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AUTHOR Ginns, Ian S.; Watters, James J.
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ABSTRACT

This paper reports the results of a longitudinal study into the personal and science teaching efficacy of a group of preservice elementary teachers. Quantitative and qualitative research methods were employed in the study. Using a pretest and a post-test one group research design, quantitative data were obtained from the administration of a psychometric test, Science Teaching Efficacy Belief Instrument (STEBI-B), at the commencement and mid-point of a three-year teacher education program. Qualitative data were derived from interviews. The results revealed that science courses and the broad contextual environment of the teacher education program do not appear to influence subjects' sense of self-efficacy but have produced a significant change in their beliefs about children's ability to learn science. Data gathered from interviews suggest that beliefs appear to originate from a number of issues such as, gender bias, lack of practical work, and focus on formal examinations in science courses. Several conclusions related to the provision of science courses for preservice elementary teachers are discussed. (Author/ZWH)

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A Longitudinal Study of Preservice Elementary Teachers' Personal and Science Teaching Efficacy

Ian S Ginns & James J Watters

Centre for Mathematics and Science Education
Queensland University forTechnology
Locked Bag No 2
Red Hill 4059
Australia

A Longitudinal Study of Preservice Elementary Teachers' Personal and Science Teaching Efficacy

Abstract

This paper reports the results of a longitudinal study into the personal and science teaching efficacy of a group of preservice elementary teachers. Quantitative and qualitative research methods were employed in the study. Using a pretest, posttest one group research design, quantitative data were obtained from the administration of a psychometric test, Science Teaching Efficacy Belief Instrument (STEBI-B), at the commencement and mid-point of a three year teacher education program. Qualitative data were derived from interviews. A randomly selected subset of the total group were interviewed after the posttest in order to probe subjects' recall of events or incidents that could be construed as having a causative impact on their beliefs about their ability to teach science and their ability to produce positive outcomes in science for children. The results reveal that science courses and the broad contextual environment of the teacher education program do not appear to influence subjects' sense of self-efficacy but have produced a significant change in their beliefs about children's ability to learn science. Data from the interviews suggest that beliefs appear to originate from a number of issues such as, for example, gender bias, lack of practical work, and a focus on formal examinations in science courses. Several conclusions related to the provision of science courses for preservice elementary teachers are discussed.

A Longitudinal Study of Preservice Elementary Teachers' Personal and Science Teaching Efficacy

Introduction

Preservice elementary teachers enter teacher education programs with established attitudes, beliefs, values and their own sense of personal and teaching efficacy. It has been argued that an individual's sense of efficacy is situation specific (Bandura, 1977) and consequently, a preservice teacher's sense of efficacy may vary according to the specific teaching and learning experiences and contexts he/she is exposed to at any particular time during the undergraduate program (Ashton & Webb, 1986). The importance of personal and teaching efficacy may be reflected in, for example, the concerns of prospective teachers about their competence as teachers or doubts about their students' ability to learn (Ashton, Webb & Doda, 1983). In a situation specific context such as the teaching of science in elementary schools, any concerns that preservice teachers have about their competence as science educators may eventually result in the implementation of poorly conceptualized and ineffective learning experiences in science that involve little more than a token commitment of effort and time. This practice certainly seems to be the case as over the past few decades, the state of science education in elementary schools has been questioned and concerns expressed about the quality and amount of instruction in science (Driver, 1983; Department of Employment Education and Training, Australia, 1989; Claxton, 1992; Tilgner, 1990). Further, it was reported that "there appeared to be little connection between science education in teacher education programs and the likelihood that students a few years hence will be teaching much science" (Department of Employment Education and Training, Australia, 1989). The statement implies that although one could increase the amount of science in preservice courses this action would not necessarily lead to increased commitment to the teaching of science by teachers. Hence, there is a critical need to identify and establish the significance of factors which contribute to the implementation of science programs in elementary schools. A number of these factors may be the cause of problems in elementary science education, and research into self-efficacy and related science teaching behaviors (Riggs & Enochs, 1990) may provide solutions to these problems. The research reported in this paper, resulting from a longitudinal study of a selected group of preservice elementary teachers, is a response to the challenge provided by Riggs and Enochs. The objectives of the longitudinal study were to:

