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ABSTRACT

This paper reports on a longitudinal case study of an elementary teacher during her transition from preservice to inservice teaching. Bandura's (1995) concept of self-efficacy belief is used as a framework for presenting the findings of the study. The subject's experiences in science teaching provided information about her competency as a teacher, and her experiences had both positive and negative effects on her concept of self-efficacy. (Contains 23 references.) (WRM)

TEACHER INDUCTION AND ELEMENTARY SCIENCE TEACHING: FROM DREAMS TO REALITY

Paper presented at the Annual meeting of
National Association of Research in Science Teaching
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ABSTRACT

This paper reports on a longitudinal case study of an elementary teacher, Katie, during her transition from preservice to inservice teaching. The concept of self efficacy belief (Bandura, 1995) is used as a framework for presenting the findings of the study. Self-efficacy beliefs are constructed from four main sources of information, *enactive mastery experiences* that serve as indicators of capability, *vicarious experiences* that alter efficacy beliefs through transmission of competencies and comparison with the attainments of others, *verbal persuasion* and allied types of social influences that one possesses certain capabilities and *physiological and affective* states from which people partly judge their capableness, strength and vulnerability to dysfunction (Bandura, 1995). Katie's experiences in science teaching can be seen as belonging to one of the four categories described by Bandura and providing her with information about her competency as a teacher. Her experiences had both positive and negative effects on her concept of self-efficacy.

INTRODUCTION

The participant in this study, Katie, was a preservice elementary teacher who was enrolled in a three-year Bachelor of Teaching degree at an Australian university. During the second year of this degree preservice teachers studied two units of science education, one in each semester. At the end of each semester they completed a four-week field experience in an assigned elementary school. It was usual for them to teach science during this time. In the final year of the degree there were no science subjects but preservice teachers taught science units to children in the field experience blocks at the end of each semester. Katie showed a keen interest in elementary science, was invited to join an ongoing longitudinal study at the end of 1994. She began her first year of full time inservice teaching in 1995. During this year Judith, a teacher educator from the university and the second author of this paper, visited Katie's classroom to observe elementary science lessons and to interview Katie about her teaching.

PERSPECTIVES

Elementary teachers' attitudes towards science and their confidence to teach it, have for some time been identified as important in determining both the quality and quantity of science taught to children (Schoeneberger & Russell, 1986). The experience of teaching science is a powerful influence on a teacher's confidence and perception of competence and determines the extent to which the teacher will persevere with science teaching (Strawitz & Malone, 1986; West, Watson, Thomas & Parke, 1993). Unfortunately, many practicing elementary teachers have difficulty with science and avoid teaching it, so that during school placements preservice teachers are rarely exposed to good role models in science teaching (Fulton, Gates & Krockover, 1980; Grindrod, Klindworth, Martin & Tytler, 1991; Skamp, 1995).

Researchers stress the importance of the early influences on science teaching that are derived from field experience. Constraints such as time to teach science, related to the low status of science in the elementary school (Fulton, Gates & Krockover, 1980), lack of resources, management problems and lack of science content knowledge which are identified by practising teachers, also limit science teaching for preservice teachers (Abell & Roth, 1992; Grindrod, Klindworth, Martin & Tytler, 1991). The impact of the supervising teacher in whose classroom field experience takes place has been highlighted (Skamp, 1995; Sullivan, 1995; Sunal, 1980). Teachers who do not usually teach science themselves need to be open to new ideas and methods and supportive of having these ideas and methods introduced into their classrooms (Sullivan, 1996). Competition for grades and incomplete understanding of pedagogy inhibit preservice teachers from implementing good teaching practice in science (Sullivan, 1996). Expectations of co-operating teachers and university supervisors who were perceived to dislike group work and to value accountability in the form of worksheets and tests, inhibits teachers during field experience (Abell & Roth, 1992). These findings support the assertion

that the social influence of others is important in the formation of attitudes toward science and teaching science (Shrigley, Koballa & Simpson, 1988). However, preservice teachers who are enthusiastic about teaching science seem better able to persist with group work and hands-on activity (Abell & Roth, 1992) despite difficulties encountered. Preservice teachers can be assisted in overcoming many constraints if teacher educators help in the preparation of science units to be implemented in schools (Henderson, 1992; Peterson & Treagust, 1992; Skamp, 1995).

On graduation, the novice teacher may be confronted with constraints to science teaching, including a school culture, negative or apathetic toward science, her own barely adequate knowledge of science content and pedagogy (Abell & Roth, 1992; Grindrod, Klindworth, Martin & Tytler, 1991), and the sometimes overwhelming experience of induction into the teaching profession (Veenman, 1984). Little research seems to have been conducted on elementary science teaching during initial years of employment. Rust (1994) found that one of the teachers selected for case study was assigned to teach science to a whole year level and had difficulty developing as a teacher. The participant was not in her own classroom long enough to build rapport with the class, she also met opposition to hands-on investigation in science which parents saw as lacking rigor. Fernandez and Ritchie (1992) undertook a year-long study of beginning elementary teachers enthusiastic and committed to the *Interactive Teaching* (IT) approach to science. During the year the teachers changed their method of science teaching to some extent but retained their child-centred beliefs. By the end of the year the teachers set their own goals in science teaching and used some aspects of more formal conventional methods. The researchers suggest that these teachers had strong beliefs about and commitment to, the teaching strategies they were implementing, however, they needed considerable support from others, particularly in the form of materials and interaction with university staff.

