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# Sources of Self-efficacy in a Science Methods Course for Primary Teacher Education Students

D.H. PALMER
*School of Education, University of Newcastle*
*E-mail: David.Palmer@newcastle.edu.au*

**Abstract**. Self-efficacy has been shown to be an issue of concern for primary teacher education students – many of them have low self-efficacy and this can negatively affect their future teaching of science. Previous research has identified four factors that may contribute towards self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion and physiological/affective states. It could also be argued that there are additional sources of self-efficacy that apply to primary teacher education students, namely cognitive content mastery, cognitive pedagogical mastery and simulated modelling. The main purpose of the present paper was to investigate the relative importance of the various sources of self-efficacy in a primary science methods course. Data on changes in self-efficacy and sources of self-efficacy were collected throughout the course using formal and informal surveys. It was found that the main source of self-efficacy was cognitive pedagogical mastery.

Key Words: self-efficacy, science, primary teacher, elementary teacher

Bandura (1982) proposed that self-efficacy represents a person's belief in his/her ability to perform a difficult task: "Self-efficacy is concerned with judgements about how well one can organise 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). Self-efficacy has been shown to be a powerful predictor of performance. People who have strong self-efficacy for a particular task will make vigorous and persistent efforts and thus will be more likely to succeed, but those with low self-efficacy will give up after minimal effort, or even avoid the task altogether. Self-efficacy is very similar to self-confidence, and in many studies the two terms have been used interchangeably (Appleton & Kindt, 2002; Cannon & Scharmann, 1996; Rice & Roychoudhury, 2003; Settlage, 2000; Watters & Ginns, 2000).

Bandura (1997) described four main sources of self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion and physiological/affective states. *Enactive mastery experiences* are authentic successes at dealing with a particular situation. Bandura (1997) considered these to be the most influential source of self-efficacy because they provide authentic evidence that the individual has the ability to succeed at the task. *Vicarious experiences* are situations in which people estimate their capabilities in comparison to others who have modelled the desired behaviour. There are several modes of modelling influences: (1) 'effective actual modelling' occurs when one sees a person similar to oneself perform the task successfully; (2) 'symbolic modelling' occurs when individuals are exposed to effective models provided by television and other visual media; (3) 'self-modelling' occurs when individuals' performances are videotaped for them to watch, but only after the recordings have been edited to show only the favourable aspects; and (4) 'cognitive self-modelling' occurs when individuals visualise themselves performing successfully at the task. *Verbal persuasion* refers to situations in which individuals are given positive feedback from others – if a person is told that he/she does possess the capabilities to succeed in the task, then that person will be encouraged to try hard to succeed. *Physiological and affective states* refers to individuals' responses to their own stress, fear and anxiety – moderate levels of stress can energise high achievers but can debilitate low achievers.

One group of people for whom science teaching self-efficacy is an issue of concern is primary teacher education students. Many of these students had negative experiences of science in high school (Jarrett, 1999; Mulholland & Wallace, 1996) and they lack confidence in their ability to teach the subject (Tosun, 2000). Teacher lack of confidence is a serious problem because it impacts on classroom behaviour. Appleton and Kindt (1999) found that beginning teachers with low confidence avoided hands-on science and used strategies based on reading and writing.

As a result of findings such as these, a number of studies have investigated how best to enhance the science teaching self-efficacy of primary teacher education students. It has been found that science methods courses that involve extensive use of hands-on activities can be very successful in this regard (Jarrett, 1999; Schoon & Boone, 1998; Watters & Ginns, 2000). However, the reason why hands-on activities can positively affect students' self-efficacy remains to be established. In order to resolve this issue it is necessary to interpret the content of courses from the perspective of Bandura's sources of self-efficacy.

