Journal of Science Teacher Education, 11(4), 277-313.

This is the authors' version of a paper that was later published as:

Watters, James J and Ginns, Ian S (2000) Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education* 11(4):277-313.

Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education

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Abstract

The rapid growth in knowledge over recent times has meant that teachers have to be responsive to new and ever changing demands of society. Science is among those key areas of knowledge that has experienced overwhelming growth and thus developing scientific literacy is a priority if citizens are to participate effectively in society. Failure to develop children's interest in science will disempower a generation of children in an era when scientific knowledge is at the foundation of our culture. Unfortunately, many elementary teachers express a lack of confidence in their ability to teach science with dire consequences for the quality of teaching. This paper reports a study involving a cohort of 161 elementary preservice teachers in the third year of a four-year Bachelor of Education program enrolled in a core science education (methods) course. An instructional program that addressed five essential dimensions of meaningful learning – the knowledge base, metacognition, motivation, individual differences and context – was implemented. Quantitative and qualitative data obtained through surveys, observations and focus session reviews revealed that a learning environment based on social constructivist perspectives was effective in developing students' conceptual and pedagogical knowledge, and most importantly enhanced students' sense of science teaching self-efficacy. Particular initiatives that were identified by students as being of value were collaborative learning and associated strategies, reflective journal writing, and assignment tasks that adopted principles of problem based learning. While statistically significant gains in science teaching self-efficacy ($p < .001$) were observed overall, qualitative data enabled a more detailed analysis of the changes in motivations and goals of individual student teachers. The paper explores how the experiences developed their confidence and will to teach science in elementary school and how opportunities were provided that empowered the student teachers to be proactive seekers of knowledge and become lifelong learners.

Introduction

Children of today will need opportunities to develop a disposition towards learning that will empower them throughout their life to be proactive seekers of knowledge – lifelong learners – keeping pace with, and informing, the process of change (Dearing, 1997; Rutherford & Ahlgren, 1990; West, 1998). The key to providing the appropriate environment where this can occur lies with teachers who model enthusiasm for learning and exhibit personal commitment to life-long learning. Developing these attributes in preservice teachers is a critical element of preservice education.

Science education in particular has a major role to play in the development of critical and informed citizens in a rapidly changing technological society. The task is to make science education meaningful and useful for children of today in order that they can, as Rutherford and Ahlgren (1990) argue:

> ... develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent and vital (p. v).

At the core of making science meaningful for children are the actions and initiatives of classroom teachers. Teachers must be capable of responding effectively, not only to societal expectations but also to the changing nature of the profession, and to a reform agenda that includes the introduction of new curricula and initiatives in science education. Among the reform initiatives is a reconceptualization of the purpose of science education and the role of educating children to become scientifically literate, socially adept, and enthusiastic lifelong learners.

Preservice teacher educators will play a major role in the reform agenda by providing meaningful experiences for undergraduate students through which they can develop appropriate dispositions and understandings of the process and role of science. Developing positive dispositions towards science is problematic as preservice and inservice elementary teachers, in general, have poor attitudes and beliefs about science and their capacity to be effective teachers of science. For example, preservice teachers doubt their ability to teach science effectively in classroom settings (Stevens & Wenner, 1996), and many experienced classroom teachers feel uncomfortable and unqualified when asked to teach science (Abell & Roth, 1991; Kahle, Anderson & Damjanovic, 1991; Manning, Esler & Baird, 1982; Mechling, Stedman & Donnellan, 1982; Tilgner, 1990). These beliefs and attitudes develop as a result of their own science-related experiences in elementary and high schools (deLaat & Watters, 1995; Watters & Ginns, 1995). Science teaching in elementary schools will continue to be singled out as a major source of concern for a number of stakeholders (Australian Science Technology and Engineering Council - ASTEC, 1997; Weiss, 1994) until teacher education programs confront preservice teachers' negative attitudes to science and lack of motivation to teach science.

We need teachers to go beyond traditional school science with its emphasis on "key" concepts (Eisenhart, Finkel, & Marion, 1996) and focus also on the processes of learning and thinking about learning. This paper describes a study of the effectiveness of an approach that attempts to develop these attitudes and behaviors in preservice teachers.

Theoretical framework

Five essential dimensions of meaningful student-centered learning can be identified in any context and are summarized in Table 1 (Alexander & Murphy, 1998). Preservice teacher education programs need to address all of these dimensions if graduates are to become truly lifelong learners with a disposition towards scholarship, ethics and leadership in the community and effective role models for their own students. Each of these dimensions presents particular issues that need to be considered in a curriculum designed to develop those attributes valued in a learned graduate. The dimension of motivation and affect is of particular concern given the well-entrenched attitudes of elementary teachers to the teaching of science. From the learner perspective, David Ford's (1987) living systems framework argues that motivation, skill, biological structure and function, and a responsive environment are necessary components for competent functioning.