Similarly, Enochs and Riggs (1990) suggest that teacher belief systems could be important in contributing to the state of elementary science teaching. Two types of belief seem important, belief that student learning can be influenced by effective teaching (outcome expectancy beliefs) and confidence or belief in one's own teaching ability or self-efficacy (Gibson & Dembo, 1984). This paper uses the concept of self-efficacy belief (Bandura, 1995) to explain the impact of science teaching experience and of significant others on the development of a beginning teacher in the contrasting contexts of university and school.

METHODS

Qualitative research methods were used in order to make sense of the complex world of teaching and teacher education. During the study the Judith, the second author, worked with a beginning teacher in an attempt to better understand practice (Connelly & Clandinin, 1986) and drew on her own experiences, knowledge and theoretical dispositions, to collect and analyse data (Glesne & Peshkin, 1992). The particular interpretative paradigm adopted in this study is constructivist-interpretative with case study as its orchestrating perspective. The study consisted of two phases, a preservice phase and an inservice phase. A variety of data sources were used in the preservice phase of the study, including journals, audio-tapes of interviews and a science background information questionnaire. During the preservice phase, Katie, the beginning teacher, kept a reflective journal to document her progress as a science student in the first science education unit in semester one 1993. In the journal, Katie was asked to discuss topics of importance to her as a learner and a teacher of science. A semi-structured interview was held at the end of final year of the Bachelor of Teaching in 1994 to document experiences of science teaching that occurred later in the preservice phase of the study. During the inservice phase of the study, Katie kept a written journal during school terms one and two of 1995. An unstructured interview was held after the first six months of teaching. Classroom observations followed by interviews occurred in the second half of the initial year of employment. Audio-tape was be used to record classroom interactions and the subsequent interviews. Judith also made field notes. A process of analytic induction described by Erickson (1986) was used to analyse data from observational notes and interview transcripts. Data sources were read and events, episodes and transactions marked when they represent instances of phenomena of interest. Open coding (Strauss & Corbin, 1990) was used in developing categories into which data could be organised. Analysis was ongoing so that initial

interpretations were shared with Katie and altered if necessary. After the final phase of analysis, Katie read and commented on a completed case study describing her experiences.

The concept of self efficacy belief (Bandura, 1995) is used as a framework for presenting the findings of the study. Self-efficacy beliefs are constructed from four main sources of information, *enactive mastery experiences* that serve as indicators of capability, *vicarious experiences* that alter efficacy beliefs through transmission of competencies and comparison with the attainments of others, *verbal persuasion* and allied types of social influences that one possesses certain capabilities and *physiological and affective* states from which people partly judge their capableness, strength and vulnerability to dysfunction (Bandura, 1995). Katie's experiences in science teaching can be seen as belonging to one of these four categories and providing her with information about her competency as a teacher. Other terms for belief system used in this paper, outcome expectancy beliefs, teaching self-efficacy (Gibson & Dembo, 1984) and science teaching efficacy (Enochs & Riggs, 1990) are derived from Badura's earlier (1982) work on self-efficacy theory.

FINDINGS

Preservice science teaching

Katie did not see any of her co-operating teachers teach science while she was a preservice teacher. It seemed to her that teachers only taught science topics they were comfortable with and that science was not an integral part of the curriculum in any of her four field experience schools.

> No. ...I never saw one modelled. They showed me the list, they pulled out the Sourcebook and said "We've done a bit of this and a bit on this. What would you like to do?"...So I just chose something that I thought would be good and they didn't mind. ...actually all the teachers I've had have said, "We don't do science very much."...The first thing they've said "We've only done a bit on this. I like *Space* and I like *Life*. I haven't done anything else". Every prac. there was always the same things left like *Energy* and things like that. *Space* was always done.... That just seems to be the one that's always being done. By the time you get there they always leave you with what they haven't done which is usually what they don't really like.
>
> (Interview 1-12-94)

Katie told the story of her first science teaching experience in her journal. She identified management as an issue.

> I'd like to use this journal entry to comment on management in my Science lesson presented yesterday.... I arranged the children into four groups to look at the inside of a hen's egg. I did not pre-empt the group situation becoming difficult to monitor and as a result the children misbehaved. The classroom situation is unlike the university where there are large group desks. I was unable to supervise all the children at the same time as there were two groups on the floor at the back of the room and two groups at the front. When I was assisting one group the other groups were out of eye sight and were off task.... In the conclusion I took the children outside and sat them in a circle... I discovered that a change of environment and a circular class group does work for control in the Science lesson. This however contradicts an important objective of science in the elementary school, "hands-on". I found that as soon as the children were in their groups doing "hands-on" investigating with the egg they were difficult to control and monitor. The noise was exceedingly high and the children were mucking around.
>
> (Journal 24 April 1993)

When Katie's teacher suggested a teacher demonstration with pupil assistance Katie was pleased with the improvement in the children's behaviour but disappointed that all of the children did not have hands-on experience. She got the opportunity to repeat this lesson at the end of the following year. She identified her previous experience with the lesson and her knowledge of the children as important contributors to her success on this occasion.

> I did the same lesson as in the first prac,... there was a different group of kids so that they were much better at working with each other and plus it was the end of the year so they knew each

other. And they were all ready in groups of desks. I moved them into groups the day before. I didn't want anything to go wrong. But the groups were made of one troublemaker-one kid that might muck up surrounded but three that wouldn't. So I put them in groups like that. It did work because none of them threw egg or whatever like last time. Egg-rolling was done outside in the whole group....You sort of anticipate what they're going to do, no touching the egg, leave it in the middle, don't shake it around. Make sure everyone has the chance to look. Any problems, put your hand up. Don't go wandering around, you might knock over someone else's table. Just little things that happened last time. When it's on the floor and people were stepping over it and pushing others to get to have a look. It was just horrendous. Much easier when you knew the classes well.