(a) measure preservice elementary teachers' sense of personal (self-efficacy) and teaching efficacy (outcome expectancy), in the situation specific area of science, at the commencement and mid-point of their undergraduate studies;

(b) determine if the performance of preservice elementary teachers in undergraduate science content, and science methods courses influence personal and teaching efficacy; and

(c) analyze the subjective reflections of preservice elementary teachers for prior experiences that could influence the development of personal and teaching efficacy.

It is conceivable that the successful implementation of worthwhile science programs in elementary schools may depend on teachers' sense of personal and teaching efficacy, that is, their personal beliefs about their ability to teach science and their ability to produce positive outcomes in science for children.

<u>Background theory</u>

Teacher efficacy is a construct derived from Bandura's (1977) theory of self-efficacy. He suggested that behavior is based on two factors, firstly, people develop a generalized expectancy about action-outcome contingencies through life experiences, or outcome expectancy, and secondly they develop a more personal belief about their own ability to cope, or self-efficacy. In cases where both self-efficacy and outcome expectancies vary, behavior can be predicted by considering both factors. For example, Bandura hypothesized that a person rating high on both factors would behave in an assured, confident manner. He emphasized that self-efficacy is a situation specific determinant of behavior not a global personality trait. Reinforcing this hypothesis, Riggs and Enochs (1990) argued that teachers' efficacy beliefs appeared to be dependent on the specific teaching situation. Consequently, teachers' overall level of self-efficacy may not properly reflect individual beliefs about their ability to affect specific subjects such as science teaching and learning. They noted that a specific measure of science teaching efficacy beliefs should be a more accurate predictor of science teaching behavior. As a result of this work, Enochs and Riggs (1990) devised the Science Teaching Efficacy Belief Instrument (STEBI-B) containing two scales titled the Personal Science Teaching Efficacy (PSTE) Belief Scale and the Science Teaching Outcome Expectancy (STOE) Scale for use with preservice elementary school teachers. The development of STEBI-B represents an important step in our ability to monitor preservice teachers' sense of science teaching efficacy at various stages of their undergraduate program. The instrument has been validated on a population of Australian preservice elementary school teachers (Lucas, Ginns, Tulip & Watters, 1993).

Methodology

This research employed a combination of quantitative and qualitative research methods. Quantitative data were obtained from the administration of STEBI-B in a pretest, repeated posttest one group research design, as well as the compilation of respective course achievement grades. Qualitative data were derived from interviews. Self-efficacy theory assumes that a person's ability to cope with a specific situation results from prior experiences. The interview was designed to probe the subjects' recall of events that could be construed as having a causative impact on their beliefs about science and about their ability to cope with science. To complete the longitudinal study, it is planned to administer STEBI-B and conduct an additional series of interviews at the completion of the preservice teachers' undergraduate program.

Methods

Subjects

The subjects of this study were undergraduates in a 3-year preservice Bachelor of Teaching (Primary) degree program at a large Australian metropolitan University. The majority enrolled directly from high school. At the commencement of their degree program, the median age of the intake was 17.6 years and 86% were female.

Instruments

The instruments used in the study are described as follows:

(a) A standardized psychometric test (STEBI-B) which measures personal and teaching efficacy as they relate to the teaching of science in elementary schools. High scores on the first scale (PSTE), relative to other respondents, indicate a strong personal belief in one's own efficacy as a science teacher, and on the second scale (STOE) high expectations with respect to the outcomes of science teaching. Possible scores on the PSTE scale range from 13 to 65, and on STOE from 10 to 50.

(b) Achievement data consisting of grades for science content and science methods courses were compiled. Assessment items included examination and assignment tasks.

(c) Semi-structured interviews were conducted with a small subset of the total population who completed the STEBI-B posttest.