A few authors have taken the approach of identifying the sources of self-efficacy in their methods courses. Cantrell, Young, and Moore (2003) found that mastery experiences, consisting of time spent teaching science to children in a primary classroom, were associated with increases in personal science teaching efficacy in their methods course. Wingfield, Freeman, and Ramsey (2000) found that a site-based preservice education program enhanced self-efficacy in several ways: mastery experiences occurred when students assisted in small group activities with children, then planned and implemented whole class science lessons; vicarious experiences were provided by peer reviews, critiques and modifications of lessons; and verbal persuasion was provided by the site-based teachers, the university coordinator and peers. Settlage (2000) measured self-efficacy before and after a science methods course. He found a significant improvement and proposed that "The microteaching would be classified as a performance accomplishment, the classroom videos as vicarious experiences, lectures and discussion as verbal persuasion, and visits to the classrooms ... as emotional arousal" (p. 49). It thus appears that there are several ways in which mastery experiences, vicarious experiences and verbal persuasion could possibly be included in these courses. However, the relative importance of each of these sources is still an open question. Bandura (1997) proposed that enactive mastery experiences are usually the most powerful source of self-efficacy, but corroborating evidence that this is the case in science methods courses is yet to be obtained.

It could also be argued that, with respect to primary teacher education students, there are other sources of self-efficacy in addition to those proposed by Bandura (1997). For example, in addition to enactive mastery (in which students actually teach primary children) other forms of mastery could be possible. Firstly, science content knowledge is one factor that has been linked with increased confidence and self-efficacy of primary teacher education students (Schoon & Boone, 1998), so it is possible that mastery experiences in *understanding science content* are important. Understanding science can be a difficult and daunting task for many students, particularly at high school level when science is compulsory. The fact that preservice primary teachers' memories of their school science experiences arouse feelings of fear, anxiety and intimidation (Bell, 2001) suggests that understanding science content represents a significant efficacy issue for them. Successes in mastering understandings of science subject matter could therefore be expected to enhance their feelings of efficacy for teaching science. This type of mastery experience is distinct from enactive mastery because it involves success in understanding something rather than success in doing something. It could therefore be referred to as 'cognitive content mastery.'

A second factor that has been linked to increased confidence of these students is science pedagogical knowledge. For example, Appleton (1995) found that a constructivist/interactive science methods course resulted in positive changes in confidence even in content areas that were not in the course – implying that pedagogical knowledge was important to these students. Similarly, Settlage (2000) found that instruction about the learning cycle (a pedagogical technique) contributed to preservice elementary teachers' self-efficacy. It is therefore possible that mastery of specialist pedagogical knowledge may provide a source of science teaching self-efficacy. Again, it is not easy for primary teacher education students to develop a confident knowledge of how to teach science, because there are comparatively few positive role models available. For example, Mulholland and Wallace (2001) found that the low status of science in primary schools and the inexperience of the teachers in the subject meant that there was a lack of positive role models for new teachers. It is therefore not uncommon for primary teacher education students to enter their science methods courses with very little understanding of how to teach science in a way that will capture the imaginations of the children. Success in mastering an understanding of some motivating and effective techniques for teaching science could therefore be expected to make an important contribution towards developing their science teaching self-efficacy.

This type of experience could be referred to as ‘cognitive pedagogical mastery’ for science teaching.

There is also a third possible alternative source of self-efficacy. Bandura (1997) described vicarious experiences as those in which individuals observed other people modelling the target behaviour. For primary teacher education students, a vicarious experience could be provided by watching a video of a teacher or peer successfully teaching a science lesson to primary students. However, there is another type of modelling that is also associated with improved self-efficacy. Posnanski (2002) found that personal science teaching efficacy was improved in a course that included a type of modelling in which the tutor assumed the role of a primary teacher and the students assumed the role of children, as they participated in hands-on activities in preparation for real experiences in schools. Rice and Roychoudhury (2003) argued that this type of modelling was an important component of a science methods course for elementary teaching. This type of modelling does not fit neatly into any of Bandura’s (1997) categories of vicarious experiences because it does not involve any observed teaching of real children. Instead, the tutor and the students simulate the conditions of a primary classroom by a type of role playing. This type of vicarious experience could therefore be referred to as ‘simulated modelling.’