Table 1.
General statements relating to learner-centered principles

The knowledge base	One's existing knowledge serves as the foundation of all future learning by guiding organization and representations, by serving as a basis of association with new information, and by coloring and filtering all new experiences.
Strategic processing and Executive control	The ability to reflect upon and regulate one's thoughts and behaviors is essential to learning and development.
Motivation and Affect	Motivational or affective factors, such as intrinsic motivation, attribution for learning, and personal goals, along with the motivational characteristics of learning tasks, play a significant role in the learning process.
Development and individual differences	Learning, while ultimately a unique adventure for all, progresses through various common stages of development influenced by both inherited and experiential/environmental factors.
Situation or context	Learning is as much a socially shared undertaking, as it is an individually constructed enterprise.

Motivation is a complex psychological construct that attempts to explain behavior and the effort applied in different activities. M. Ford (1992) describes motivation as the "organised patterning of an individual's goals, emotional arousal processes and personal agency beliefs" (p. 5). He argues that motivational processes help people imagine or predict future events and consequences of engagement in those events. Thus, the way a person performs or behaves in a given situation depends on attitudes that are manifestations of both cognitive and affective attributes of that person (Ajzen, 1985; Bandura, 1977, 1986, 1997; Ford 1992; Prawat, 1985; Shrigley, Koballa, & Simpson, 1988). Humans are usually quite rational in making systematic use of knowledge available and evaluating the implications of actions before they decide to engage in any form of action (Ajzen, 1985). In deciding to engage in a particular action, humans make decisions about goals, the expected outcome of engaging in the action and the emotional consequences of involvement.

Certain behavior is valued either because of the need to meet intrinsic or extrinsic goals (Covington, 1993; Dweck & Leggett, 1988; Pintrich, 1989) or the task has some perceived significance (VanZile-Tamsen, 1998). Extrinsic motivation is instrumental in form and focuses on external rewards such as the desire to obtain high grades and complete the program. Intrinsic motivation may stem from a personal goal derived from an interest in the course area. It also may be present because of some value associated with the endeavor. For example, if a teacher believes that knowledge of science is important socially, he or she values the task of teaching science, will attempt to learn it, and feels obligated to teach it well. However, the goal orientation affects the type of learning that may ensue with more surface learning accompanying extrinsic motivation compared to the learning resulting from intrinsic motivation (Entwistle, 1998).

Setting goals requires well-formulated and reasoned plans (Fishbein & Ajzen, 1975). An individual's intention to undertake some activity depends on his or her attitude and beliefs. Attitudes represent the individual's favorable or unfavorable evaluation of the target object, while beliefs represent the information the individual had about the object. Fishbein and Ajzen claimed that attitudes toward objects were determined by joining the product of the evaluation of a particular attribute associated with the target object and the subjective probability that the object had the attribute. Accordingly, they contended that the evaluation of the attribute contributed to the individual's attitude in proportion to the strength of his or her beliefs. Whether a person undertook that behavior was influenced by his or her beliefs about the likely consequences of success or failure. Ajzen (1985) argued that a person will attempt to perform an action "if he (sic) believes that the advantages of success (weighted by the likelihood of success) outweigh the disadvantages of failure (weighted by the likelihood of failure)" (p. 36).

A prominent place in explanations of human behavior is assigned to the notion of personal agency, which is an intention to undertake some action based on an evaluation of the likelihood of success in that particular action. Bandura (1987, 1997) conceptualizes this intention to act on the basis of belief about particular outcomes as expectancy. Expectancy is influenced by beliefs about the extent to which a person is in control of his or her own destiny and judgments of those beliefs. People behave with reluctance if they acquire expectancies that they cannot affect outcomes through their actions (Rotter, 1966). In general, a person who attributes success or failure to external events and thus has an external locus-of-control is less active in pursuing challenging tasks. Self-referent expectancy systems also regulate behavior. For example, a person holds beliefs about his or her ability to engage in particular activities and the likely outcome of such engagement, that is, self-efficacy beliefs. These beliefs influence behavior. Self-efficacy beliefs are born out of successful or unsuccessful antecedent experiences (Bandura, 1977, 1986, 1997).

Preservice teachers who are expected to engage in teaching science in elementary school commonly hold low self-efficacy beliefs about their ability to teach science after graduation (Enochs & Riggs, 1990; Ginns, Watters, Tulip, & Lucas, 1995; Ginns & Watters, 1996; Watters, Ginns, Enochs & Asoko, 1995). This low sense of self-efficacy militates against them engaging effectively in learning science. Furthermore, attitudes and beliefs about science held by many teachers are argued to be counterproductive to reform especially involving ideas about constructivism (Czerniak & Lumpe, 1996). Bandura's (1986, 1997) self-efficacy model has provided the most significant insights into the general behavior of teachers (Ashton & Webb, 1986; Dembo & Gibson, 1985; Greenwood, Olejnik & Parkay, 1990). Therefore, self-efficacy should be an important consideration in the preservice preparation and induction of new teachers. M. Ford (1992) uses a similar construct – personal agency beliefs – in his model, and like Bandura, sees this as an integral part of motivating students. However, the concept of self-efficacy being task specific offers more insights into the behavior of teachers engaged in the discrete act of teaching science.