(Interview 1 December 1994)

When Katie chose a unit on *Chemical Change* for a Year 7 class in another field placement, the supervising teacher split the class of twenty into two and took half herself while Katie taught science to the remainder. Katie did most of the lessons as teacher demonstration, combined with individual student participation. This management strategy was appropriate for both Katie's teaching experience and the limited amount of equipment available, much of which had to be borrowed from the university. When management problems were minimised Katie enjoyed the children's enthusiasm and interest. The result was a very positive experience for Katie, as a consequence of which she elected to do an investigation of children's attitudes to science as her project in her final year at university

And I took ten around the desk, and we did all the chemical change and they had their own booklet and things like that and it worked very well with ten. The topic that things happened, things changed, even if its only the light bulb going on, or bubbles around the copper. They really liked to see something happen..... That's what made me do that research assignment on science in the upper elementary, because those kids said to me, "Well, what subject is this in high school. How can we do more of this? What do we do?" And I said "Well this is chemistry...but you'll probably have it in bits and pieces in junior high school." And that really surprised me, well it didn't surprise me I suppose, because I was the same. But when they were exposed to it they asked lots of questions about it. I brought along a grade nine science book because I had got some information out of that on chemical change. I said, "We were just doing a bit of grade nine work." And they went, "Oh, were we? Wow." And I said, "Everyone should be interested in science. Don't be frightened of it. ..."I was saying to them what should have been said to me, you know, don't be frightened of it.

(Interview 1 December 1994)

A major constraint to effective science teaching during field experience while at university was the lack of role models. The participant, Katie, did not see experienced teachers taking science classes and was thus deprived of an important source of efficacy belief namely vicarious experience (Bandura, 1995) and seemed to learn to teach science by trial and error. In her first field placement she had difficulty obtaining and managing manipulatives in the classroom, she was unable to anticipate the behaviour of children and had problems supervising when children worked in groups. She was able to overcome some of these problems during subsequent attempts at teaching science which provided her with the important enactive mastery experiences (Bandura, 1995). For example, a science unit during which she taught half the class at a time was particularly satisfying. Management of children's behaviour and manipulatives was much easier and Katie felt rewarded by the children's interest in the topic. She also taught for the second time the science unit that had given her difficulty during her first field experience. On this second occasion the unit was successful and provided a mastery experience helping Katie to appreciate the advantages of being able to anticipate problems. The enthusiasm of children during science lessons acted as a form of social persuasion (Bandura, 1995) which strengthened Katie's science teaching efficacy beliefs (Enochs & Riggs, 1990). Katie began to believe that teaching science at elementary school was a way of helping children develop confidence in their ability to learn science that would assist them to avoid some of the negative experiences of science that Katie herself had had at high school. Katie chose children's attitudes toward science as her research project topic during her final preservice year, and at the end of her Bachelor of Teaching degree, ranked science teaching as one of three preferred teaching subjects.

Katie was one of the first of the newly graduating students to be offered a permanent teaching position. The school to which she was appointed is located in a town situated in a "growth area" on the east-coast of Australia. She was able to visit the school at the end of 1994 to find out which class she would be teaching and to collect resources. Katie was assigned one of three year six classes and during the holidays began to plan her science program from the state science Sourcebooks. However, when she returned to school in January 1995, for the pupil-free days before the first school term, she discovered that the school was changing from the Sourcebook-based science curriculum to a new curriculum, *Primary Investigations* recently produced by the Australian Academy of Science. This curriculum emphasises co-operative learning and in many lessons children are organised into groups of three to carry out investigations. Katie described how the inservice in the new curriculum increased her anxiety about coping with her first teaching position. Although she was aware of the necessity to teach co-operative learning skills to the children, she had great difficulty with this in the first school term.

> We went last year in November or late November to the school and found out you had the jobs, they gave you a basket full of books and the Sourcebook was in there. So in the holidays I was looking through the Sourcebook, thinking what I'd like to do and I chose one unit that I had done on the prac. that worked well and it was fairly tame with regards to materials and that so I though well I would start off with that, that will be a nice one to ease into. ... but then we got back on the three inservice days the week before and they gave us the new book and that threw me, ...I thought I had it all planned and we had one of our first inservice days then but I think it was the whole bit starting a new school as well, starting with the job and all inservice, ... it would be Monday night panic stations (*the inservice sessions were held on a Monday night)* because you would think all the things they talk about you have to be on top of them but you don't you know... we have to know what they are talking about. It threw me a bit because I thought oh no I have got to start all over again. ... I was planning to do co-operative learning the first term but I found they couldn't, I couldn't, it just didn't eventuate in the first term. ...I think it was the wrong time for me to do it because you know my head was in spin with everything else from school so, you really had to teach it (*co-operative learning*) before you can expect them (*the children*) to do the groups.
>
> (Interview, 27 June 1995)

Katie and Margaret, who had another year six class at the school, decided not to begin their *Primary Investigations* book at unit one, *Introducing Energy*. They were both concerned about being able to manage the children's behaviour if materials, described in the teachers' book, were available in the classroom. They selected instead, the unit *Design and Efficiency* as the materials looked simple and there did not seem to be much content to understand. Katie described the reaction of the more experienced year six teachers, whom she met during the inservice program, to an introductory lesson "*Liquid Layers*". This lesson was a *team game,* designed to help the children practice team roles before the year's Science concepts were developed.