Procedure

Seventy two (72) subjects completed both the pretest STEBI-B at the beginning of their program and the posttest after three semesters. Two subjects neglected to answer one of the questions on the PSTE scale during the posttest administration.

The treatment can be considered to be the three semesters of undergraduate study comprising courses in child development, education studies, mathematics foundations, a range of curriculum studies and, in particular, two courses in science. Subjects participated in a 13 week science content course in the second semester of their studies. The course focused on the development of content knowledge particularly in areas of the physical sciences. The subjects progressed to a science methods course in the third semester of the program. Subjects' achievement grades on five items of assessment in the science content course, and their final grade on the science methods course, were recorded.

At the completion of formal testing in the science methods course, but prior to the release of assessment results, 20 subjects were selected at random for interviewing. The interview probed subjects' recollections of school and university experiences in science and the influence of these experiences on their beliefs about their ability to teach science, children's ability to learn science and the relative importance of teaching science. The structure of the interview was based on the critical incident technique described by Flanagan (1954) and each interview was conducted by a research assistant who was familiar with the objectives of the study but had no prior contact with the subjects. The questionnaire (Table 1) used in the interview was designed to elicit open ended responses which the interviewer encouraged by following up the responses with requests for further detail including specific examples. Interviews were audiotaped and transcribed. The purpose of the interview process was to obtain in depth data that would describe specific events leading to the development of behaviors or attitudes explicit in the formal questionnaire.

Insert Table 1 about here

Each transcript was read and checked for accuracy. The transcripts were read again and a profile of the respective interviewee was constructed by interpreting and combining responses to each question as was considered appropriate by the researcher. Three months after the interviews, subjects were invited to a second interview conducted by the research assistant in which each subject was presented with his/her profile for validating. Nineteen subjects agreed to participate in this process. However, only nine attended at the prescribed appointment time, therefore, profiles were mailed to the remainder with a request to review and verify the content and to append any further explanation. Seven replies were received. The profile of each interviewee appeared to have some face validity since no significant changes were made by any subject to the structure and emphasis captured.

Results

Quantitative data

Means and standard deviations for pretest and posttest scores on STEBI-B, for the longitudinal study group are presented in Table 2. Mean scores on STEBI-B for PSTE changed from 45.1 (range 32-56) to 46.1 (range 26-60) and mean scores for STOE changed from 33.5 (range 18-47) to 34.9 (range 25-43). Based on pretest scores, Table 2 also shows the means for subjects classified into three clusters, a low score cluster, a medium score cluster and a high score cluster for each scale. There was a significant difference between the pretest and posttest means on the STOE scale ($t(71)=-2.1$, $p=.04$, 2 tailed), but no significant difference ($p<.05$) between pretest and posttest means on the PSTE scale. The results of the cluster analysis indicate that changes in individual scores on PSTE and STOE are not uniform in direction and magnitude. It should be noted that efficacy beliefs of the low score subjects improved marginally for both PSTE and STOE .

Insert Table 2 about here

No statistically significant correlations were observed between efficacy belief scores and any achievement data for science content and science methods courses.

Qualitative data

Changes in efficacy scores were available for 15 of the 20 subjects interviewed. The remainder were either new to the University because of transfers or had not been present during the STEBI-B pretest or posttest administrations. Details of the subjects and their self-efficacy scores are presented in Table 3.

Insert Table 3 about here

Three profiles illustrative of either large changes in PSTE and STOE scores (Sn. and Ca. respectively), or negligible changes in the scores (Pa.) are shown in Table 4. Sn.'s pretest-posttest PSTE scores changed from the low score cluster to the high score cluster (Table 2) and Ca.'s pretest-posttest STOE scores changed from the low score cluster to the high score cluster.

Insert Table 4 about here

Discussion

Longitudinal study group

The important intervention for the longitudinal study group involved two science courses presented in sequence. The science content course was designed to develop students' background knowledge in the physical sciences and was implemented in a manner which catered for the particular concerns, experiences and anxieties of preservice elementary teachers. The roles of science and technology in society were considered, along with basic topics dealing with matter and energy concepts. The science methods course was presented in the following semester and provided opportunities for students to apply their content and pedagogical knowledge with children, and to develop implementable teaching units. The teaching strategies adopted in both courses attempted to provide successful experiences and to improve students' attitudes to science and, hence, one would have expected positive changes in the STEBI-B scores.