In summary, it has been argued that cognitive content mastery (successes in understanding science content), cognitive pedagogical mastery (successes in understanding how to teach science) and simulated modelling (in which teaching is role played) could be sources of self-efficacy in addition to those proposed by Bandura (1997). However, the relative importance of each of these in comparison to the other sources remains to be established. The purpose of the present study is to investigate this issue. The research questions are:

1. In one particular primary science methods course, what is the relative importance of each of the factors that can influence self-efficacy?
2. To what extent can these sources enhance the science teaching self-efficacy of the students?

## Materials and Methods

### *Participants*

The research was carried out at a regional university in south-eastern Australia. The participants were primary teacher education students who were enrolled in a one-semester science methods course. There were about 190 students enrolled, but as explained below, not all students participated in each phase of the data gathering. About 84% of them were female, and most were in the 20–30 years age group. These students were in the third year of their four-year undergraduate program and had previously completed a one-semester science foundations course.

The foundations course covered science concepts in areas such as physics, chemistry and biology.

### *The Methods Course*

The main purpose of the methods course was to teach the students how to teach science to primary children (i.e., children of ages 5–12) but it also aimed to reinforce the students' science content knowledge and to develop positive attitudes towards science. It ran for one semester of 13 weeks, and each week there was a 1-h lecture to the whole group and a 1-h workshop to subgroups of about 30 students. All the lectures and workshops were presented by the same tutor.

The lecture content covered topics such as process skills, student misconceptions, lesson planning, programming, safety issues and teaching techniques such as demonstrating, investigating and problem solving. In order to interest the students and arouse their enthusiasm for teaching science, the lectures involved many demonstrations of hands-on activities, and the use of numerous examples of lessons and lesson sequences that were relevant to primary classrooms. The tutor also modelled simple explanations of science concepts, at a similar level to that which could be used with primary children.

The workshop content covered topics such as sound, water, air, magnets, static electricity, plants and animals. The emphasis was on the use of hands-on activities to teach these topics. The tutor modelled how to provide teacher explanations of science concepts and how to provide instructions for the hands-on activities. The students usually did the hands-on activities themselves and also participated in investigating and problem solving. The hands-on activities were carefully selected and in many cases they had surprising or unexpected results, so as to appeal to the students. They also used everyday materials rather than specialised scientific equipment, and this was intended to make the activities more relevant to primary schools, where specialised equipment is often not available.

As one of the assessment tasks for the course, students were required to teach a hands-on science lesson to a single child of primary age (i.e., a 1:1 teaching situation) and self-evaluate the experience. This was to be done outside of course time and in informal settings such as private residences, rather than in schools. This was intended to give students an opportunity to have a successful experience in teaching science to a child.

The teaching of the course was not modified in any way to meet the requirements of this study. The course did not contain any experiences in a real school. This means that there were no opportunities for effective actual modelling (i.e., seeing a person teaching in a primary school). Neither did it contain any videos, pictures or films of teaching, so there were no opportunities for symbolic modelling or self-modelling. Thus, this particular course did not contain the full range of Bandura's sources of self-efficacy.

*Data Collection*

The study involved both quantitative and qualitative methodologies. Data were obtained through the use of two formal surveys and three informal surveys, as follows.

*Formal Surveys*

These were used to measure students' self-efficacy levels. The instrument used was the Science Teaching Efficacy Belief Instrument Form B (STEBI B). This was developed by Enochs and Riggs (1990) for use with preservice primary teachers. It consisted of 23 items, each of which was linked to a 5-point Likert-type scale consisting of the choices 'strongly agree,' 'agree,' 'uncertain,' 'disagree' and 'strongly disagree.' Some of the items were worded positively and others negatively. The items were scored 5, 4, 3, 2 or 1 in which 5 was the maximum positive response and 1 was the most negative response. The instrument contained two scales: the Personal Science Teaching Efficacy Belief Scale (PSTEB) contained 13 items, and the Science Teaching Outcome Expectancy Scale (STOE) consisted of 10 items. Enochs and Riggs (1990) showed that the PSTEB had an alpha coefficient of 0.9, and the STOE alpha coefficient was 0.76. All items loaded highly with their own scale, under factor analysis. The instrument was validated for use with Australian students by Ginns, Watters, Tulip, and Lucas (1995) and has been widely used in recent years (Bell, 2001; Cannon & Scharmann, 1996; Cantrell, et al., 2003; Schoon & Boone, 1998; Settlage, 2000; Watters & Ginns, 2000; Wingfield, et al., 2000).