Affect refers to a wide range of phenomena including feelings, emotions, moods, and drives. The emotional aspect manifested in fear, joy, anger, anxiety can have physiological origins with concomitant interruptions of the attentional mechanism of the human nervous system and produce interfering demands on cognitive processing (Simon, 1982). In contrast, moods may be beneficial to task commitment as sadness or happiness may influence cognitive functioning and there may develop an association of these feelings with particular endeavors. Another aspect of affect relates to feelings of self-esteem, self-image, or self-concept. In competitive, individualistic societies, where one person's success is another's failure, social comparison enters inevitably into self-appraisal. In maintaining public approval, a person may choose to minimize investment of energy into risky enterprises.

People engage in self-observation, self-judgment and self-reaction, and the benchmarks against which decisions are made are socially experienced (Bandura, 1986). Hence, the context in which learning occurs is a contributor to the integration of the motivational components such as self-efficacy. Motivation, professional knowledge, moral and political sensitivity will develop within a culture defined by the experiences they have in becoming a teacher and by the individual teacher's locale. The extent to which teachers will teach science in elementary school, is influenced by the teachers' knowledge of science and the issues in teaching science as well as their feelings or attitudes towards those cognitions (Morrisey, 1981). These attitudes may develop during their own schooling but may also be influenced by their preservice training experiences. For example, Germann (1988) postulated that students' fatalism, their perceptions of the value of science, teacher quality and classroom social environment and organization appeared to be of significance in determining attitudes. Others have explored the relationship between the teaching of science and the student's perception of science (and technology) (Hewson & Hewson, 1989; Rubba & Harkness, 1993), the role of conceptual knowledge (Tilgner, 1990; Franz & Enochs, 1982) and "perspectives towards teaching" (Zeichner, Tabachnik, & Densmore, 1987). However, attitudes are modifiable if, as Enochs and Riggs (1990) predicted, preservice experiences specifically target students' beliefs and enhance self-efficacy (Abell, & Bryan, 1997; Ginns & Watters, 1999; Huinker, & Madison, 1997).

Success or failure appears to pervade any discussion about values, goals, self-efficacy and affect when considering an individual's intention to undertake any task. Therefore, it is incumbent upon science teacher educators to provide opportunities for preservice teachers to experience success in terms of learning content, pedagogy and professional practice. An instructional program focussing on motivation and affect and designed to provide successful experiences is discussed in the following section.

The instructional program for learning to teach science

Planning of the science education course for the preservice teachers in this study was informed by a recognition of the role of science education in society and the framework incorporating the five essential elements of student-centered learning with special attention to motivation and the component expectancy. The salient instructional strategies adopted for this course involved collaborative learning workshops, a problem based assignment, and reflective writing. Workshops of two-hour duration were implemented each week. Teams of four to six students investigated a range of topics that included: *The Nature of Science, Constructivism, Establishing and interpreting prior knowledge, Questioning and explanation, Language in science, Ethics, Authentic science and inquiry practices, The social nature of learning, Conceptual change, Instructional designs, Designing units of work,* and *Selecting and resourcing activities.*

A number of collaborative learning strategies were implemented by each team of students with guidance from the tutor who scaffolded the processes to ensure that genuine collaboration was adopted (e.g. Blumenfeld, Marx, Soloway & Krajcik, 1996). A key strategy to develop collaborative learning included a metacognitive evaluation of their learning through which students analyzed critically not only what they were learning, but also how they were learning through collaboration (Macbeth & MacCallum, 1996). At a practical level, the groups assigned responsibilities for certain tasks to various members. Participants explored their own previous experiences in relation to set activities and negotiated common solutions to problems. A variety of structures of groups were also implemented, for example, the *jigsaw* strategy which uses home groups and expert groups, *think-pair-share,* and *three-step interviews*. All workshops included content from one of the broad conceptual areas of energy, matter, earth and weather, life science, and space. For example, students would explore strategies such as concept mapping to investigate children's prior knowledge of matter or space.

In order to foster students' personal reflections on learning, they were encouraged to keep a reflective journal or diary that was assessed. The journal was described to the students as an ongoing, personal "scratchpad" of thoughts, records, and reflections about their learning. In particular, students were supported to review, refocus, analyse and reconceptualize critical incidents and experiences in their journal. A variety of formats was acceptable but the crucial element was the quality of personal reflection examples of which were provided in a workshop manual. These intentions were in accord with research that supports the use of reflective writing as a strategy to encourage students' thoughts about their own learning (Horning, 1997; Kroll 1996).