However, this intervention occurred in a broader context in which the students experienced a range of courses that addressed components of teachers' content and pedagogical knowledge, including knowledge of the purposes, history and philosophy of education, of children as learners, and of educational environments. Competent teaching practice requires an integration of such knowledge (Shulman, 1987), therefore, it could be predicted that the sum of the students' experiences in the program would impact more on outcome beliefs (STOE) than on personal self-efficacy (PSTE).

Our observations were consistent with this analysis. A comparison of pretest with posttest means indicates that only outcome beliefs (STOE) were significantly affected. Positive changes in STOE may result from successful experiences with children in the science methods course where observing enthusiastic children successfully undertaking science activities may influence preservice teachers' beliefs about children's abilities to learn science. Qualitative data from the interviews support this contention. Personal science teaching efficacy may encompass other personality traits such as self concept and hence, changing beliefs about personal science teaching efficacy may be more difficult than changing beliefs about the potential for teachers to improve children's learning of science.

Interview group

An analysis of the profiles revealed a number of issues that will now be discussed.

Science in the wilderness in elementary school. The first question (Table 1) required subjects to recall memories of science classes experienced in elementary school. Responses to this query generally fell into three categories. Nine of the students had recollections of elementary science being oriented towards copying information from a book or blackboard, or preparing assignments and project work, with little useful practical work involved. For example Ke. stated "...the most I remember about science is like copying done stuff off the blackboard". The consensus among these students was that science was boring. Another group comprising seven students, which included most of the mature age students, had virtually no recollection of doing any science in elementary school. For example, Tr. asserted that he only remembered doing science with a student teacher in Grade 6. Only four students, Ca., Su., Ro. and Ma. had positive recollections of elementary science which tended to focus on some specific activity that generated enthusiasm. Ca., for example, could recall an experiment involving rolling bottles filled with different liquids down a ramp. "Yes it was fun. It's probably the only reason I remember it". Three of these students had average or better PSTE scores.

The jungle of the high school. In contrast to recollections of elementary school, memories of secondary school were much more explicit and definitive. Secondary science elicited a sense of enjoyment and positive feelings for some and left the remainder with strong negative images and feelings about science. Positive feelings appeared to be tempered in several cases by a regret that performance did not match enjoyment and interest. For example, Ke. contrasted negative recollections of elementary science, typified by copying from the blackboard, with high school science which involved experimentation and discussion. Ca. and Tr. both attributed their poor achievement in secondary science to a lack of self-motivation. Ca. indicated that she liked chemistry, worked hard and was good, however, her interest waned and that she could have "studied harder". Tr. described the positive feeling experienced when he was able to get an experiment to work but also described a negative learning environment dominated by disruptive behavior to which he contributed. It is interesting to note that Tr., on leaving school, was employed as a science laboratory assistant.

The need for relevance. Relevance, or the practical value of science, was an issue raised by a number of students. Middle school science was generally perceived in a more positive light as it was believed by many to be more practical, exemplified by Da. who stated "...I was a bit more interested because it [science] was more practical ". Biology was also believed to be more practical and useful by several students including Ke., Su. and Pa. Am.'s only positive comment about high school senior science related to the study of muscles and bones of humans. In contrast, Sn. found biology practical work uninteresting and poorly developed. Many students mentioned dissection as a memorable event without expressing any belief as to its value or ethical position. Positive memories were also expressed by Ad. who recalled a very practical activity based on the construction of a working irrigation system. The most positive recollection of high school science came from Ta. who attributed her success and interest in middle school science to her Grade 8-10 teacher who made science fun. This positive feeling carried over into senior chemistry and biology, but not senior physics. An outstanding performance on a state wide exam in year 10 characterized Mu.'s recollections of high school science.