The STEBI B was administered to the students as a pre-test, on the first day of the course, and as a post-test on the final day of the course, 13 weeks later. Students were asked to write an anonymous identifier (e.g., their mother's given names) so their pre-test and post-test results could be paired.

Analysis of the STEBI B data was carried out using paired *t*-tests. For each student, the two scales were summed and compared separately. It was recognised that the use of two paired *t*-tests could possibly increase error margins, so the decision was made to adopt a lower significance level, of 0.01 instead of 0.05, to compensate.

*Informal Surveys*

The purpose of the three informal surveys was to provide data about the sources of self-efficacy and the relative importance of each source. The relative importance of each source would be indicated by the number of people who mentioned it. The three informal surveys were designed to focus on different components of the course. The course consisted of two main types of experiences: the lectures, in which students were relatively passive members of a large audience; and the workshops, in which they actively participated in group work, hands-on activities and discussion. It was decided to seek feedback on each of these separately, as well as feedback about the course as a whole, so three surveys were needed. In addition, the disadvantage of having a survey at the end of the course was that students would be forced to rely on their memories of what had happened over the previous 13 weeks, which may have introduced some error or bias into the results, so it was decided that the other two surveys would be carried out during the course itself. The three informal surveys therefore complemented each other by focussing on different aspects of the course and by being carried out at differ-vent times.

The first informal survey was carried out in Week 5 of the course, at the lecture. This lecture addressed the topic of ‘air’ – the tutor presented background information about the composition of air and demonstrated several hands-on activities that could be used to show the properties of air. The tutor also described a student-centred investigation on the topic of bubbles, and outlined a sequence that could be used to structure student investigations. At the end of the lecture, each student was provided with a sheet of paper and asked to write an answer to the question “Has anything in today’s lecture helped to make you more confident to teach science? Please write as much detail as possible.”

The second informal survey occurred in the Week 8 workshop. The topic for this workshop was magnets, and students were presented with a description of several lessons that represented a short unit of work on magnets. For each lesson, the tutor described the knowledge that the children would be expected to achieve, a hands-on activity that could be used to help them understand, and one or two ideas for assessment tasks that the children could do to demonstrate their learning. The students in the workshop actually did most of the hands-on activities. At the end of the workshop they were asked to answer the question “Was there anything in today’s workshop that helped to make you more confident to teach science? Please write as much detail as possible.”

The third survey was carried out at the end of the semester, when students were asked to reflect back on the course as a whole and “Write something that stands out as being a useful or valuable aspect of the course in giving you more confidence to teach science.” In each survey, the time provided for writing was 5–10 min.

Analysis of each of the surveys firstly involved the creation of categories representing sources of self-efficacy. Students’ responses were then allocated to the categories and the proportion of students in each category was calculated. To check the reliability of the categories, a representative sample of 79 student statements taken from all three surveys was independently coded by the author and a second person who had a higher degree in education. Agreement was found in 86% of cases.

## Results

### *Formal Surveys*

Paired pre- and post-test responses were obtained from 108 students. The results of the paired *t*-test analysis (Table 1) showed there had been a significant improvement in both scales. Effect size was calculated by finding the difference between the group means and dividing it by the mean standard deviation (Cantrell et al., 2003). This showed that for both scales, the effect size was large (using this calculation, any effect size above 0.8 is considered large). These results indicated that students' self-efficacy had improved by a considerable amount over the period of the course.

