

2015

Changes in Science Teaching Self-efficacy among Primary Teacher Education Students

David Palmer

University of Newcastle, David.Palmer@newcastle.edu.au

Jeanette Dixon

University of Newcastle, Jeanette.Dixon@newcastle.edu.au

Jennifer Archer

University of Newcastle, Jennifer.Archer@newcastle.edu.au

Recommended Citation

Palmer, D., Dixon, J., & Archer, J. (2015). Changes in Science Teaching Self-efficacy among Primary Teacher Education Students. *Australian Journal of Teacher Education*, 40(12).
<http://dx.doi.org/10.14221/ajte.2015v40n12.3>

This Journal Article is posted at Research Online.
<http://ro.ecu.edu.au/ajte/vol40/iss12/3>

Changes in Science Teaching Self-efficacy among Primary Teacher Education Students

David Palmer
Jeanette Dixon
Jennifer Archer
University of Newcastle

Abstract: Many preservice primary teachers have low self-efficacy for science teaching. Although science methods courses have often been shown to enhance self-efficacy, science content courses have been relatively ineffective in this respect. This study investigated whether a tailored science content course would enhance self-efficacy. The participants were preservice primary teachers and data collection was by survey and interview. Self-efficacy increased during the course and the increases were stable after a 10-month delay period. The factors that enhanced self-efficacy were: learning science content, perceptions of learning how to teach science, and teacher enthusiasm.

Introduction

Self-efficacy has been defined as a person's judgments about his/her ability to "organize and execute courses of action required to deal with prospective situations that contain many ambiguous, unpredictable, and often stressful, elements (Bandura, 1982, pp. 200-201). One form of self-efficacy is efficacy for teaching. High teacher efficacy is a belief that one can successfully teach students, even difficult students; whereas low teacher efficacy is a belief that there is little one can do if students are unmotivated or if there are oppositional influences (Bandura, 1997). Teacher efficacy is important because it is a powerful predictor of instructional behaviour. Tshannen-Moran, Hoy, and Hoy (1998) reported that teachers with high efficacy expend more effort in teaching and show greater persistence in the face of obstacles. In addition, they are more likely to try new instructional approaches in an effort to find better ways of teaching, and are more willing to work with students who are experiencing difficulties.

Primary science teaching is one area however, in which low teacher efficacy has long been a problem. Bencze and Hodson (1999) argued that many practicing primary teachers had low confidence for teaching science, and as a result they taught as little science as possible, usually using expository methods rather than inquiry. Petersen and Treagust (2014) for example reported that science was one of the least taught subjects in the primary school curriculum. A similar problem also applies to *preservice* primary teachers: Tosun (2000) reported that preservice primary teachers had mainly negative beliefs about science teaching; and Buss (2010) found that preservice primary teachers had less efficacy for teaching science and mathematics than for other subject areas in the primary curriculum. This is an important issue, as Appleton and Kindt (2002) reported that those students who graduated with higher self-efficacy make better progress as teachers of science in primary schools.

Consequently, in recent years there have been many studies devoted to enhancing the science teaching self-efficacy of preservice primary teachers (Avery & Meyer, 2012; Ford, Fifield, Madsen, & Qian, 2013; Liang & Richardson, 2009; Watters & Ginns, 2000). It has

been found that science methods courses (i.e., those that teach how to teach science) and field placements that include opportunities to practice science teaching can often be successful in this regard (Settlage, Southerland, Smith, & Ceglie, 2009).

However, the results for science content courses (i.e., those that teach the concepts of science) have been more mixed. In early studies it was widely acknowledged that confidence is dependent on subject content knowledge (Harlen & Holroyd, 1997), yet paradoxically, authors such as Watters and Ginns (2000) reported that the science content courses were less successful than science methods courses in enhancing confidence. One reason for this may have been the design of the courses, as Schoon and Boone (1998) reviewed a number of other studies (e.g., Ramey-Gassert & Schroyer, 1992; Westerback & Long, 1990) and concluded that science courses that were specifically designed for primary education majors were more likely to be of value. In recent years, science content courses have often taken a more inquiry-oriented approach, and this has sometimes helped to enhance self-efficacy (e.g., Liang & Richardson, 2009), but it has also been found that students can struggle with open-ended and student-directed formats (e.g., Ford, Fifield, Madsen, & Qian, 2013). Avery and Meyer (2012) reported that an inquiry-based science course resulted in self-efficacy gains for some students, but worsening for others. The effectiveness of science content courses in enhancing self-efficacy is therefore an open question.