The role of teachers and parents. Teachers and parents were important in We.'s recollections of science. She described the role her father played in sending her on nature hunts and indicated that she does the same with her own children. Her recollections of her own high school teacher were very strong. The teacher was perceived to be interested in his students and prepared to explain concepts in a constructivist way by making links with prior knowledge. We. also reflected, in her follow-up interview, on her recently completed field experience. After describing how she achieved a maximum grade of 7 for her science methods course her practice teaching supervisor allowed her to teach the prepared science unit to Grade 4:

> " I was so excited. This is the most important thing about science. My excitement and my interest just generated that whole class into um ... an enthusiasm for finding out about it [lunar eclipses]. They were bringing stuff themselves and when the dinner bell went ... lunch, they

all went 'Ah! Do we have to go to lunch?'".

Reference to Table 3 will show that most of the students who displayed a positive recollection of science tend to have a high PSTE score.

Two interesting subjects include Le. and Ro. Le.'s PSTE score was 32, among the lowest recorded for the whole cohort. However, she recalled having done well in Year 8 science and having a positive attitude to science but believed she was "not really good" at science and hence she was "sceptical" of science. A comment added by Le. after the review of her profile indicates a reluctance to view conceptual knowledge as important as methodology:

> "I have just completed a three week field experience session and the only lessons I really enjoyed and were successful were science lessons. My only problem was that I did not understand the concepts very well. I was not able to explaining starting and finishing energies, why one structure was stronger than another and could not give the children challenging questions. This clearly demonstrates my point above [she described the need to find out how to teach children and believed that her University courses in science did not achieve that] that we should be learning experiments and their fundamental ideas that ... can be shared with elementary school aged children. Children love science".

Ro. also displayed a relatively low PSTE score of 36. She described a positive recollection of Year 8 science, particularly biology and astronomy but was unable to proceed with science because her mother directed her towards a commercial strand which was incompatible with science.

<u>Other issues.</u> Negative impressions and recollections were prevalent and a range of issues were identified such as teachers' competence particularly in physics, gender issues such as the belief that girls do not do science, orientation of senior high school science towards achievement in examinations at the cost of understanding (Ja., Am. & Ma.), lack of practical work, and dependence on textbooks.

Ly., for example, in her original interview described her mathematics and science teacher as the major factor in her leaving school. As a mature age student reflecting on attitudes prevalent in the 1960s, she recollected that her male teacher believed that females did not need to know science and therefore were seated at the rear of the class. The belief that Ly. developed was that "science became something that you did if you were male and brainy". In the follow-up interview, she expanded on her recollections when probed about her teacher: "Well I just...just did not bother. When you are being told often enough that you're either not good enough to do it, or you don't need to do it, then you give up". Her recent field experience also surfaced in the second interview. She associated the style of her classroom supervising teacher with her former high school teacher:

> "He just believed in telling. ...they don't tend to get a lot of science. Um ... which I find a bit hard to understand. Because I do think it's important for kids to have knowledge and understanding of science. Um.. and they don't ... in the way they're taught, what science they get is that they're given out sheets all day, told a lot of things from the board or whatever and it's still the same old way of doing things that I don't like".

Clearly, Ly. has strong feelings based on teacher competence. Her STOE scores are relatively high and there is evidence that her observations of school aged children interacting positively with science, and experiences with her own children, have reinforced her beliefs about outcomes. However, it appears that her own sense of self-efficacy is low.

Su. and Ke. shared Ly.'s belief that science in middle school was not for girls. Su., for example, said "The boys would come in and they would make things like batteries and we girls would go 'wow', why would you want to do that in your spare time?". Nevertheless, Su. did complete grade 12 biology and echoed Le.'s call for the University science courses to be more oriented towards the content of the "elementary syllabus". Ke.'s experience was that the girls had to do all the "dirty stuff".