> ... we went to that seminar and we saw them all (*the lessons in the first unit)*. The other grade six teachers their mouths just about dropped open, "what!" they said "can you imagine coloured water, rubber bands, straws and water in the same room." You could picture all these things happening in the first few weeks and I just sort of felt I couldn't afford to lose them (*the children)*. Not that I it mightn't of been the case anyway but that's how I felt.
>
> (Interview27 June 1995)

Katie eventually did this lesson as a teacher demonstration.

> I know this is against the co-operative learning model of *Primary investigations*, but the tone of my class did not lend itself to group work just yet! Also food colouring and straws were difficult to organise. The children were very interested and excited, it was probably the most interesting lesson I'd done! We pushed the desks back and they sat on the floor with their books to record results. I think the lesson went OK, as I still had relative control. I know that future group lesson will have to have noise and disruptions.
>
> (Journal week three first term 1995)

When Katie began the chosen unit, children had difficulty working in groups. Staying on task and even working with their own team proved challenging.

> In the groups the children designed a balloon powered car and then built it. Once again there were arguments in groups and not many children stayed in their groups. Wandering around the room occurred a lot. One afternoon was not enough for the children to complete their cars. There were a few "break away" factions designing their own cars and some children were distracted with the materials. (I had rubber band flicking and paddle pop stick knives for days)!!! Their enthusiasm was high, however I still feel their ability to work in groups is poor. In the presentation only one group managed to fulfils the requirements. How do you get children to get along and share? (A habit of eleven years is had to break).
>
> (Journal week four first term 1995)

The design of extra-curricular objects caused Katie some concern, and she began to doubt the wisdom of having a lot of materials in the classroom. Problems with rubber bands, match sticks and paddle pop sticks occurred for up to two weeks after the initial design lesson.

> The equipment and making out of paddle pop sticks knives, they were sharpening it to a point and joining to the rubber bands it was quite interesting how they did it and so it would flick up as a little sort of knife, even during the science lesson they were making these things and I had a whole box full of confiscate, I couldn't throw them out at the school bin I had to wait until I got home to do it or they would just go and get them, was just a lot of extra hassle when they had all this material. ....it ended up the next two weeks after that we had paddle pop sticks and rubber bands and match sticks flicking all across the room all the time like every time you turn your back to the back wall, ... calling out you know so and so's flicking me.
>
> (Interview 27 June 1995)

Katie identified the key to *Primary investigations* as the co-operation in groups but at this stage it was a problem to her and not a strength. She attributed the children's' behaviour in part to their lack of experience of group work and also to her own newness. She was aware of the children's obvious enjoyment, mentioning that some continued to design at home and bring new ideas and models to school. She was also aware of her own reluctance to teach Science under the prevailing conditions.

> I just think it was particularly difficult to do something to do a unit like this like *Primary investigations* with these type of kids you know in grade six, me there, first year, I just sort of felt that I couldn't do it all at once. I didn't know whether to choose or to concentrate on co-operative learning and really do that or just get the content across as quickly as possible and you know something like that. The teacher last year, until she retired end of last year,... was a very old lady. You could tell from day one they were just used to writing and sort of old fashioned type things not, when I wanted to do something different, they didn't know what was happening. Science was a bit different for them altogether, they did love it there wasn't one kid that didn't like science when we did it and I was the only one that shuddered when we did it. (Laughing)
>
> (Interview 27 June 1995)

On the whole, Katie was much happier with the unit of work she and Margaret chose for term two. She began to understand why teachers who had supervised her in field experience, had a preference for teaching *Space* topics. At this stage Katie began to teach science twice a week rather than only once. We concluded that Katie needed a degree of control in several areas of science teaching and that the Astronomy unit provided this is a number of ways. Firstly, the materials were easy to manage and the content could be easily accessed.

> I think most teachers enjoy Astronomy I know I did because the fact that it's stops two things that teachers are afraid of in science which is the messy experiments and the content. There is always enough content and information about astronomy there's hardly a question you can't answer but maybe not straight away but you can find out just go to the book and there's always enough information. ...and there's none of that pouring water into a beaker or whatever or making these little devices the only thing they made was the planisphere and the moon thing we'll have to make that soon, maybe when we get back, even that one looks pretty tame. ...It's got some good explanations in it the book for teachers. ...you don't want to appear in your first term that you can't answer a question to the kids and they sensed that I was young and new and so its probably a silly thing to think but you just don't want to appear not able to answer, not able to explain. (Interview, 27 June 1995)

Even in areas where Katie was confident about her own knowledge of the topic, she changed lessons so that they became more teacher-directed. Being in control helped her to feel more confident about what the children were learning.

> It did suggest you have a balloon and use that as the earth and torch and tennis ball for the moon and the sun. I sort of felt it would be easier to get the information across if I did it myself and just got different kids up to do it, we did it a few times, we drew a picture on the board. ... I felt that was easier than explaining it in groups. Time wise it was probably better but I know that it is not part of the whole *Primary investigations*
>
> (Journal: term two, *Our Sun and It's Planets*).

The need to control learning, made Katie reluctant to provide extension activity even though she realised it was needed.