In order to analyse these various types of science courses it is important to understand the factors that can potentially enhance self-efficacy amongst preservice teachers. Bandura (1997) proposed that four factors might produce changes in self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological/affective states. *Enactive mastery experiences* are authentic experiences in which one demonstrates the capability to succeed in the task. In studies of preservice primary teachers, mastery experiences have often included successful participation in science teaching practice (Kenny et al., 2014; Mansfield & Woods-McConney, 2012). Roberts and Henson (2000) argued that mastery experiences could also include successful mastery of new information. Velthuis, Fisser, and Pieters (2014) for example, reported that higher levels of self-rated subject matter knowledge contributed to higher levels of science teaching self-efficacy. In addition, Rice and Roychoudhury (2003) reported that the students learnt pedagogical techniques when the science methods tutor modelled teaching methods that were appropriate for primary science. Palmer (2006) referred to these forms of mastery as *cognitive content mastery* (i.e., learning information about science content) and *cognitive pedagogical mastery* (i.e., learning information about teaching techniques).

Bandura's (1997) second source of efficacy information was *vicarious experiences*, and these occur when attainment is modelled by another person. Thus, seeing or visualising a person perform a task successfully can enhance the observer's belief in his/her capability. Vicarious experience can occur when instructors model teaching behaviours during teacher education courses – Posnanski (2002) reported that this involved a heavy emphasis on hands-on activities, cooperative learning, and discussion. Similarly, Rice and Roychoudhury (2003) reported that modelling of good science teaching included both teaching strategies *and* attitudes that were appropriate for use in primary teaching. They argued that the instructor's enthusiasm and sense of humour provided a model of how to create a positive classroom environment, and this in turn increased the students' confidence that they could do it themselves.

Bandura's third and fourth sources of efficacy information were *verbal persuasion*, which occurs when "significant others express faith in one's capabilities" (Bandura, 1997, p. 101), and *physiological/affective* states, which refers to one's reactions to stress, fatigue and mood. Verbal persuasion has been reported to occur through the professor's role as a mentor and his/her comments to the class (Gunning & Mensah, 2011), and students have been helped

to deal with their stress and anxiety about science learning by having extensive classroom discourse (Gunning & Mensah, 2011). However, Bandura (1997) considered these to be less influential than the other sources.

Thus, the current evidence (Posnanski, 2002; Rice & Roychoudhury, 2003; Velthuis, Fisser, & Pieters, 2014) suggests that the science teaching self-efficacy of preservice primary teachers might be positively influenced by: science education courses that contain opportunities for learning information about science content; learning teaching techniques for primary science; practicing hands-on activities; working in cooperative groups; and participating in discussion. This could be aided by observing instructors who model good teaching behaviours including enthusiasm and humour. These are intriguing findings, because many of these elements could be argued to be easily integrated into a science content course. The only exception would arguably be that science content courses differ to science methods courses as the former has a focus on the concepts of science whereas the latter has a focus on teaching techniques for science (Cantrell, Young, & Moore, 2003).

A separate issue is the question of the durability of changes in self-efficacy. Previous studies for example, have convincingly demonstrated that well-designed science method courses can effectively induce positive changes in science teaching self-efficacy by the end of the course. However, there is very little information about how long the changes might persist after completion of the course. It may be hypothesised, for example, that student beliefs may be temporarily improved at the end of an interesting and well-presented course, but they may decline again as students complete their other (non-science) studies prior to graduating. This is a particularly important issue, as a key feature of self-efficacy is that it is a relatively stable belief, so once established it should endure at the higher level for a considerable period of time. However, it is not yet clear whether a science content course could have this effect.

The aims of this study were:

1. to investigate whether science teaching self-efficacy is enhanced in a science content course that is developed specifically for preservice primary teachers;
2. if so, to investigate whether the changes in self-efficacy persist for a substantial period of time after the course;
3. to identify the effective sources of efficacy information in the course.

One issue for this study was to make the important distinction between self-efficacy and confidence. The term “confidence” is a colloquialism rather than an educational construct, but it does have the advantage in that it is a term in general usage among the population so it can be more easily understood by participants in research studies (e.g., Rice & Roychoudhury, 2003; Watters & Ginns, 2000) than can the more technical term “self-efficacy”. However, Bandura (1997) argued that although they have similarities, the two are not equivalent: they are similar in that they both refer to the strength of a belief, but the term confidence “does not necessarily specify what the certainty is about” (p. 382) whereas self-efficacy does specify the type of attainment to be achieved. In order to resolve this dilemma the approach used in the present study will be to use the term confidence but *also specify what the confidence is about*. In this way, the validity of the participants’ responses is not compromised by use of technical terminology, and the differences between the two terms may be reduced to a minimum. Thus, although the aims of this study concern self-efficacy, the interview questions will use the term confidence, with a specific focus on confidence to teach primary science.

Method

This study used a longitudinal design (Wiersma, 2000) comprising a single-group pre-test, intervention, immediate post-test and delayed post-test. Data collection was by survey and interview. Validity and reliability were investigated by computation and by triangulating the two sets of data.