One of the more dramatic increases in self-efficacy PSTE scores was that of Sn., (Table 4). In her interview she contrasted her poor performance in high school, and a belief that she could not do well in examinations, with an improved confidence after the science methods course. In particular she noted that the high school teachers were not helpful whereas the methods lecturers could "simplify everything so that we understand it which helped us all as a group". Su., Pa. and Da. also attributed their negative recollections of high school science to poor teaching. The positive experiences of We. with her teachers has been described previously, and other students made the point that having teachers who were prepared to explain enhanced the learning environment.

The disturbing feature highlighted in these data is that most of the preservice teachers seem to have had undesirable experiences with science at both elementary and secondary school level which may have influenced their beliefs. When questioned about their future responsibilities for teaching science all, with one exception (Sn.), admitted knowing that they would have to teach science and most expanded on this statement with apprehension. Ja., for example, in his statement expressed a common feeling: "When I started my preservice course I knew that I would have to teach science but felt that I did not know enough." Some students such as Ca. expressed more positive ideas:

> "When I started university, I knew that I would like to teach it [science] but there was always the problem of whether I had the ability to teach it and whether I would know enough content knowledge. Since I have been doing University, I have come to realise that the content is out there, all around you. But you have to look for it. However, I am still concerned".

It is apparent that field experiences have affected the attitudes of a number of subjects and teaching a science unit as part of their practice seems to have had an impact on their beliefs. Le. and We.'s experiences have already been described. Ke.'s recollections are powerful in reconciling the prior experiences, beliefs and university experiences with practice.

> "I have since had another field experience session at preschool and used science as a basis for my teaching unit. We called it water and I used a great deal of curriculum ideas I picked up in the science methods course. I felt confident teaching it and I know my supervising teacher was suitably impressed as she took a copy to use next year. The unit was basically science with mathematics, language, physical education, human relations education, social studies slotted into it. I feel that the science courses taught at University are virtually the only ones that have given me something to teach with as well as the confidence to change my way of thinking and make science a part of my teaching."

She continued her argument challenging the value of the science content course and praising the methods course. Her expressed beliefs are not reflected in large changes in the PSTE score.

Beliefs about the general ability of children to learn science were positive. At one extreme, Ca.'s beliefs had changed from a position in which she believed that not all children could learn science to one in which, given good teachers, all children can learn science. This change was reflected in a large change in STOE scores (Table 4). Most subjects accepted that, subject to quality of teaching, motivation of the children, relevance of the material, all children could and should learn science.

Conclusions

A number of generalizations can be made. The science courses and the broad contextual environment of the teacher education program do not appear to have influenced subjects' sense of self-efficacy but have produced a significant change in pretest and posttest scores on STOE for the longitudinal study group. The result supports, in part, the suggestion by Ashton and Webb (1986) that preservice teachers sense of efficacy may fluctuate during the undergraduate training program. The observation that no significant correlations were observed between achievement data for science courses and efficacy belief scores suggests that any successful or unsuccessful experiences in the University science content and methods courses were not impacting on the subject's sense of efficacy. Given that this has not occurred in our study, or at best any changes were marginal, attempts to improve efficacy beliefs may require a deliberate strategy not included in standard preservice courses. In summary, subjects' personal beliefs about their ability to teach science were quite stable up to the mid-point of their teacher education program and clearly, we need to identify what constitutes a successful or unsuccessful experience in science. Subtle or more complex changes in efficacy, and reasons for any changes, are not revealed through the use of the psychometric test.

The interviews revealed that many students have had negative science experiences in elementary and high school contexts and have been provided with few opportunities for spontaneous or guided exploration of science. They are students who have struggled when confronted with formal science and consequently a number have chosen to avoid studying science courses at various times. Arguably, they are students who required positive interventions on the part of teachers to provide guidance and encouragement. Generally, their beliefs appeared to originate from one or more of the following, gender issues, a lack of practical work and personal involvement in science courses, a dependence of science courses on textbooks, a focus on formal examinations in science courses, and the need for teachers who can adopt explaining and caring roles in the classroom. A number of studies recommend that preservice elementary teachers should undertake more science content and methods courses (Tilgner, 1990; Enochs & Riggs, 1990; Department of Employment Education and Training, Australia, 1989). We agree with these recommendations, however, the results of this research, particularly in relation to the minimal changes in personal efficacy, indicate that science teacher educators must structure existing and any new courses to include experiences that make students aware of, and able to confront, their existing beliefs about their ability to teach science. Ashton's (1984) suggestion that preservice teachers should complete teacher efficacy belief instruments may be one way of heightening this awareness.