The instructional program included problem oriented assignment work of an authentic pedagogical nature. It involved a two-phase task in which students, in groups, were required to explore ideas held by selected children using interviews about instances or other techniques (e.g. White & Gunstone, 1992), and subsequently to develop appropriate teaching units of work suitable for these children. There was also an expectation that students would review existing literature concerning children's understanding of the topic selected and research on teaching this topic. The task extended over ten weeks of the semester and was conducted in the students' own time with support from the tutors. Feedback was provided at the conclusion of the first stage before the preparation of the unit of work. Each group presented its unit of work at a collaborative learning workshop in the last three weeks of semester. Students were assessed as groups with scope for negotiation in situations where the collaboration was not effective.

The instructional strategies also attempted to recognize that learning in authentic learning environments should simulate experiences that allow students to derive understanding in contexts in which they need to apply that understanding. The tasks employed in the course were modelled on practices that the students would be engaged in as beginning teachers. Authentic learning environments establish a sense of personal control over what and how the learner learns. When a sense of personal control is established learners should be able to pursue their own independent learning endeavors albeit guided by a supportive teacher.

In summary, the instructional strategies applied the five essential elements of student-centered learning (Table 1). In particular, the instructional strategies attempted to enhance motivation by incorporating:

- Authentic learning environments simulating real life pedagogical practices of diagnosis, planning and teaching, in essence problem-based-learning;
- Collaborative learning; and
- Personal reflection on learning.

It can be claimed that through the use of these instructional strategies, students were provided with opportunities to engage with content, pedagogy, and professional practice. Table 2 shows the five essential dimensions of meaningful student-centered learning and how these dimensions were addressed via the instructional strategies employed in the Science Education course.

Table 2

Implementation of student centered learning strategies

Dimension	Strategy
The knowledge base	Problem based learning assignment Collaborative groupwork in workshops
Strategic processing and Executive control	Reflective journal writing
Motivation and Affect	Authentic learning practices embedded in assignment Collaborative learning Activities in workshops, which generated interest and fun
Development and individual differences	Flexible learning opportunities for students to pursue areas of interest
Situation or context	Learning environment that provided opportunities for students to voice beliefs

Aims of this paper

This paper focuses on an implementation and evaluation of instructional strategies in a core science education (methods) course within a Bachelor of Education (Primary) preservice program. Graduates of this program are expected to teach children in eight key learning areas including science in elementary schools from grades 1 to 7 (ages 5 to 12). The study examines how a collaborative learning experience that incorporated components of problem based learning was implemented and how students reacted to and reflected upon this approach. The paper explores how a student-centered approach enhanced students' motivation and their stated confidence and will to teach science. The study is on-going and provides a situational analysis of a long term action research program in which the authors have attempted to address the quality of preservice educational experiences for students who will be required to teach science in their professional career.

Methods

Participants

The participants in this study were 154 students enrolled in the four-year preservice Bachelor of Education (Primary) program in 1997. Eighty five percent were female. All students completed a core science content course (Science Foundations) in the first year of the preservice program and a core science education course (Science Education) in the third year of the program. At the beginning and end of the science education course students were surveyed to determine a range of beliefs including their personal sense of science teaching self-efficacy. This study was conducted with all students who were part of the year's enrolment. The Science Education course was structured with two lectures per week and the two-hour workshop described previously. Workshops were facilitated by one or other of the authors or by a part-time tutor who had received oral and written briefing information on the instructional strategies being used and whose workshop was monitored regularly by the researchers.

Procedures

Both qualitative and quantitative data were collected. Quantitative data were obtained using a survey instrument. The preservice teachers' efficacy beliefs in the specific area of science were measured using the Science Teaching Efficacy Belief Instrument (STEBI-B), designed by Enochs and Riggs (1990) and validated in an Australian context (Ginns et al., 1995). The instrument consists of two scales, the Personal Science Teaching Efficacy (PSTE) scale, and the Science Teaching Outcome Expectancy (STOE).

Qualitative data were collected through classroom observations, focus group sessions held at the conclusion of the course, and through the analysis of workshop notebooks and the reflective journals kept by the students. The reflective journals were open ended diaries in which students reflected not only on workshops but also on lectures, learning resulting from the problem oriented assignment and instructional strategies incorporating collaboration and real-life problem scenarios as described previously. Students also completed workshop notebooks through which they provided immediate responses to experiences, ideas, and activities engaged in during workshops, in a structured format that required them to discuss, think about and reflect upon key questions related to pedagogy and curriculum.

Five focus groups sessions were held with 22 students about 2 months after the conclusion of the semester and after assessment processes had been completed and students informed of grades. A research assistant, who had been briefed on the course, facilitated the focus sessions. Students were encouraged to reflect on their experiences with limited input from the research assistant. Effectively, there were no constraints on the student input. When conversation seemed to be exhausted, she directed students to focus on particular issues such as the impact of collaborative groupwork or the research component of the problem oriented assignment work. Some of these issues may have been addressed in the open conversation but, if not, they were explicitly explored. Each focus session closed with a summary of all participants' concerns.

Qualitative data analysis involved coding using a constant comparative methodology (Strauss & Corbin, 1990). Analysis of the data enabled the examination of relationships between teacher efficacy, patterns of behavior and students' assertions and concerns.