Participants

The participants were preservice primary teachers enrolled in a one-semester science content course at a regional university south-eastern Australia. These students were in the first year of a four-year program of teacher education. There were approximately 500 students enrolled in the course, of whom 313 volunteered to participate in the pre-test survey. Most of these students were aged 18-22 years and 74% were female. However, many of them missed one or more of the subsequent post-tests, so their data were incomplete. Consequently, it was decided that only the 104 students who participated in all three iterations of the survey (pre-test, immediate post-test, and delayed post-test) would be analysed, as it was this group that would provide the most reliable measure of any changes in self-efficacy. The 104 students who participated in all three iterations of the survey had a similar demographic to the class as a whole, as 82% were female, and most were 18-22 years of age. Twenty-five students also volunteered to be interviewed.

Students were recruited in the following way. The first and third authors of this paper, who were not teaching in the science course, attended tutorials and invited students to complete the survey, and to place it in a box available at the back of the room when finished. Students who did not wish to complete the survey also placed their blank survey sheets in the same box. They were informed that their responses would be anonymous, and that participation would not influence their grades in the science course.

Many of the participants had come directly to university from high school. In Australian high schools, science is a mandatory component of the school curriculum in grades 7-10, so the participants can be assumed to have studied science to grade 10 level (i.e., ages 15-16 years). Science is not compulsory during the final two years of high school, but some students normally choose to study biology in preference to physics and chemistry. Thus, the science experiences of the students in the study would be expected to vary, with some not having studied science for at least two years.

The Science Content Course

The science course was compulsory for these students, and occurred in the first semester of the teacher education program. It lasted 10 weeks, and comprised weekly lectures and tutorials. The second author developed this course to suit the needs of primary teacher education students, and she taught all the lectures and tutorials for the participants in this study. The lectures typically used a transmission approach to a large audience, and in these there was a low level of interaction. The tutorials however, comprised groups of up to 25 students and were highly interactive, as students participated in hands-on activities, group work, and discussion, as well as studying artefacts such as unusual fossils. The science topics focused on those that would be most relevant to primary schools, and included the Earth, energy, force, astronomy, biology and the human body.

This science course was unusual by comparison with those reported by other authors

(e.g., Avery & Meyer, 2012; Ford, Fifield, Madsen, & Qian, 2013; Liang & Richardson, 2009; Settlage et al., 2009) because it did not include opportunities for practising science teaching in field placements, and nor did it include the use of higher level inquiry as a pedagogy. Instead it used a relatively traditional approach in which science content was explained by the lecturer and explicit instructions were provided for the hands-on activities. It was notable however, that the lecturer tried to make the presentations as interesting as possible; by making regular use of examples from everyday life, pictures, diagrams, humorous personal anecdotes, fun facts and demonstrations that supported the explanations of science content. She also made an effort to use everyday language, and to avoid overuse of scientific jargon in her explanations of science concepts. In the tutorials, the hands-on activities were unusual because they typically used everyday materials rather than specialized scientific equipment, and this was designed to make them more relevant to real life. In addition, many of the science demonstrations had a surprising or unexpected result, as this was designed to enhance their appeal to students (Shrigley, 1987).

Data Collection and Analysis: Survey

The purpose of the survey was to measure changes in science teaching self-efficacy (Research Questions 1 and 2). The instrument used was the *Science Teaching Efficacy Belief Instrument – Form B (STEBI-B)*, developed by Enochs and Riggs (1990) for use with preservice primary teachers. The instrument contained 23 items representing two scales: the Personal Science Teaching Efficacy (PSTE) scale was designed to measure self-efficacy; and the Science Teaching Outcome Expectancy (STOE) scale was designed to measure the belief that students could learn science if they were taught effectively. The STOE scale has been the subject of considerable debate, as it often has been found to have a relatively low reliability and many researchers have questioned its validity, so there is considerable disagreement about exactly what it is measuring (see Roberts & Henson, 2000). It was included in the data collection of this study simply to maintain the integrity of the instrument as a whole, but it was not included in the analysis (this was also because outcome expectancy was not an aim of the study).

This survey was administered three times, as a pre-test during the first week of the science course, as an immediate post-test in the last week of the course, and as a delayed post-test, which was carried out 10 months after the end of the course. The survey was administered by a person not associated with the science course (the third author), and students were allowed as much time as they needed to complete it. They were asked to write an anonymous identifier (their mother's maiden name) on the survey to enable their responses from the three administrations of the survey to be compared, while maintaining anonymity.

In the analysis, each item was scored 5, 4, 3, 2, or 1, with 5 being the maximum positive response and 1 being the most negative. The 13 items of the PSTE scale were:

1. I will continually find better ways to teach science.
2. Even if I try very hard, I will not teach science as well as I will most subjects (reversed).
3. I know the steps necessary to teach science concepts effectively.
4. I will not be very effective in monitoring science experiments (reversed).
5. I will generally teach science ineffectively (reversed).
6. I understand science concepts well enough to be effective in teaching science.
7. I wonder if I will have the necessary skills to teach science (reversed).