> We only got through half this lesson as the children found it difficult to use their planisphere. There is a large difference in abilities in this class and this means that a handful of children finish early and there is four or five still not clear what to do. Giving them extra work only discourages these children and besides, I find it difficult to gather enough information and work for the lessons let alone extra work. I really think though, that having children on different activities is confusing (for me) and it tends to create noise. This may sound like a trivial excuse for not having extension work, (and it is), but the feeling of being in control and in command of every child's level of task is important to a beginning teacher like myself. I find it very unsettling moving from child to child who are on different activities.
>
> (Journal: term two, *Spinning in Space.*)

The transmissive style she used for a number of astronomy lessons made the children's behaviour easier to manage. Katie described these lessons as more like a maths lesson.

> As this unit progresses the experiments tend to get more and more like chalk and talk and less like group work. (Not that I'm concerned at all, but relieved). I showed a video on our solar system that I had from a Year six prac. The whole class were really engrossed by it. Even my worst ADD child pulled his head in from the window at the sound of how many earth's make up Saturn's volume. Afterwards we collated information the children had noted about each planet onto the backboard. Easy lesson: interest was there, class were in a " controllable" position, information, learnt/absorbed was clear and evident. While this sounds like a recipe for success (or teacher sanity), I realise it is not part of the *Primary investigations* method of learning.
>
> (Journal: term two, *Our Sun and It's Planets*).

Katie planned her first science unit during the holidays before she began full-time teaching. She was upset when she went to school for the pupil-free days before term one, and found that these consisted of professional development for a new science program with which she was unfamiliar. The new program emphasised co-operative learning and hands-on investigative strategies. Special lessons were included in the program to give children practice with these ways of learning. Katie was influenced by some experienced teachers in her school who were anxious about giving children manipulatives and about teaching science that involved unfamiliar concepts. She taught the practice lesson as a teacher demonstration and chose to begin the year with a technology unit. During this unit she had difficulty with manipulatives and co-operative learning. Although she still believed in hands-on investigation in science she doubted her ability to teach in this fashion. Through what Bandura (1995) termed social persuasion, other teachers had negatively influenced Katie's efficacy beliefs and the ensuing experiences of science teaching seemed to further damage these beliefs. However, an incentive to continue with co-operative groups in science was the children's obvious enthusiasm for this style of learning, another form of social persuasion that helped to balance Katie's otherwise negative evaluation of her science teaching. When Katie began the second science unit on astronomy, she was relieved to find that the manipulatives were often simple pencil and paper devices and easier to manage than the materials need for construction during the technology unit. When the topic allowed, she changed group work to teacher demonstration even though she believed this to be

inappropriate. Katie enjoyed teaching this unit and was once again enthusiastic about teaching science. The astronomy unit can thus be seen as an important mastery experience for Katie.

Inservice science teaching: the last half of the year

During school terms three and four of 1995, Judith made a series of visits to Katie's classroom to observe science lessons and afterwards, to discuss the observations and the previous interviews. Katie's classroom was on the top of a double storied brick building. A wide covered veranda ran the length of the building providing shade for the classrooms on the upper and lower levels. A flight of stairs ran from directly outside her room to the ground level. At the beginning of term three, when Judith first visited, the children's desks were arranged in five clusters of six, with three such clusters at the front of the room and two at the back. Katie had decided on this arrangement in the hope of getting the children used to group work. Each desk cluster consisted of two science groups so that movement of science groups at the beginning of the lesson was not necessary. One boy who had had difficulty with group work was sitting alone on the veranda side of the room. Katie had displays of the children's art on the pin board at the back of the room. A set of class rules jointly written by Katie and the children were also on display. Three of the rules were concerned with unnecessary noise in the classroom and the other two with interaction between children.

After morning tea the children worked in four reading groups on different activities. One group was downstairs with a parent, one on the veranda and two in the classroom. Just before 11.30 Katie began to prepare for science. She wrote the lesson title *Jumping with Energy* on the board and under it the words, *Investigation: Can we find evidence of stored energy in a flic flac?* Children were instructed to get out their science exercise books and to write this down as they waited for the group from downstairs to return. A boy gave a *Primary Investigations* student book to each group of three. The children became a lot noisier than they had been in reading and Katie was obviously tense, as this extract from the audio tape shows.

Katie — Still waiting for some people. (Children becoming much quieter). Settle down. Get focused. ..Put your hand up if you don't have a badge, if you were in the reading group outside and you don't have a badge. (Katie hands badges to a few children, telling them their roles, director, speaker etc. class becomes noisy again). Excuse me grade 6 we are going to do a science lesson right now (voice raised), instead we are wasting time and other people in this classes time. (Children quite now). You should be on.. directors know which page we should be on, the second experiment jumping with energy. This is our question, (indicates question written on board), Can we find evidence of energy stored in a flick flac? OK look at what you need, instead of three of everything we'll only get one of everything, so you have one cardboard square, two because you need two to join it together, a pair of scissors, or a hole punch, I have two hole punchers, some groups have their own, I'd prefer that you use a hole punch rather than scissors, masking tape, I have one roll I'll come around and give you a little bit of masking tape each, one elastic band, one match stick. At the end of the lesson I want back one rubber band and one match stick.