Results

A summary of the quantitative data is presented in Table 3. The STEBI-B scores for four students, Judy, Barbara, Catherine, and Kelley are reported for completeness as the contributions of these students in the focus group sessions are discussed later. These four students were purposely selected to provide examples of the range of students in the focus groups. The qualitative data provided by the four students exemplify the comments and reflections of students who displayed low, moderate and substantial changes in PSTE.

The quantitative data highlight the marked gains in the PSTE scores and the stability of STOE over the semester. There were significant changes in PSTE overall for the focus group students ($p = .008$, n = 22). Implementation of the end of course survey proved logistically difficult and consequently only 22 students were surveyed. These students did not represent any identifiable subgroup and the pretest mean score of this group using STEBI-B was not significantly different from the mean of the whole group of 154 students (45.72). The significance statistics shown in the table were calculated using matched pair t-test comparisons. Of the 22 students, only one significant decrease in PSTE was noted in a student whose pretest score was 59 and posttest score 51. The effect size of 0.64 indicates a relatively large change (Howell, 1985). These data demonstrate clear indications that the students perceived an increase in their sense of self-efficacy as teachers of science. An increased sense of self-efficacy implies a greater confidence in their ability to cope effectively with science teaching. These increases in self-efficacy highlight the effectiveness of teaching approaches that address student-centered learning and replicate the findings of other studies that have adopted a variety of strategies all of which acknowledge the importance of addressing motivation (Huinker & Madison, 1997; Riggs, 1994; Scharmann & Hampton, 1995; Yeotis & Bakken, 1991).

STOE scores were more variable. The small changes in STOE indicate that students were less optimistic about the outcomes of science teaching attributing external factors as potential inhibitors of effective teaching. These results are consistent with previous work (Watters, et. al., 1995).

Table 3
Changes in PSTE and STOE scores on self-efficacy scale

Student	PrePSTE	Post PSTE	Effect Size	PreSTOE	PostSTOE	Effect size
Judy†	36	50	2.56	42	38	-0.9
Barbara	31	33	0.37	33	33	0
Catherine	44	49	0.92	37	30	-1.6
Kelley	30	51	3.85	37	33	-0.9
Whole group✦ (22 students)	44.8	49.2	0.64	35.0	35.2	0.07

†Effect size for individuals = Post-Pre/mean sd; ✦Effect size for group = $t / \sqrt{df}$

The qualitative data obtained through the focus sessions were analyzed to obtain insights into how each student's perceptions of the course and his or her own capability to teach science changed. The format of the focus group sessions or conversational interviews allowed students to generate spontaneously claims, issues, or concerns about their experiences. The focus group facilitator provided an introduction to the sessions with the general statement: "What Jim and Ian want to do is look at the effectiveness of the science education course that you've recently done in relation to your confidence and your competence in teaching science, and what you think about science teaching in relation to that course." Consequently, the participants in the focus group sessions proceeded to reflect on their experiences in these terms. The major issues identified in the transcripts of the focus sessions will be described and explanations derived from the instructional strategies implemented by the teaching team.

Confidence - Findings

One of the major issues arising from the focus group sessions was that of confidence to teach science. The quantitative data that indicated gains in self-efficacy or confidence in their ability to cope effectively with science teaching are supported by the qualitative data from journals, workshop notebooks, and focus group sessions. The students in the Science Education course had, in their first year of the preservice program, studied the course Science Foundations that focused on conceptual understanding of science and was designed to provide a broad introduction to the major concepts of science. Success in high school science is not a prerequisite for entry into the preservice program and, for many, the foundation science course was a major challenge. Many students remarked upon the focus on content in that course in negative terms typified by the feelings expressed in Judy's comment in a focus group session:

> I really didn't like the first one [Science Foundations] very much, where we had to do all these experiments and things. It reminded me of years ago when I did high school science and I just didn't like it at all, just racing around trying to get all these experiments done within the allotted time, it was rush rush rush. We had four hours solid.

Most students contrasted the Science Foundation course and the Science Education course in terms of how the latter course impacted on their confidence and competence. The Science Education course was acknowledged by many students as being more useful than the Science Foundation course in developing understanding and confidence. Even Barbara, (pre to post PSTE; 31 to 33) the most anxious or "sciencephobic" student noted the Science Education course helped her understand some of the concepts she did not understand in high school science:

"Science Education sort of cleared everything of that up for me." She also began to understand how to apply some of the activities in the course to teaching science in the classroom.

A common assertion about the development of, or changes in student confidence as a result of engagement in the Science Education course was expressed by Catherine (pre to post PSTE; 44 to 49):

> I think my confidence has grown. I think I've learnt more about science itself, science experiments, and just a little bit on how to explain science. I probably need more interactions with children to actually build my confidence more with actually teaching it. (Journal entry)

The positive change in student confidence was attributed by students to a range of initiatives such as "hands-on" activities, more relevant content that was suited to elementary school, access to resources and also to several key components of the course's instructional strategy. For example, students singled out the collaborative learning and the authentic nature of the assignment for comment. In one focus group, a student described her experience with group work: "it's all group work, you know, everybody bounces everything off each other and, the assignment that we've done sort of helped how you'd work with your peer."