Three semesters of university studies in education have had some positive effects. The science methods course has provided insights into how children learn science and strategies for teaching science, an emphasis that appears to have impacted on outcome expectancies, with students now believing that science can be taught well and, under these conditions, children can find science interesting and manageable (Pa.). The positive impact of field experiences on a number of subjects' beliefs should also be noted. The data provide evidence which tentatively supports the suggestion that self-efficacy can be enhanced through modeling and successful mastery experiences (Bandura, 1981). We agree that these techniques can be included in existing microteaching and field experiences (Enochs & Riggs, 1990). Science teacher educators must, therefore, provide leadership in this regard and ensure that all preservice elementary teachers have positive and beneficial practical teaching experiences.

The need for a sound background content knowledge is still perceived to be a problem by a number of students, however, the approach taken in the science content course does not appear to fully address this need. Indeed, the science content course was a negative experience for several students even though the content material covered in the course was selected for its direct relevance to the elementary school curriculum. There appears to be a gap between what science teacher educators perceive as relevant science content and what students see as being necessary for teaching science in the elementary school. Some students felt strongly that they required a prescriptive guide to content that was perceived by them as relevant to elementary school and no students explicitly sought more intensive grounding in discipline content. Achieving a shared belief between science teacher educators and students on this particular issue may present us with our most important challenge.

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Table 1
Efficacy Interview Questionnaire

1. Do you remember doing much science in elementary school?
2. What do you remember about secondary science?
3. Were you successful at science?
4. If you were good/not good at science why do you think this was the case?
5. Have you had any contact with a science teacher/scientist outside school?
6. When you came to University did you expect to have to teach science as part of the elementary school curriculum?
7. Do you now feel that you want to teach science?
8. Do you now feel that you are able to teach elementary school science?
9. Do you think that all children can learn science?
10. Do you feel that your perception of the importance of teaching science has changed during your University career? In what way has your perception changed? In your view, what factor or factors, have initiated the change?

Table 2
Personal Science Teaching Efficacy Belief Scores and Science Teaching Outcome Expectancy Scores on STEBI-B

		PSTE					STOE			
		Sem 1		Sem 3			Sem 1		Sem 3	
Level[a]	n	mean	sd	mean	sd	n	mean	sd	mean	sd
low score	11	37.1	2.6	43.5	6.9	12	25.3	3.0	34.3	3.4
med score	49	45.4	2.8	46.1	6.0	50	33.9	2.4	34.6	4.4
high score	10	52.2	1.8	49.1	7.4	10	41.2	3.3	37.5	3.3
whole group	70	45.1	5.0	46.1	6.4	72	33.5[b]	5.1	34.9	4.2

Note: [a] low PSTE <40, med 40-50, high >50; low STOE <30, med 30-37, high >37; [b] Difference in means $p = 0.04$.

Table 3
Pretest-posttest Self-efficacy Scores for Sample of Interviewed Subjects

Subject	Age	Gender	PSTE		STOE	
			Pre	Post	Pre	Post
Ca.	19	f	50	40	24	39
Ke.	19	f	45	36	33	34
Sa.	21	f	38	35	31	25
Ly.	35	f	40	38	47	43
Ja.	20	m	39	48	35	35
Tr.	32	m	43	45	31	33
Am.	21	f		49		33
Sn.	23	f	37	51	28	36
Su.	25	f	44	50	37	38
Mu.	20	m	55	51	36	30
Le.	21	f	32		27	
Ad.	22	m	48	58	32	28
We.	39	f	50		30	
Ro.	19	f		48		37
Da.	23	m		43		36
Ma.	24	f	45	45	33	36
Ke.	38	f	47	46	32	42
Ta.	19	f	51	41	34	41
Ro.	37	f	36	38	33	33
Pa.	40	f	51	53	40	38