The remainder of students in the course either missed the pre-test or the post-test, or their pre-tests and post-tests could not be reliably paired, or they did not answer all the questions in the survey. To check whether the responses of these students were different in any way to the 108 who provided complete responses, the following analysis was carried out. The results were recorded for any student who provided a complete response for at least one of the two scales, even if they answered only one survey. On this basis, 52 additional students' responses were obtained for the pre-test and 42 additional responses for the post-test. The means and standard deviations for these additional students were as follows: PSTEB pre-test = 43(5.0), post-test = 51(6.4); STOE pre-test = 34(4.0), post-test = 38(3.5). Comparison with the results in Table 1 indicates that the corresponding means were quite similar. This implies that the students for whom full responses were obtained were not substantially different from other students in the course.

### *Informal Surveys*

After initial reading of the survey responses, a list of sources of self-efficacy was created. This included categories described by Bandura (1997) as well as the additional categories of cognitive content mastery, cognitive pedagogical mastery and simulated modelling. An additional category of unspecified cognitive mastery was included, as some responses indicated a successful learning experience, but

Table 1
*Mean (Standard Deviation) for STEBI B Scales.*

| | Pre-test | Post-test | *t* | df | Probability | Effect size |
|---|---|---|---|---|---|---|
| PSTEB | 42 (6.8) | 53 (4.8) | 16.6453 | 107 | <0.01 | 1.9 (large) |
| STOE | 34 (4.4) | 38 (4.3) | 8.6262 | 107 | <0.01 | 0.9 (large) |

were too vague as to whether it was content or pedagogy. The categories of effective actual modelling, symbolic modelling and self-modelling were not included as there were no opportunities for them to participate in these activities in the course, and none of the students' responses referred to them. The final list therefore contained the following categories:

1. enactive mastery (i.e., a successful experience teaching a child);
2. cognitive content mastery (i.e., a successful learning experience involving the understanding of science concepts);
3. cognitive pedagogical mastery (i.e., a successful learning experience involving the understanding of science teaching techniques);
4. unspecified cognitive mastery (i.e., a successful learning experience was indicated, but whether it was content or pedagogy could not be established);
5. cognitive self-modelling (i.e., students imagined themselves teaching);
6. simulated modelling (i.e., role playing a primary class);
7. verbal persuasion (i.e., students received feedback that their teaching was successful);
8. physiological /affective states (i.e., coping with stress, fear and anxiety);
9. other (i.e., students whose responses could not be categorised).

The numbers of students responding to the three surveys varied as not all students attended the lectures or tutorials. In the first survey, responses were received from 124 students, 175 responded to the second survey and 163 responded to the third.

The survey responses supported the results from the STEBI B as many students stated that their confidence had increased. The following are some selected responses. The first two (from Survey 1) are especially interesting because they indicate that significant shifts in confidence had occurred as early as Week 5 of the course.

I didn't like science before these lectures. Now I feel confident to teach and feel confident the kids will enjoy. (Survey 1)

These are excellent lectures. I am now feeling confident to teach science. I would not have before this series of lectures. (Survey 1)

I use [sic] to dislike science but now I think it will be a great subject to teach. (Survey 3)

Several sources of self-efficacy were indicated by the responses, and these are shown in Table 2. For each survey, percentages add up to more than 100 because some students made more than one type of response.

In each of the three surveys, the majority of students made statements that were categorised as cognitive pedagogical mastery (i.e., the students indicated they had learnt information about how to teach science). Responses were included in this category if they indicated that students had learnt or been shown how to do science

Table 2
*Frequency of Sources of Self-Efficacy (percent).*

| | Survey 1 (*n* = 124) | Survey 2 (*n* = 175) | Survey 3 (*n* = 163) |
|---|---|---|---|
| Enactive mastery | 0 | 0 | 0 |
| Cognitive content mastery | 18 | 19 | 9 |
| Cognitive pedagogical mastery | 59 | 88 | 75 |
| Unspecified cognitive mastery | 15 | 2 | 4 |
| Cognitive self-modelling | 21 | 26 | 26 |
| Simulated modelling | 8 | 5 | 10 |
| Verbal persuasion | 0 | 0 | 0 |
| Physiol./affect. states | 2 | 0 | 2 |
| Other | 7 | 6 | 12 |

lessons, activities, explanations, demonstrations or procedures for teaching science. Responses were also counted in this category if they wrote that science lessons, activities, explanations, demonstrations or procedures for teaching science had been clear, easy, helpful or good, as this was taken to imply that they had learnt something about these techniques. The following are some examples of the types of responses included in this category (where appropriate, the critical words and phrases have been italicized):