8. I will find it difficult to explain to students why science experiments work (reversed).
9. I will typically be able to answer students' science questions.
10. Given a choice, I will not invite the principal to evaluate my science teaching (reversed).
11. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand (reversed).
12. When teaching science, I will usually welcome student questions.
13. I do not know what to do to turn students on to science (reversed).

Principal components factor analyses (using SPSS) were conducted on the items at three time points: Time 1 - at the beginning of the science content course (313 students responded); Time 2 - at the end of the science content course (199 students responded); and Time 3 - 10 months after the end of the science content course (136 students responded). In each factor analysis, three components were identified. For variance accounted for at Time 1: component 1, 30.1%; component 2, 12.2%; and component 3, 7.8%. For variance accounted for at Time 2: component 1; 32.9%, component 2, 8.7%; and component 3, 8.0%. For variance accounted for at Time 3: component 1, 34.5%; component 2, 10.4%; and component 3, 9.2%.

On inspection of the component matrices, the first three items for the Time 1 analysis were the weakest items loading on the first component (0.34, 0.38. and 0.36 respectively). However, these three items loaded above 0.4 on the first component for factors analyses at Time 2 (0.47, 0.59, and 0.46 respectively) and at Time 3 (0.48. 0.50, and 0.41 respectively). Given these results across the three time points, it was decided to include all 13 items in the self-efficacy scale. Using all items in the PSTE scale would enable comparisons with other studies using the scale. The Cronbach's alpha coefficients of reliability of the PSTE scale for Time 1, Time 2, and Time 3 were 0.80, 0.82, and 0.83 respectively. It was concluded that the PSTE was a relatively robust scale for the participants in this study.

To compare pre-test, immediate post-test and delayed post-test means, a one-way repeated measures analysis of variance was carried out using data from the 104 students who had participated in all three of these data collections. Significant differences between means were identified using Bonferroni post hoc tests.

Data Collection and Analysis: Individual Interviews

The 25 interviews were carried out over the two weeks immediately following the end of the science course. The purpose of the interviews was to provide additional evidence for any changes in self-efficacy and also to identify the reasons for the changes (Aim 3). In order to maintain confidentiality and to enhance reliability, all interviews were conducted by the first author, who was an experienced interviewer, and not involved in the science course. A semi-structured technique was used, in which students were asked the same guide questions, but with additional probing or clarifying questions as needed. Each interview lasted up to 20 minutes. The guide questions were:

1. What was your confidence to teach science before the course? Where would it have been on a scale of positive, neutral or negative?
2. What is your confidence to teach science now, after the course? Where would it be on a scale of positive, neutral, or negative?
3. Did the science course have any effect in changing your confidence to teach science? If so, what happened in the course that helped to make you more confident to teach science?

As explained earlier in this paper, the term self-efficacy was not used in the interviews as it is a technical term with a very specific meaning that may not have been validly interpreted by the interview participants. Consequently it was decided to use the term “confidence to teach science” as this would provide an affirmation of an expected capability level as well as personal agency in a specific endeavour, both of which are necessary in order to characterise self-efficacy (Bandura, 1997). Construct validity was further enhanced in the interviews by extensive use of probing and clarifying questions in order to adequately confirm the nature of the underlying belief. Triangulation of the interview responses with those obtained from the surveys provided a measure of internal consistency. Finally, inter-rater reliability of the coding was carried out by the first author and the second author, who independently coded a representative sample of 29 responses, and agreement was found in 89% of instances.

The audio recordings of the interviews were transcribed verbatim, and then initially coded using low inference descriptors. Where codes seemed to express the same idea they were grouped into larger categories representing changes in self-efficacy and causes of the changes.

Results

Survey Results

For the 104 students who participated in all three iterations of the survey, the means and standard deviations for the PSTE scale were 43.5 (5.61) for the pre-test, 48.81 (6.20) for the immediate post-test, and 47.59 (5.99) for the delayed post-test ($n = 104$). For the one-way repeated measures analysis of variance, the F value was determined to be $F(2, 206) = 36.13$, $p = .000$ and the effect size was medium ($\epsilon = .39$).

The post hoc pairwise comparisons of the PSTE results showed there were significant increases for personal science teaching efficacy (PSTE) from the pre-test to the immediate post-test (mean difference = -5.31, $p < .001$), and from the pre-test to the delayed post-test (mean difference = -4.09, $p < .001$) but no significant difference from the immediate post-test to the delayed post-test (mean difference = 1.22, $p > .05$). In summary, the survey results indicated that science teaching self-efficacy increased from the pre-test to the immediate post-test and then stayed at the same (higher) level during the ten months following the science course.

Interview Results

Comparison of Interview Question 1 (confidence before the course) with Interview Question 2 (confidence after the course) indicated that all 25 interviewees had experienced a positive change in confidence to teach primary science. The following is a representative

response to Interview Questions 1 and 2 from one student:

[*What was your confidence to teach science before the course?*] Not confident at all. I would have stayed very far away from that.