(Observation 18 July 1995)

The fact that the children reading down stairs had come in late kept the class waiting and this contributed to the noise. Katie was very concerned about the materials used to make the flic flacs, and decided to allow only one flic flac to be made per group instead of three, as the book suggested. She was also afraid of having holes punched with scissors and so used a "hole punch" device. Unfortunately, there was only one of these in the classroom. Restriction of materials led to noise and frustration as the children waited to punch holes or use sticky tape. Flic-flacs are small and only one or two group members were involved in construction. The activity was designed so that everyone made a flic-flac. Comparison of flic-flacs then allows the children in the one group to see how to make modifications that enable the flic-flacs to jump higher. Katie had a whole class demonstration of the flic-flacs made by each group to achieve this comparison. The children lost interest as this took some time, and the class became noisy. In the discussion after the lesson Katie indicated that she was caught in a dilemma. On one hand she wanted the children occupied but on the other she wanted to restrict the amount of material in the room. She cut down on the number of flick flacks made, to cut down on noise and activity. However she allowed

complete construction of the flick flac, even though there were not enough hole-punchers, in order to keep the children busy. She seemed to be looking for a balance, sufficient activity to eliminate the noise caused by chatter if there is not enough to do, but not so much activity that noise and materials became too much for her to manage. After the demonstration of the flic flacs, Katie began the whole class discussion of energy change and transfer that is outlined in the *Primary Investigations* teachers' book. The class gave reasonable answers here although some children were evidently seeking attention by being silly. She sent one child out of the room.

In an interview a few weeks after this lesson Katie discussed her development as a teacher in some depth. She believed that she had made a lot of progress during 1995 and realised that her experiences would be of great assistance next year. Her image of gaining experience as "doing time" gave us an insight into just how difficult and painful her growth as a teacher had been.

> Yeah, well I suppose like when you do this whole year next year again you've done that lesson and you remember from last year that you, you know, you've got to tell them that before you start. So things like that well I wish you had it now but you can't you know. . That's exactly what I want, experience without actually doing the time.
>
> (Interview 9 August 1995)

Judith later asked Katie to elaborate on this idea. She explained some of the things she had learned while "doing time". One of the most important was allowing the children more freedom in the classroom.

> I think I was too, too concerned with being really quiet and being on task all the time every minute of the class time and not giving them a chance to have a break and talk and chat and then get back to it. I used to pull up everybody every second. And now you give the, well you don't worry so much unless they prolong their chat or prolong their little chat. ...So the control factor, I think, and one of the teachers said to me, ..."I thought that a good class meant being quiet and being controlled and under the teacher's thumb" and she said "I was wrong"..... She said "you've got to let them do their own thing sometimes you know".
>
> (Interview, 9 August 1995)

A difficult idea for Katie had been that some children had very different needs from others. This had initially offended against her idea of justice and was a bone of contention with other members of the class.

> I was thinking you don't, everyone is equal, you do the same thing. ...I sort of relaxed my feel a bit, the way I sort of controlled everybody, and I had to assess each kid differently. Like, with Ken getting uptight, or getting really fidgety and really angry, there's no point in me yelling at him saying you do your work now or we'll go somewhere else, because he'll just blow his top. ... someone sort of gave me that idea, the, the behaviour counsellor. He said, send them on a message. That's why we have buddy classes too so you can get them out of the room. And you give them a job.... So, or sometimes just a message like, take these books back to the library, empty the bin. Bins always got to be emptied. ...I used to think well why should I send them on a message. And a few kids have told me this recently. "How come you send the naughty kids on a message? We're good, we do all the things right and you never send us". And I think, oh, how do you, you know, how do you explain that?
>
> (Interview 9 August 1995)

Katie had had to accept a completely different set of rules for measuring success. She learned to have realistic expectations of children.

> I suppose it was changing my view of being able to master things. You know I would just, took up, say, the piano. I'd just keep practising till I got it right. When I got the song right I was happy. And so I was thinking if I hadn't got this right, so I'm not doing, I'm just doing something wrong. What am I doing, you know. And then after six months you realise that you're not doing anything wrong, you're just thinking, you're putting too much, sort of, putting too much into it for a start. You know, you're expecting too much of the kids. That they be good all the time.
>
> (Interview 9 August 1995)

At this point in the interview Katie said that university study did not prepare her for a situation in which she would have to achieve through others. The possible exception was the field experience. However she went on to say that this was in some ways unrealistic and did not fully prepare her for teaching her own class.

> ... But the pracs in a way were just satisfying the prac teacher type of thing and that's all. I mean there was some degree of everything else like controlling and interacting with the kids but for four weeks, you know, it wasn't really long enough to get anywhere but, it was very surface. Like we do surface things to get the kids on your side. Knowing in the long run that if I had a class of my own I could never do this, like give out the lollies or the tickets all the time to get them to listen but you're only there for.four weeks so you do things that will last for four weeks. Its a lot longer than four weeks when you're really in a classroom.
>
> (Interview 9 August 1995)

She had also found that she did not have the same amount of time to put into unit preparation if she was to benefit from being able to relax in the holiday periods.

> I remember my first Easter holiday, I spent the whole week just doing work. And I came back in term two and I was really tired and really cranky. And um, and the next holidays, I didn't do anything and I came back more refreshed. And I sort of did it during the nights for the first week, you know.
>
> (Interview 9 August 1995)

Katie had begun to overcome her tendency to focus on control and derive satisfaction from the children's learning.