Another student provided more detailed reflections:

> I'd have to agree I think that, for my own self-confidence and what I feel my, what I think I will be capable of, has grown. I never thought that I would ever look forward to teaching science, or be capable of writing an entire science unit, and I did find that doing the assignment together that did help because, that group work, because I had a lack of confidence with science itself I found that doing that project, because it was such a huge assignment, but it was yet so useful, but it did need the work of two people I felt. (Focus group session)

The instances described above are representative of the views of students expressed in the data. Other students in the focus groups made similar comments about the greater understanding of content, the authenticity of the assignment and how it contributed to a sense of social learning, and the effect of collaborative learning strategies such as different group structures using jigsaw and think-pair-share techniques.

We argue that a number of factors associated with these strategies orient students towards greater motivation in a number of ways. The social nature of collaborative work addresses social goals, which include beliefs about achieving well among peers (Urdan & Maehr, 1995). As students were also encouraged to explore their own misconceptions and, in a risk-free environment, share these beliefs they came to recognize that others also held similar beliefs and misconceptions about science. This revelation appeared to reassure them that they were not alone in their anxiety about science. The acknowledgment of basic tenets of constructivism such as recognition of prior experiences, active engagement with challenging tasks scaffolded by knowledgeable peers and instructors was critical in establishing a student-centered environment. In this context, the instructors supported learning using strategies such as *modelling*, *coaching*, and *scaffolding* all of which are central to the *cognitive apprenticeship* model articulated by Collins, Brown and Newman (1989).

When confidence was discussed in the focus sessions, a number of qualifiers and issues arose. It was evident from the qualitative and quantitative data that the confidence of most students increased during the course, although many identified a number of constraints. Working with peers in a workshop situation presented opportunities to explore and explain ideas but many were unsure that they could do the same when confronted with a class of children. In addition, knowledge of content was a common but not exclusive concern, especially if implementing activities that do not apparently work as Kelley mused: "what will we do now it hasn't worked? (If I) just discuss why it didn't work and the kids'll say, we don't know and then I'm stuck again."

In contrast, others indicated that they were prepared to capitalize on such events, or review content themselves, believing that they could cope by knowing effective pedagogical strategies: Indeed, those who had taught science already on practice teaching experience expressed greater confidence in their ability to implement effective science programs.

> I felt that I got a lot of things of how to teach, the fact that, like I said before, the content is easy to look up, but for myself, seeing different strategies and thing like that, took that pressure off, because if you can organize your classroom you're half way there, if you can get them all in the one spot listening to what you're doing and thinking that they're having fun well, you know just throw any content at them and it'll, you know, it'll get there.

The concept of fun played an important role in changing confidence. There was a common acknowledgment that unless it was fun it was not worth teaching. Indeed one student in a focus session was adamant about the intent to set up an enjoyable experience in science: "Oh, mate! when I get out there and teach it look out, they're going to be having a ball!"

The students also reflected on how the activities in the workshops were challenging but also fun. The challenge for one student was completing all the set tasks in each workshop, yet that student found it "really fun, enjoyable, you could sit there, you could talk (about the experiment.)" This notion of fun is critical to motivation in that it enhances the affective component and heightens the experience of success (Ford, 1992). Ford argues that the "emotion of satisfaction-pleasure-joy evolved to help motivate people to continue to behavior episodes in which they are making progress toward their goals" (p. 148). Moods or emotions may be beneficial to task commitment and a sense of happiness, pleasure, satisfaction and safety during the workshops develops an association of these feelings with the particular endeavors, namely learning to teach science.

The same student also described the important role that the tutor played in scaffolding the group's interaction and learning by probing questioning and reinforcement. The strategies used by the tutor were subsequently made evident to the students in debriefing sessions held at the conclusion of each workshop. In this way, students came to see the tutors as modeling practices that would be important for the students to use themselves in their future teaching.

The Assignment as a Focus for Learning

The assignment was designed with principles of problem based learning in mind, in which real life professional practices of diagnosis, planning and teaching were simulated. The task involved working with a child to identify his or her understandings of a concept and then to develop a program to teach that concept to the child. As students worked in groups on the problem they were expected to develop collaborative problem solving strategies. The lectures and workshops provided theoretical and practical support for the students to work in their own time on the assignment. Several students affirmed the effectiveness of this process, exemplified by one student's statement:

> Well in some ways I really appreciate the ideas of cooperative learning and collaboration, you know, sharing ideas and, bringing science down to everyone's level so it's not a scare thing, you know, but on the other hand, I feel confident to teach astronomy now and nothing else, because that was what I did in my assignment.