Yes, *learning a range of practical things you can do* to develop children's understandings of air. i.e., demonstrations, activities etc (Survey 1)

Tutorials are prescriptive and therefore *we learn the procedures* necessary to teach a science lesson effectively. (Survey 2)

The thing that was most helpful in my understanding of science and teaching it was the excellent teaching activities and *strategies that were provided* in each lesson. I feel more confident to teach this subject as I have a background knowledge of science topics and have *learnt great strategies*. (Survey 3)

Table 2 shows that fewer students gave responses indicating cognitive content mastery. Responses were placed in this category if they implied improved understanding of science concepts or improved ability to answer children's questions about science. The comments indicated that understanding science content had been facilitated not only by the explanations given by the tutor but also by the hands-on activities. For example,

Simple explanations of why things happen help my own understanding of science. (Survey 1)

I never understood magnetic pulls now I have a basic understanding. You can't teach without understanding yourself. (Survey 2)

I found that hands-on activities extremely helpful. They explained science concepts that I didn't fully understand . . . (Survey 3)

In each survey, small numbers of responses were categorised as unspecified cognitive mastery (Table 1). Responses were placed in this category if they indicated that the lecture/tutorial/course had been informative or had improved their understanding, but the nature of the learnt material was not clear. For example,

I have more confidence now because I have a better knowledge base. (Survey 2)

The results provided no evidence that enactive mastery was a source of self-efficacy in the course. The students had an opportunity to experience enactive mastery through the assessment task that required them to teach a hands-on science lesson to an individual student. However, in their written comments, none of the students specifically mentioned the 1:1 teaching experience, and the comments that referred to the assessment tasks were too vague to be reliable.

The most frequent type of modelling in each survey was cognitive self-modelling (i.e., imagining oneself teaching) and this was the second most important source of self-efficacy in all three surveys (Table 2). Responses were placed in this category if they referred to future teaching, or future use of ideas for teaching or potential use of ideas or techniques. Responses were also placed in this category if they stated that the course had provided resources for teaching, as this was taken to indicate they had thought about whether they could use the ideas in a classroom:

Yes. The use of practical examples . . . makes me *believe that I can teach using these* practical activities. (Survey 1)

Yes. Real stuff that *we can see is going to be useful* when we go into schools. (Survey 2)

The way in which each new lesson/concept was presented. It was practical and *I could see myself teaching science* in the same way. (Survey 3)

Interestingly, many of the students wrote responses that indicated both cognitive self-modelling and cognitive pedagogical mastery:

Yes – the activities and demonstrations [the tutor] gave, I think I could use them in a classroom. (Survey 1)

By giving us examples of lessons and lesson sequences, I feel that I could apply them to a class. (Survey 3)

These types of responses suggest that the students had been shown teaching techniques that they had understood, and were then imagining themselves teaching using these techniques.

Table 2 shows that small numbers of students provided responses that were categorised as simulated modelling (i.e., role playing of teaching). Responses were placed in this category if they indicated that the tutor had taught them as if they were children in a primary class, or the tutor had taught them in the same way that they would teach children. In addition, some responses indicated that individual students had experienced science learning or motivation from activities in the course, so they believed that primary children would also learn from and be motivated by those activities – these types of responses were also categorised in this group because they implied that the student was taking the place of primary children. Examples of this category are:

These lectures do make me more confident to teach science. In this lecture, as others, *the way* [*the tutor*] *explains to us as we would explain to students,* and examples as to demonstrations etc. fantastic! (Survey 1)