> I keep thinking, imagine if I'd done this in term one it would be chaos for me and for them because ...if I don't have the kids sitting down and doing their work I'd feel like I'd lost control. ... where as now I think well if they are learning I don't mind the noise and the mess and that sort of stuff, but in term one I felt as if I had to be to have absolute control.
>
> (Interview 9 August 1995)

At the end of an interview in October, Judith was able to discuss Katie's intentions about the teaching science during the final term. Katie was planning to teach all the lessons in the next unit, except one on electricity. We were surprised at this as Katie's undergraduate science subjects had included a very thorough unit on electricity. Katie said however, that she doubted that the school would have the necessary equipment. Judith offered to lend her university equipment and she agreed to include the lesson in her unit and that this lesson would be observed on the next visit. We decided on a date about a month away, when a teacher aide would be in the classroom so that only half the class would do science at one time, and we would need only five sets of equipment. We assumed that when Judith came back Katie would have had time to complete the three science lessons that came before the one on electricity. We found out later that she had in fact skipped two of these in order to do electricity. End of year activities such as the school musical were a problem, and took the time usually allocated to science.

Katie began the lesson by sending half of the class to the library with the teacher aide. This caused some problems as Katie did not realise that the teacher librarian was absent that day and the children were not supposed to be in the library without a teacher even though the aide was present. The children who remained had already written the questions to be investigated in their science note books. Katie gave each group one of the kits. Each kit contained a cell, two wires, two torch bulbs and a selection of small items that could be tested to see whether or not they conducted electricity. The first task was to get the bulb to light using the battery and wires. When this task was complete the children were asked to draw a diagram showing the flow of energy in the circuit. Katie attempted to stop the group work here and have a class discussion of results. When the second group did the science activities Katie did not attempt this break. In the discussion she said,

> I didn't stop them half way. Because it didn't work the first time, I don't think anyway. I think they wanted to go on to the second half for the experiment and they were doing it already so I thought well instead of trying to stop them, trying to get the things out of their heads, I'd just let them go.
>
> (Interview 7 November 1995)

The uninterrupted lesson was much more successful. The fact that Katie had been able to so quickly solve a problem and see immediately that her solution was appropriate, was one of the rewards of using sections of the class for science and repeating activities. Both groups of children were very interested in the mornings' activities and tested many objects in the classroom as well as those in their kits. It was interesting to note that they were not able to list as many insulators as conductors at the end of the lesson. Seeing the light turn on may have prompted the children to take more notice of conductors. The children had carried out a number of investigations of their own. One group constructed a switch and Katie made a point of getting them to show it to the class. She emphasised their co-operation as a team and also praised the boy who had thought of the idea. She felt that this praise was important as he did not have good skills in other subjects.

The bell rang at this stage and the class collected their lunches. Katie was on playground duty but Judith walked around with her and discussed the lesson. She was very happy with the science lesson and nominated it as the best she had taught that year. She was also enthusiastic about continuing the unit. The children had enjoyed the lesson and carried out many tests of their own design. The small group in the room had helped to keep the noise level down and Katie was more tolerant during this lesson. She recognised that having a small group was beneficial but was not optimistic about being able to do this on a regular basis. She said she needed to check with the teacher/librarian as it was usual for the class teacher to accompany the children to the library. She also rejected the idea of having some children do science while the others had reading.

> I think it'd be too difficult because um, like they want to come in, they want to have a look what they're doing. They just can't stand the fact that they're doing something else and people are doing science or something fun. They don't seem to realise that they're going to be doing it soon anyway. ...Its more trouble that its worth.
>
> (Interview 9 August 1995)

Judith left the science equipment with Katie in the hope that the other year six teachers might have time to use it. Judith also left some books containing games that the children could make using simple circuits. Katie said during our final interview in December that no one else had made use of the equipment and that she herself had not taught science again after my last visit. She acknowledged that it was often difficult to find time to teach science, which needed a bigger block of time than other subjects. She was however, looking forward to teaching science again in 1996 and was to teach all the year 6 classes. We were be interested to know if this arrangement allowed more science to be taught or if Katie had to comply with the wishes of other teachers who did not have time to teach science.

Katie gained a great deal of experience in her first year and had the confidence to offer to teach all of the year six science in the new year. She had however, anticipated enjoying her science teaching right from the start.

> Oh yes, its still good but I just sort of dreamed it would be better. I don't know why. I always thought I'm going to get them interested in science and sort of not like what happened to me. You know, not that I wasn't interested, I just didn't think, if I can't do it why bother. And that's something I wish hadn't happened.
>
> (Interview 7 November 1995)

We received a short note from Katie half way through term one 1996. She described science as "going really well". She was teaching Astronomy as the first unit of the year.

> 1996 is going really well. I have 22 children, a new classroom and one year's experience behind me. I'm teaching science to all the year six classes (three a week) and we are starting with Astronomy. We've had the Brisbane Astronomical Society out for an evening with their telescopes, it was a big hit. Also, next Friday we're taking all the year six children to the Brisbane Planetarium.
>
> (Letter 19 March 1996)

Judith spoke to Katie at the end of 1996 as we were curious about her experiences as science specialist. She had been teaching all the year six classes, taking each group in rotation. She reported that she had enjoyed this and was able to attempt some of the lessons she had omitted the year before. The other two teachers took an English unit and a Mathematics unit respectively, also in each class in rotation, while Katie taught science. English and Mathematics were seen as important so that Science did have a regular time slot each week, protected as it were by key subjects. One draw back was that if a child were absent when his/her group was studying English he/she was often required to miss science and make up the English lesson. Katie was disappointed when this happened but because of the importance of English in the elementary school curriculum and her own status as junior teacher, felt unable to protest. A bonus of her role as science specialist was the extra time she now took to prepare science lessons. She said that teaching science for three hours each week, made extra effort in preparation worthwhile. Science, while still unimportant in the school as a whole, had become important to her and a larger slice of her teaching load.