Table 4
Sample Profiles Produced from the Transcripts of Interviews

Ca. [19y; f]

I don't remember very much of elementary science other than doing an experiment with liquids which I think was science. You had bottles with different liquids in them and they were rolled down a ramp and we timed them. It was fun but I don't know what we learnt. In secondary school I liked science particularly chemistry and worked hard and was good but my interest wore out. I could have studied harder.

When I started my preservice degree at University I knew that I would have to teach science and I felt pretty good about it. I knew that I would like to teach science but there was always the problem of whether I had the ability to teach it and whether I would know enough content knowledge. Since I have been doing University I have come to realize that the content is out there, all around you, but you have to look for it. However, I am still concerned. [PSTE: 50-40]

I did not always believe that children could learn science but now I am much more positive. Successful learning of science is a partnership between teacher and student. Some students don't seem to be able to get the concept of science. Like some of my friends just had no idea of science. But I guess all children have the ability, it's just having good teachers to bring it out. [STOE: 24-40]

I think that science is important because it's a more real world subject. Kids can actually learn and discover things they would not in maths and language. They can learn about everyday life and what they are made of and then how they work. And I come to believe this because I was able to do hands-on things myself in our course and I can see that children can also do that.

At University, I was average in my science content course getting grades between 4 and 6 although I failed the problem solving section of the exam. On my methods course I did well and got a grade of 6 out of 7.

Sn. [23y; f]

I do not remember doing any science in elementary school or middle school. I did biology in years 11 and 12 and enjoyed the reading aspects of it but our practical work was not so interesting or useful. We cut up bull's eyes but generally the practical work was minimal on and not discussed usefully. I did not do particularly well and I don't think the teachers were helpful.

I did not expect to do any more science after school and I did not expect to have to teach science. My friends who did University science found it too hard and dropped out and so I was apprehensive about doing the science content course. However, after the science methods course I now feel much more confident. I realise that Science is not that hard because everyone seemed to simplify everything so that they could understand it, which helped us all as a group. [PSTE: 37-51]

I think children can learn science if it is presented in a way that they find out things for themselves. They need a lot of questioning and answering and interaction amongst themselves. Noise is good for science. However, the teacher is important and must make science interesting. Teachers have to play an active role. Science is important because it makes you think a lot more and it can help you in other subjects. [STOE: 28-36]

Pa. [40y; f]

I don't remember any elementary science at school at all. I attended an all-girl high school and the teaching nuns taught science out of a book but we never did any practical work. I never considered doing physics or chemistry when I left that school for Grade 11 and 12 because I thought well, I don't have any background. I cannot do science.

To get University entrance years after, I did a biology course out of interest. I've sort of always been really good at English and that extra study there would not benefit me. I never wanted to do maths because I hate maths and so I thought biology would be interesting. I took it and loved it. Because we were adults there were plenty of discussions and the teacher was effective. My daughter has him for maths and he is a good maths teacher as well.

I expected to have to teach elementary science because its part of the curriculum. Now my feelings are that the more I do science the more I realise that it is interesting and there are interesting ways of presenting it to children. [PSTE: 51-53]

Science is to do with everyday, natural things that children come into contact with, like motion, electricity and machines. You know children need to know for safety reasons or enjoyment how they work. Boys are interested and it's just a matter of getting the girls interested. Teachers have got to be interested and innovative. Success depends on the teacher. My son, he is in Grade 5, and since I did the science content course he is just right into science. He worked through the course with me. We would do activities together and discuss the results. He is very interested in science. The same approach would work with all children. [STOE: 40-38]

I probably believed that at the beginning of my course that mathematics and english are the most important because you hear about them. Now I believe they are all important but you won't need a separate english curriculum. They can do english and science together. Language skills will be learned by application to curriculum areas such as science better than by just getting them to read books.

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