In a problem-based-learning approach, the students are in control because they must identify the knowledge required to solve a problem, learn that knowledge and apply it to the problem (Baud & Feletti, 1998).

Reflection

The reflective journal provided students with many opportunities to regularly record thoughts and reflections about the course and their own learning. Specific instruction was given early in the semester on the strategy of maintaining a reflective diary. Student reaction to the journal identified two issues.

First, keeping a journal that would be used for assessment was problematic but was acknowledged as a worthwhile strategy in their own practice to monitor children's thinking. For example one student who expressed concern about having to write the journal acknowledged:

> I think, personally, I think the journal is an excellent idea for kids to learn. … -cos they get to reflect on their ideas and you know, see what they understand. You can actually read what they've written, you can sort of see their understanding, or their conceptual understanding of it.

Some amelioration of this conflict between reflection and assessment was needed. Clear written instructions about the structure and purpose of the journal, reiterated several times during the semester, placated concern about assessment as noted by another student:

> I'm not normally a supporter of journals because I think, because it was in black and white at the front of the workshop manual, and it said write to yourself, write personally, write what you think then, I felt so much more at ease, there wasn't the pressure to live up to someone else's idiosyncratic expectations.

Second, others acknowledged the metacognitive value of the journal believing that this aspect helped them to understand course content. Although many saw the keeping of journals as tiresome, the quality of journal writing revealed deep thinking about the content and instructional strategies adopted in the course and about the students' learning. These reactions are consistent with research that identifies an explicit connection between reflection, self-awareness and deep learning and the cathartic effect on reducing anxiety (Mortimer, 1998).

Goal Setting

Although most students in the focus groups or interviews expressed increased confidence in their perceived ability to teach science, some remained extremely anxious about having to teach it. For example, Kelley (a large change in pre to post PSTE, 30-51) presented a particularly interesting case, which is expressed in the following vignette compiled from her journal and input into a focus group session.

Kelley's lack confidence of in herself as a science teacher was attributed by her to rejection by her elementary grade 7 teacher. Although she studied science in high school, she was not a successful student. She avoided taking some responsibility for tasks in science allowing firstly her father, then her boyfriend, to take the initiative in completing the tasks. She said she was able to learn to teach science but says she does not like science. However, she recognized good science teaching and wanted to ensure that her students would have the opportunity to learn science and to enjoy the experiences. She talked often about active understanding underpinning her teaching. She would employ strategies she learnt in the Science Education course, such as collaborative learning, to ensure that children could learn from each other. She was keen to involve the students in inquiry science but expressed concern that if she did that she would not be able to answer their questions. Thus, when the crunch came she stated a preference not to teach science herself.

A strong feature of Kelley's approach to learning evident in the vignette was her explicit goal direction of ensuring that her students would have the opportunity to learn science. She exhibited a strong sense of where her strengths lay and what strategies she needed to adopt to be a successful teacher. Kelley's concern about her teaching science was intrinsically motivated. Although she was personally not interested in science she *valued* science and had set a personal goal because she believed that knowledge of science is important socially. She felt obligated to teach it well, or to ensure that her children would receive the opportunity to learn science. The quantitative data provided a further indication of her changed sense of self-efficacy. While remaining apprehensive and not enamoured by science, her experiences provided the basis for a major shift in her personal sense of agency. Her Personal Science Teaching Efficacy score on the STEBI-B instrument changed from 31 to 51 – an effect size of four. The change in PSTE indicates an enhanced expectancy that she would be able to cope with teaching science and she testified that participating in the Science Education course provided successful experiences and positive feedback for her. In one respect, this augurs well for her future teaching career involving science. Some of the beginning teachers explored in a previous study showed a similar commitment to teaching science while not necessarily having initial positive attitudes to science (Ginns & Watters, 1999).

Kelley's statement about her commitment to teach science was representative of the views of many other students. Most were more positive than Kelley was in that they expressed an overt desire to teach science. However, when confronted with her own class, it appears that Kelley may accept the challenge of science teaching, in spite of expressed doubts noted in her vignette.

Discussion

This study builds upon previous research that suggested a number of key assertions about the willingness of students to engage in the learning of science. In previous research, five factors emerged as being associated with a student's sense of self-efficacy in teaching science (Watters & Ginns, 1995). Students' science teaching self-efficacy was enhanced in situations where first, their previous experiences in school science were positive and teachers provided recognition of students' interests in science. Second, when learning science was fun, interesting, and enjoyable, the experience provided intrinsic rewards and positive feedback. Third, self-efficacy was enhanced when opportunities were provided for discussion and interaction, which promoted the maintenance or improvement of self-efficacy and provided an environment where risk taking was encouraged. Forth, it was also evident that students were driven by both internal and external motivation. A desire to finish the preservice program and graduate was a powerful motivator that in some instances outweighed feelings of anxiety about science. Finally, direct experience with teaching children science in field experience sessions enhanced students' outcome expectancy for the teaching of science.