Because I am a hands-on learner I find the tutorials excellent for deep learning and enjoyable. *I think kids would enjoy to be taught the same way*. I have always disliked science and now I am quite happy to teach this to primary school students. (Survey 2)

The fact that [the tutor] would take us through an actual lesson, do the experiment, let us also do experiment and generally *simulate the classroom procedures* by asking questions at various intervals of exercise showed us how to teach in science. I am much more confident as a result. (Survey 3)

In all three surveys there were very small numbers (less than 5% in all cases) of students who made comments about coping with fear, anxiety and other negative physiological/affective states:

Yes, because [the tutor] gave us specific activities to do with a class and then explained etc which makes approaching science less *threatening* and more fun. (Survey 1)

I now know not to *fear* science in a classroom because already I will have captured their interest which is half the battle. (Survey 3)

These types of comments implied that learning about science teaching techniques had helped these students overcome their fears.

The surveys contained no evidence that verbal persuasion had been a significant factor in enhancing confidence. Only one student made a comment about the feedback given from the tutor, but it was too vague to be reliable.

## Discussion

### *Sources of Self-Efficacy*

The results provided evidence that cognitive content mastery, cognitive pedagogical mastery and simulated modelling can be sources of self-efficacy in addition to those proposed by Bandura (1997). It could be rightly be argued that content knowledge and pedagogical knowledge are prerequisites for enactive mastery in teaching, as a successful teaching experience would partly depend on having a good knowledge of content and teaching methods. However, the students' comments in this study suggested that they gained confidence directly from success in understanding content and pedagogy, which thus makes them distinctive mastery experiences in their own right, as well as being prerequisites for enactive mastery. In addition, simulated modelling is a type of vicarious experience which differs from other types because the modelling process does not involve real children. Instead, the tutor and students are to some extent role playing the teacher and children in a primary classroom. Through this type of modelling, the students could still be *shown* how to teach children, rather than just being told, and this helped to improve their confidence that they could teach science effectively.

The results also showed that cognitive pedagogical mastery (i.e., successes in understanding how to teach science) and cognitive self-modelling (i.e., imagining oneself teaching) were the two most common sources, and many students appeared to use the two in combination.

Cognitive content mastery (i.e., success in understanding science content) was a source of self-efficacy for 9%–19% of students, and this appeared to have been partly facilitated by the use of hands-on activities. It thus appears that extensive use of hands-on activities can enhance efficacy in two ways – firstly, by providing effective instructional strategies (cognitive pedagogical mastery), and secondly, by consolidating the science content understandings of the students themselves (cognitive content mastery).

Simulated modelling was a source of self-efficacy for only 5%–10% of students. These responses indicated that self-efficacy had been enhanced through role play situations in which they had been taught as children would be taught in a school. Some of these students wrote the following types of responses:

> Asking if the students have any questions, lets us find out the sorts of questions that we want to know and so do the kids. (Survey 2)

> The practical ideas are great. Kids love it hell I love it. (Survey 2)

Comments such as these suggest that the students had directly experienced motivation and content learning under the simulated conditions at university, and this led them to believe that the same techniques would also be effective in the primary classroom. Whilst it is to be hoped that those techniques would in fact be effective in the primary classroom, there is a potential problem with this type of modelling. Teacher education students are at a vastly different educational level to primary aged children, so it should not be assumed that a technique that can promote motivation and learning in adult tertiary students would be just as effective with young children. Hence there is the potential that the use of this type of modelling could create false expectations of efficacy. Perhaps one solution to this problem would be for the tutor to make students aware of the issue by discussing it with them in conjunction with the simulated experiences.

The results also indicated that several of Bandura's sources of self-efficacy were not significant in this study. These included enactive mastery, actual modelling and verbal persuasion. A small number of students made comments about coping with stress, fear or other physiological/affective states, and their comments indicated that these feelings had been reduced by learning about the activities, demonstrations or experiments that could be used to teach science. This suggests that cognitive pedagogical mastery may play a role in reducing negative visceral arousals. This is roughly in agreement with the view of Bandura (1997) who stated that anxiety could be diminished by modelling or mastery experiences.