[*What is your confidence to teach science now, after the course?*] Highly positive. I definitely feel I'd be able to walk into a classroom and not even having a lesson plan there but be able to say 'I'm going to teach about this', and go 'We're going to learn this today guys'. And off we go.

Similarly, when the interviewees were asked to rate their confidence levels as positive, neutral or negative, a positive change from pre-test to post-test was identified for every student: 15 students changed from negative to positive; five changed from neutral to positive; and five changed from negative to neutral. The following is an example of one student's responses:

[*On a scale of positive, neutral and negative before the course your confidence to teach science would have been?*] Probably negative. I wouldn't have the passion to go out and do it because I've not always been really interested in it and I wouldn't have had the confidence to do it.

[*On a scale of positive, neutral and negative after the course, where would your confidence to teach science be now?*] At the top, positive.

In response to Interview Question 3 (i.e., whether the science course had changed their confidence to teach science) all interviewees indicated that the science course was the thing that had positively changed their confidence to teach science:

From seeing Jeanette teach, I can use her as a role model and be able to be enthusiastic and she's helped me understand a lot of key concepts, and I feel much more confident in teaching.

Yes, it has improved it a lot. I didn't have any idea before on how to approach it. Having her show us practically all the different games and things, gave me a lot of ideas that I could use in a class.

As part of Interview Question 3, interviewees had been asked what happened in the science course that helped to make them more confident to teach science. Many students described more than one cause of a positive change. The following broad categories were created from their responses: *a perception of learning how to teach primary science*, *understanding the science concepts*, and *teacher qualities*, as follows.

A Perception of Learning How to Teach Primary Science.

Responses were placed in this category if they indicated that learning how to teach primary science had improved their confidence. It should be noted that the science course was not intended to teach students how to teach science, but the responses from the students indicated that they had a perception of acquired knowledge about teaching by watching the tutor teaching. Most of the responses referred to learning how to teach science using techniques that had been used in the course, including hands-on activities, experiments with everyday materials, demonstrations, stories, pictures, analogies, and fun facts. This was the

most common reason given for an increase in confidence (100% of interviewees). For example,

Yes. I do feel more confident as a result of being in this course having got all of these new ideas and observed Jeanette in practice. Her actual example of teaching doing the tutorials is like an example of teaching I can emulate in my classroom. I've got some sort of mental image how I would be standing in the classroom teaching a lesson on science because I have actually been in that lesson, looking at Jeanette teach.

Understanding the Science Concepts.

This category was used when students stated that understanding the science content increased their confidence to teach science. This was the second most common reason for increases in confidence (92% of interviewees). For example,

If you are going to have confidence to teach a class, you going to have to know what it is that you were talking about. So I have learned from someone who knows what they are teaching.

She broke down science into simpler terms.

Now, because I have a deeper understanding, I feel more confident to teach the science.

Teacher Qualities.

Responses were assigned to this category if the interviewees implied that tutor qualities such as enthusiasm and humour had increased confidence for teaching science. This was a minor reason, as it was only mentioned by 28% of the interviewees. For example,

Just seeing Jeanette as not being the super science geek, but being this ordinary woman who loves and is really passionate about science, and just teaching it out of that passion. Jeanette being real about it and having a passion for it has been really good for building my confidence to teach.

Discussion

The first aim of the study was to investigate whether self-efficacy was enhanced in the science course. The survey and the interviews both provided evidence that self-efficacy had been enhanced. The PSTE scale in the survey showed that self-efficacy had increased from the pre-test to the post-test, and this was supported by the interview transcripts, which showed that all 25 interviewees had experienced a positive change in self-efficacy. This was an interesting finding, as historically, science content courses have not always had a positive effect on primary teacher education students: Avery and Meyer (2012) for example, reported that their inquiry-based science course had a positive effect on some students but a negative effect on others. The science course in the present study was more traditional in that it was not inquiry-based, but instead comprised transmission-style lectures supported by interactive

tutorials. Its main feature however, was that it was developed specifically for primary teacher education students: it used everyday materials rather than specialised scientific equipment to demonstrate science concepts, the lecturer used everyday language and tried to avoid overuse of jargon, and the lecturer utilised a wide range of teaching techniques in order to enhance understanding. Thus, this relatively tailored approach may have been the key feature distinguishing this science course from those reported in other studies.

One issue however, was that although the interviews and the survey were both in broad agreement in indicating a positive change in self-efficacy, the actual amount of change appeared to be subtly different. In the present study, the Personal Science Teaching Efficacy (PSTE) scale means changed from 43.5 (pre-test) to 48.8 (post-test) and the effect size was medium. However, the actual possible range of scores on the PSTE scale is 13 – 65, so the results of the present study imply a pre-test self-efficacy that is just positive (43.5) followed by a relatively modest change (to 48.8). However, many of the interview responses implied a more substantial change had occurred. In fact, the majority of interviewees indicated that their self-efficacy had changed from negative to positive. Thus, the interview data implied that the size of the change had been significantly greater. A possible explanation is that the interviewees may have been more greatly affected by “social desirability bias” as participants in face-to-face interviews have been known to present more positively than survey respondents (e.g., Nederhof, 2006). However, the important finding is that the survey results were in general agreement with the interview results, confirming positive increases in self-efficacy.