This study has provided further evidence in support of those assertions. Motivation in terms of expectancy, value, and affect were enhanced through the instructional strategies used in the science education course. The students' perceptions of the value and importance of science was improved, their expectancy to be able to cope – science teaching self-efficacy – increased and they were able to experience success, enjoyment and fun through the activities.

The important finding is that the adoption of course design features that focus on student centered instructional strategies of the kind described has changed students' beliefs about their ability to teach science. Students acknowledged that learning occurred during the implementation of a number of specific strategies such as engaging in authentic problems, collaborative group work, and reflective journals. A commitment to learning and improved understanding was evident in the reflections of students. The modeling of strategies by tutors in the workshops, the problem based nature of the assignment and the interactions with peers in workshops were acknowledged as valued experiences. The assignment demonstrated the importance of probing a child's knowledge base and, as acknowledged by the students, this made them aware of their own basic understandings as well as a need for this strategy in their own practice.

Huinker and Madison (1997) have reported positive changes in preservice elementary teachers' changes in science teaching self-efficacy as a result of engagement in science and mathematics methods courses. They attributed the changes to positive experiences as learners of mathematics and science, a subtle but pervasive emphasis on verbal persuasion, and authentic fieldwork experiences during the course. The exact nature of the positive experiences and verbal persuasion was not examined in depth by these authors. The provision of authentic fieldwork experiences as an integral component of science method and curriculum courses in order to raise science teaching self-efficacy has been explored elsewhere by Ginns and Watters (1999).

Journal writing provided opportunities for students to engage in reflection about their learning. Although many felt this a chore, as time progressed they came to value the task for the insights it gave them about their growing understanding of the course content. The main issue to emerge from the study was the impact of the course on enhancing motivation. While changes in some students may have been moderate, in all cases students indicated a preparedness to implement science programs in schools. Underpinning this enhanced motivation was a revision of their view of science in that a more learner centered, inquiry based approach was valued along with an acceptance of the tentative nature of scientific knowledge.

Within the context of a course with an enrolment in excess of 160 students, the capacity to develop flexible delivery processes that matched individual learning preferences was problematic. However, flexibility was provided within tasks and workshops. Students acknowledged, in working on the assignment with different children, that they became more sensitized to the variations in individual children's knowledge, understanding and capabilities. Finally, the social environment facilitated discussion and debate. The workshops were structured around groups in which students were free to elaborate their ideas while receiving support from tutors. This risk-free environment provided the basis for developing a convivial social context. Developing discursive practices that engaged all learners in sharing, questioning, reflecting on and challenging ideas and to move from authoritative to facilitative discourse played a major role in the instructional strategies.

Stevens and Wenner (1996) have shown that preservice teachers doubt their ability to teach science effectively. In addition, many experienced teachers consider themselves to be ill equipped to teach science (e.g. Abell & Roth, 1991). Elementary and high school science experiences appear to be the antecedent reasons for the development of such beliefs and attitudes (deLaat & Watters, 1995; Huinker & Madison, 1997; Watters & Ginns, 1995). Our research provides further evidence that student-centered instructional strategies that address the dimensions of meaningful learning, and motivation and affect can change preservice teachers' beliefs about their ability to teach science.

Conclusion

This study has been undertaken in a climate of radical curriculum reform in Australia which parallels reform elsewhere (National Research Council, 1996; Rutherford & Algren, 1989). Most of these students will enter a profession confronted by a new suite of syllabuses that endorse concepts such as life-long learning, outcomes based education and a futures-oriented perspective. Science education has been endorsed as a key learning area necessary to equip students to be effective citizens of tomorrow. Teachers will be required to teach science in ways that develop interest and positive dispositions in students. Student teachers therefore need to experience effective and fun science education programs that encourage them to value science and the teaching of science. Thus, the primary objective in the instructional strategies of this course was to model for preservice teachers a culture of learning involving discourse in a risk-free, enjoyable environment in which they could experience success. The teaching focussed on supporting discussion, debate, argumentation, and exploration of authentic and meaningful problems. However, in a collaborative learning environment in which a disposition to lifelong learning is to be facilitated implies certain responsibilities for the students. Students have to accept responsibility for learning, develop collaborative orientation, and acknowledge learning involves collegiality. They need to have the confidence to challenge assertions, to seek justification and warrants for arguments and to appropriate discursive practices that allow for negotiation of meaning. There needs to be a will to contribute, co-operate, develop curiosity, and to seek support when needed and share experiences with teacher and peers.

Establishing an environment for life-long learning requires a deliberate communication and reinforcement of instructional strategies to students to afford them the sense of empowerment to be active contributors and proactive seekers of knowledge, hence becoming life-long learners with an awareness of themselves as creative problem solvers. Development of preservice teachers' learning of teaching by enhancing motivation and affect through the instructional strategies used in this study can provide them with the ability to "risk take" in teaching in a society where there is rapid technological change and consequently respond to professional uncertainty. Enhanced beliefs can enable teachers to cope better with entrenched practices and cultures that are resistant to change.

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