In the second part of the year Katie again tried to use co-operative groups in science. Manipulatives remained a concern and she struggled to find a balance between controlling the amount of manipulative material available in the classroom and keeping children involved in the activities. Katie appeared to be actively seeking mastery experiences by constantly adjusting her approach to achieve what would seem to her like a successful lesson. At the same time, with the encouragement of some of the older teachers, she began to evaluate her success as a teacher in terms of children's learning rather than her control over the class. She began to understand that it was not realistic to expect on-task behaviour from children at all times. In this case social persuasion from other teachers was a positive influence and assisted Katie to reassess the ways in which she judged her performance. The other teachers had helped Katie to strengthen her efficacy beliefs by showing her how to reinterpret the efficacy information her teaching experiences provided. Katie found teaching more enjoyable once she relaxed and had time off during holidays instead of putting extra effort into planning. This can be interpreted as evidence of the importance of physiological and emotional states in judging personal capability (Bandura, 1995).

On one occasion a strategy, tried successfully during preservice teaching - of taking half the class at a time for science - provided a successful mastery experience. Katie was able to manage the use of manipulatives once fewer children were in the room and believed the lesson had been one of the most successful that year. However, Katie said that having only half the class at a time for science was too difficult to organise on a regular basis. An incentive to continue with science teaching was Katie's strong conviction that hands-on investigative science was worthwhile. She was also encouraged by various forms of social persuasion, the children's enjoyment of science lessons and the support gained from participating in this study, in terms of pressure to teach science, help with equipment and identification in the school as a science specialist. Although Katie's efficacy beliefs were at times decreased by teaching experiences and the effects of social persuasion, they were sufficiently strong to provide a motivation for her to persist with science teaching. During her second year of employment Katie was science teacher for the whole of her year level. She was very positive about this experience and was prepared to put extra time into preparation for science teaching once science accounted for three hours of her teaching load.

CONCLUSION

Achieving mastery experiences of science teaching seemed difficult but important for the beginning elementary teacher in this study. During preservice teaching the low status of science in elementary schools (Fulton, Gates & Krockover, 1980) and the inexperience of practicing teachers in this area of the curriculum (Fulton, Gates & Krockover, 1980; Grindrod, Klindworth, Martin & Tytler, 1991; Skamp, 1995) may account for the lack of vicarious experience and the absence of guidance in science teaching on some occasions during her field placements. However, when positive experiences occurred in the form of mastery experiences provided by successful lessons and social persuasion provided by children's enthusiasm, they were an important source of science teaching efficacy belief. In Katie's case mastery experience was achieved when she was better able to manage manipulatives

and children's behaviour in the classroom. Previous experience with an activity, knowledge of children and teacher demonstration assisted in this regard.

Once in the inservice situation, Katie's general lack of experience (Veenman, 1984) seemed to make science teaching more difficult than teaching some other subjects. Managing the behaviour of children who were interacting with other children and manipulative materials was especially difficult and Katie struggled to overcome these obstacles. Colleagues helped encourage the novice to be realistic in her expectations of children but held her back by sharing their own doubts and misunderstandings about science teaching. The children themselves provided disincentives to science teaching when their behaviour was exuberant but their obvious enjoyment of science and requests for more science lessons provided a pressure to continue science teaching. The social persuasion (Shrigley, Koballa & Simpson, 1988) provided by colleagues and pupils had both positive and negative effects on the efficacy beliefs of this beginning teacher. Like the teachers described in the research literature (Strawitz & Malone, 1986; West, Watson, Thomas & Parke, 1993), Katie appeared to find the experience of teaching science a powerful influence on her confidence and perception of competence. Her perseverant efforts seemed overall to assist her to build a resilient sense of efficacy (Bandura, 1995) and she accepted the position of Year six science teacher the following year. This increased importance of science in her personal teaching load renewed her enthusiasm for science and her willingness to put time and effort into preparation in this area.

In Katie's case study mastery experience and verbal and other forms of social persuasion were the major sources of influence on science teaching efficacy belief (Enochs & Riggs, 1990). There was little evidence of the availability of vicarious experience of science teaching in the elementary school, although high school and university experience may serve this purpose. Katie certainly came to the elementary school situation with strong beliefs about the importance of hands-on investigative science for her pupils. We decided that she did give one indication of the importance of psychological and affective state when she commented that she managed her class better and the children seemed to be calmer after a holiday break.

As teaching educators we believe that these findings have important implications for science education subjects at university and field placements during preservice degrees. Supporting student teachers in science teaching so that they have mastery experiences seems one of the most obvious implications. Ways to achieve this could be peer teaching at university and careful structuring of school based teaching experiences so that student teachers experience success in science classes. Katie's success with a lesson she had taught previously indicates that using peer teaching as practice for a lesson to be taught a school might be a helpful strategy. Letting a beginning teacher take half the class at a time for science also seems a useful suggestion. For Katie, this reduced the amount of manipulative material and assisted her to manage the classroom, while allowing her to have two attempts at teaching the lesson, thus increasing the opportunities for mastery. Experiences in science education subjects while at university may also be important sources of social persuasion and vicarious experience. It seems difficult for us as teacher educators to greatly modify sources of influence on self-efficacy belief in the inservice school situation. However, Katie's experiences convince us of the importance of assisting beginning elementary teachers to be successful in the science classroom. Once more elementary teachers are willing to include investigative science in their curriculum, schools would be enabled to provide vicarious experience and social persuasion that are a positive influence on the science teaching self-efficacy of the novice.

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