pedagogy linked to science content and foster a supportive environment where pre-service teachers can explore and practice their new skills. For those students who intend to teach in K-8, whether they are science majors not, it is likely that will be required to teach science. The study indicates that their intention does not matter. The preparation they are receiving is not adequately elevating their efficacy and outcome expectancy beyond the general population of college students.

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