The second aim of the study was to investigate whether the gains in self-efficacy persisted for a substantial period of time after the course. Comparison of the immediate post-test and delayed post-test results showed that levels of self-efficacy remained stable over the 10 months following the end of the science course. A key feature of self-efficacy is that it is construed as a relatively stable phenomenon, and the present results provided evidence that changes in self-efficacy can be relatively stable. Studies from science methods courses have provided similar results: Settlage et al. (2009) for example, measured self-efficacy at the beginning and end of a science methods course, and then some time later at the end of student teaching. They found that there was an increase in mean scores over the period of the methods course, with a slight reduction by the end of student teaching. The present study was important in establishing that the same type of pattern could also be experienced by students participating in a science content course.

The third aim of the study was to investigate the sources of efficacy information in the course. The factors that enhanced self-efficacy were identified from the interview transcripts. The two main causes were *perceptions of learning how to teach primary science*, and *understanding the science concepts*. The category of *perceptions of learning how to teach primary science* was coded when students referred to learning how to teach science using techniques such as clear explanations, hands-on activities, experiments with everyday materials, demonstrations, stories, and fun facts. Importantly, these techniques had not been explicitly taught by the tutor, but had been used by her as she taught science, so students felt they had learnt these techniques simply by watching her. The category of *understanding the science concepts* was coded when students stated that they had developed greater background knowledge of science content. This had increased their confidence because they felt they would need it in order to successfully teach science to children. Comments indicated that the tutor had broken science down into simple terms, and this, along with the other teaching techniques used in the course, had helped them to understand the concepts. These two factors, *perceptions of learning how to teach primary science*, and *understanding the science concepts* do correspond with Bandura’s (1997) proposed sources of efficacy information because they can be argued to represent different forms of mastery experience. For example,

learning how to teach primary science implies a perception of a mastery understanding of pedagogy, whereas learning information about science content implies a perception of mastery of science concepts. It should be noted that other studies have revealed a wider range of factors that may provide mastery experiences for preservice primary teachers: providing science teaching practice in primary schools is a notable example (e.g., Velthuis, Fisser, & Pieters, 2014), but this type of experience was not provided in this science course.

In addition, teacher qualities, including enthusiasm and humour, was identified as a source of self-efficacy. In general, it is well known that enthusiasm is an attribute of an effective teacher (Kunter, Frenzel, Nagy, Baumert, & Pekrun, 2011) and that enthusiasm can be passed on to students. This infectious nature of teacher enthusiasm has been described as “emotional contagion” (Hatfield, Cacioppo, & Rapson, 1993), but the psychological reasons for it are still unclear. However, the literature has relatively few references to teacher enthusiasm as a source of self-efficacy, and it was not explicitly listed as one of Bandura’s (1997) sources of efficacy information. In what is possibly the only other study on self-efficacy in which it has been identified as a factor, Rice and Roychoudhury (2003) reported that teacher enthusiasm and use of humour helped to create a positive classroom environment in a primary science methods class. It is therefore possible that the tutor’s enthusiasm and use of humour in the present study provided a model for how to create a positive classroom environment. Bandura (1997) argued that people actively seek proficient models who possess the competencies to which they aspire. Thus, the creation of a positive classroom environment by a competent model may have enhanced the students’ beliefs that they will be able to perform this task when they become teachers. Having an enthusiastic teacher may therefore enhance self-efficacy by providing vicarious experience. However, it should be remembered that these were teacher education students, so this argument would probably not apply to other types of students, and its generalisability is therefore limited.

Conclusions, Limitations, and Implications

In conclusion, this study has provided evidence that a science content course, which uses a traditional format of mass lectures supported by interactive tutorials, can enhance science teaching self-efficacy as long as the content and techniques are chosen to be relevant to primary teacher education students. Moreover, the changes in self-efficacy were relatively durable over the 10 month delay period. The two main factors that were sources of efficacy information were successful learning of science content and perceptions of successful learning of primary teaching techniques. In addition, the study revealed the importance of teacher enthusiasm as contributing to self-efficacy.

There are a number of limitations that should be considered when interpreting this study. The participants were preservice primary teachers, and it should be emphasised that some of the findings would probably not generalise to other types of students. For example, the students reported they had learnt teaching techniques by watching them being modelled by the tutor. While this had greatly influenced their self-efficacy, it is questionable whether it would apply to students who were not training to be teachers. Similarly, the factors that enhance self-efficacy amongst preservice teachers are not always the same as those for experienced teachers (Cruz & Arias, 2007). In addition, the study was carried out in a science course, so it was relatively easy to include a wide range of hands-on activities and demonstrations, but these might not be as relevant to other disciplines.