### *Changes in Self-Efficacy*

The results of the formal surveys indicated that students' science teaching self-efficacy had significantly improved over the period of the course. Large effect sizes were found for both Personal Science Teaching Efficacy Belief and Science Teaching Outcome Expectancy. One issue however, is that the course did not provide enactive mastery experiences, and as these are usually considered to be the most powerful source of self-efficacy (Bandura, 1997) it raises the question of whether the other sources of self-efficacy were able to raise efficacy to the same degree. It other words, it is possible that students in this course may have been disadvantaged – they may not have experienced as much growth in self-efficacy as they may have had if the course had contained opportunities for them to teach in a school. To investigate to extent to which this may have been the case, the STEBI B results from this study were compared to those from other studies that have contained in-school experiences. Three recent studies of this type were found, and their results are compared in Table 3. This table shows that the post-test scores for PSTEB and STOE were only slightly below the highest values recorded in the other studies, and were well above some of the others. This implies that the sources of efficacy identified in the present study (i.e., cognitive pedagogical mastery, cognitive content mastery, cognitive self-modelling and simulated modelling) did compensate for a lack of enactive mastery.

## Implications

The study has raised an issue about the content of future primary science methods courses, as it showed that significant gain in students' self-efficacy can occur in the absence of enactive mastery experiences. However, this should not be construed as implying that enactive mastery experiences should be omitted from courses. Rather, it is possible that if authentic enactive mastery experiences had been

Table 3
*Comparison of STEBI B Scores with Other Studies.*

| | PSTEB | | STOE | |
|---|---|---|---|---|
| | Pre-test | Post-test | Pre-test | Post-test |
| Study 1 | 46.77 | 53.78 | 36.05 | 39.32 |
| Study 2 | 45.1 | 46.1 | 33.5 | 34.9 |
| Study 3 | 46.33* | 53.58** | 25.42 | 26.00 |
| This study | 42 | 53 | 34 | 38 |

Study 1 = Wingfield et al. (2000).
Study 2 = Ginns et al. (1995).
Study 3 = Cantrell et al. (2003).
*Prior to the methods course semester
**At the end of the methods course semester

provided in this course then self-efficacy would have been improved even further. An additional advantage of including authentic science teaching experiences in real schools is that it may facilitate verbal persuasion – constructive feedback by teachers and peers will also contribute towards student efficacy – and this was also a factor missing from the present course.

However, the findings should be interpreted with the following limitations in mind. Firstly, the present study applied the concept of self-efficacy only to primary teacher education students. It is possible that for other groups of people, the sources of self-efficacy may be quite different. Cognitive pedagogical mastery for example, would obviously not apply outside of the specialist world of teacher education. Secondly, it should be remembered that the sources of self-efficacy identified as important in this particular course, may not equally apply in other courses. Other primary science methods courses have achieved comparable levels of self-efficacy through use of other sources such as enactive mastery experiences in schools, vicarious experiences observing peers teaching in schools, and authentic verbal persuasion from practicing teachers (Wingfield et al., 2000). The extent to which the findings from this study can be applied to other methods courses should therefore be determined on a case by case basis, according to course structure and content.

Finally, there are several avenues for further research in this area. Other authors have rightly argued that studies such as this provide no information about how long the positive changes in self-efficacy will persist over time, after completion of the course (Morrisey, 1981). It should also be emphasised that high efficacy does not necessarily result in effective teaching – it is a necessary first step, but the other factors influencing the process should be clearly mapped. In addition, it is tempting to speculate whether some sources of self-efficacy might have longer-lasting effects than others. Do successful enactive mastery experiences for example, have more long-term effect than successful cognitive mastery experiences? The role of perceived relevance should also be analysed, as it could be argued that this factor was common to all the sources of efficacy identified in the present study. Research that can provide the answers to these types of issues will potentially play an important role in the design of future preparatory courses for primary teacher education students.

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