The study showed that teacher enthusiasm contributed to self-efficacy, and this has an important implication for research, as the reasons for this relationship are not clear. Although teacher enthusiasm was not listed by Bandura (1997) as a source of efficacy information, it

may nevertheless have had its effect by showing students how to create a positive learning environment, so it could be interpreted as a form of mastery experience. Yet this might not apply to students who are not training to become teachers, so the extent to which this is the case should be further investigated. In fact, there has been relatively little research on teacher attributes as sources of self-efficacy, so it would be a potentially fruitful area for further research.

Finally, the study has an important implication for the teaching of science to preservice primary teachers. It has demonstrated that a relatively traditional approach can be successful in enhancing self-efficacy if it is tailored to the needs to these particular students, and is taught by an enthusiastic teacher who is willing to utilise a wide range of teaching techniques that enhance learning.

References

- Andersen, A. M., Dragsted, S., Evans, R. H., & Sørensen, H. (2004). The relationship between changes in teachers' self-efficacy beliefs and the science teaching environment of Danish first-year primary teachers. *Journal of Science Teacher Education*, *15*, 25–38. <http://dx.doi.org/10.1023/B:JSTE.0000031461.68912.3d>
- Britner, S., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching*, *43*(5), 485-499. <http://dx.doi.org/10.1002/tea.20131>
- Appleton, K., & Kindt, I. (2002). Beginning primary teachers' development as teachers of science. *Journal of Science Teacher Education*, *13*, 43-61. <http://dx.doi.org/10.1023/A:1015181809961>
- Avery, L. M., & Meyer, D. Z. (2012). Teaching science as science is practiced: Opportunities and limits for enhancing preservice primary teachers' self-efficacy for science and science teaching. *School Science and Mathematics*, *112*(7), 395-409. <http://dx.doi.org/10.1111/j.1949-8594.2012.00159.x>
- Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, *37*, 122-147. <http://dx.doi.org/10.1037/0003-066X.37.2.122>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. NY: W.H. Freeman and Co.
- Bencze, L., & Hodson, D. (1999). Changing practice by changing practice: Toward more authentic science and science curriculum development. *Journal of Research in Science Teaching*, *36*, 521-539. [http://dx.doi.org/10.1002/\(SICI\)1098-2736\(199905\)36:5<521::AID-TEA2>3.0.CO;2-6](http://dx.doi.org/10.1002/(SICI)1098-2736(199905)36:5<521::AID-TEA2>3.0.CO;2-6)
- Buss, R. R. (2010). Efficacy for teaching primary science and mathematics compared to other content. *School Science and Mathematics*, *110*(6), 290-297. <http://dx.doi.org/10.1111/j.1949-8594.2010.00037.x>
- Cantrell, P., Young, S., & Moore, A. (2003). Factors affecting science teaching efficacy of preservice elementary teachers. *Journal of Science Teacher Education*, *14*, 177-192. <http://dx.doi.org/10.1023/A:1025974417256>
- Cruz, M. J. de la Torre, & Arias, P. F. Casanova (2007). Comparative analysis of expectancies of efficacy in in-service and prospective teachers. *Teaching and Teacher Education*, *23*, 641-652. <http://dx.doi.org/10.1016/j.tate.2007.02.005>
- Enochs, L. G., & Riggs, I. M. (1990). Further development of an primary science teaching efficacy belief instrument: A preservice primary scale. *School Science and Mathematics*, *90*, 695-706. <http://dx.doi.org/10.1111/j.1949-8594.1990.tb12048.x>

- Ford, D. J., Fifield, S., Madsen, J., & Qian, X. (2013). The science semester: Cross-disciplinary inquiry for prospective primary teachers. *Journal of Science Teacher Education*, 24, 1049-1072. <http://dx.doi.org/10.1007/s10972-012-9326-8>
- Gunning, A. M., & Mensah, F. M. (2011). Preservice primary teachers' development of self-efficacy and confidence to teach science: A case study. *Journal of Science Teacher Education*, 22, 171-185. <http://dx.doi.org/10.1007/s10972-010-9198-8>
- Harlen, W., & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International Journal of Science Education*, 19, 93-105. <http://dx.doi.org/10.1080/0950069970190107>
- Hatfield, E., Cacioppo, J. R., & Rapson, R. L. (1993). Emotional contagion. *Current Directions in Psychological Science*, 2, 96-99. <http://dx.doi.org/10.1111/1467-8721.ep10770953>
- Kenny, J. D., Hobbs, L., Herbert, S., Jones, M., Chittleborough, G., Campbell, C., Gilbert, A., & Redman, C. (2014). Science Teacher Education Partnerships with Schools (STEPS): Partnerships in science teacher education. *Australian Journal of Teacher Education*, 39(12). <http://dx.doi.org/10.14221/ajte.2014v39n12.4>
- Kunter, M., Frenzel, A., Nagy, G., Baumert, J., & Pekrun, R. (2011). Teacher enthusiasm: Dimensionality and context specificity. *Contemporary Educational Psychology*, 36, 289-301. <http://dx.doi.org/10.1016/j.cedpsych.2011.07.001>
- Liang, L. L., & Richardson, G. M. (2009). Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, student-directed inquiry. *Journal of Primary Science Education*, 21(1), 51-66. <http://dx.doi.org/10.1007/bf03174715>
- Mansfield, C. F., & Woods-McConney, A. (2012). "I didn't always perceive myself as a 'science person'": Examining efficacy for primary science teaching. *Australian Journal of Teacher Education*, 37(10), 37-52. <http://dx.doi.org/10.14221/ajte.2012v37n10.5>
- Nederhof, A. J. (1985). Methods of coping with social desirability bias: A review. *European Journal of Social Psychology*, 15, 263-280. <http://dx.doi.org/10.1002/ejsp.2420150303>
- Palmer D. H. (2006). Durability of changes in self-efficacy of preservice primary teachers. *International Journal of Science Education*, 28(6), 655-671. <http://dx.doi.org/10.1080/09500690500404599>
- Petersen, J. E., & Treagust, D. F. (2014). School and University Partnerships: The Role of Teacher Education Institutions and Primary Schools in the Development of Preservice Teachers' Science Teaching Efficacy. *Australian Journal of Teacher Education*, 39(9). <http://dx.doi.org/10.14221/ajte.2014v39n9.2>
- Posnanski, T. J. (2002). Professional development programs for primary science teachers: An analysis of teacher self-efficacy beliefs and a professional development model. *Journal of Science Teacher Education*, 13, 189-220. <http://dx.doi.org/10.1023/A:1016517100186>
- Ramey-Gassert, L., & Shroyer, M.G. (1992). Enhancing science teaching self-efficacy in preservice elementary teachers. *Journal of Elementary Science Education*, 4, 26-34. <http://dx.doi.org/10.1007/BF03173752>
- Rice, D. C., & Roychoudhury, A. (2003). Preparing more confident preservice primary science teachers: One primary science methods teacher's self-study. *Journal of Science Teacher Education*, 14, 97-126. <http://dx.doi.org/10.1023/A:1023658028085>
- Roberts, J. K., & Henson, R. K. (November, 2000). *Self-efficacy teaching and knowledge instrument for science teachers (SETAKIST): A proposal for a new efficacy instrument*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Bowling Green, KY.

- Schoon, K. J., & Boone, W. J (1998). Self-efficacy and alternative conceptions of science of preservice primary teachers. *Science Education*, 82, 553-568. [http://dx.doi.org/10.1002/\(SICI\)1098-237X\(199809\)82:5<553::AID-SCE2>3.0.CO;2-8](http://dx.doi.org/10.1002/(SICI)1098-237X(199809)82:5<553::AID-SCE2>3.0.CO;2-8)
- Settlage, J., Southerland, S. A., Smith, L. K., & Ceglie, R. (2009). Constructing a doubt-free teaching self: Self-efficacy, teacher identity, and science instruction within diverse settings. *Journal of Research in Science Teaching*, 46(1), 102-125. <http://dx.doi.org/10.1002/tea.20268>
- Shrigley, R. L. (1987). Discrepant events: Why they fascinate students. *Science and Children*, 24, 24-25.
- Sun, J. C.-Y., & Rueda, R. (2012). Situational interest, computer self-efficacy and self-regulation: Their impact on student engagement in distance education. *British Journal of Educational Technology*, 43(2), 191-204. <http://dx.doi.org/10.1111/j.1467-8535.2010.01157.x>
- Tosun, T. (2000). The beliefs of preservice primary teachers towards science and science teaching. *School Science and Mathematics*, 100, 374-379. <http://dx.doi.org/10.1111/j.1949-8594.2000.tb18179.x>
- Tschannen-Moran, M., Hoy, A. Woolfolk, & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, 68(2), 202-248. <http://dx.doi.org/10.3102/00346543068002202>
- Velthuis, C., Fisser, P., & Pieters, J. (2014). Teacher training and pre-service primary teachers' self-efficacy for science teaching. *Journal of Science Teacher Education*, 25(4), 445-464. <http://dx.doi.org/10.1007/s10972-013-9363-y>
- Watters, J. J., & Ginns, I. S. (2000). Developing motivation to teach primary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education*, 11, 301-321. <http://dx.doi.org/10.1023/A:1009429131064>
- Westerback, M. E., & Long, M. J. (1990). Science knowledge and the reduction of anxiety about teaching earth science in exemplary teachers as measured by the science teaching state-trait anxiety inventory. *School Science and Mathematics*, 90, 361-374. <http://dx.doi.org/10.1111/j.1949-8594.1990.tb17225.x>
- Wiersma, W. (2000). *Research Methods in Education* (7th Ed.). Boston: Pearson.