Setting the environment for life-long learning: Collaborative and authentic learning practices in primary science teacher 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 primary 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 primary preservice teachers in the third year of a four-year Bachelor of Education course studying science education. 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 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 provided a more detailed analysis of the changes in motivations and goals of individual student teachers. The paper explores how the experiences develop the confidence and will to teach science in primary school and how opportunities were provided that empowered the student teachers to be proactive seekers of knowledge – lifelong learners.

Background

While the future has always been uncertain, the rapid pace of technological change and the growth of knowledge over the last fifty years have added a new dimension to this uncertainty. Today's schoolchildren will be confronted with a future in which there is no guarantee of continued employment in one vocation. Indeed the nature of the workplace is changing so rapidly that new disciplines and enterprises new are emerging superseding traditional professions and industries. The conceptual knowledge acquired by children may be redundant by the time they reach adulthood. Being able to access information and use information in a productive and critical way will assume greater importance and become a minimal necessity for citizens of the future. Additionally, as adults they will need coping strategies that will help them negotiate the challenges of a social world and flourish in a democratic society (McCaslin, 1996). 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; West 1998). The development of this disposition will start with the educational environment that children are experiencing today. The key to providing this environment lies with individual teachers, their capacity to model enthusiasm for knowledge and scholarship and their commitment to life-long learning.

Changing nature of the teaching profession

The face of teaching is changing in a number of ways. Technology, globalisation, children's disillusionment with traditional beliefs and values, social inequities and the governance of education are impacting on the structures and practice of education. Knowledge of how children learn has also changed and with it there are greater demands on teachers to provide effective learning experiences. It is becoming clearer that educational reform and innovation will depend on the actions of individual teachers and schools (Fullan, 1993; Hargraves, 1994). Schools possess entrenched practices and individual cultures that are resistant to change and influence beginning teachers (Ginns & Watters, 1998). The induction years of teaching are problematic – survival, and professional identification place enormous stress on beginning teachers who are unlikely to challenge the existing quo. A domain of knowledge crucial to the future well being of a technological society is science.

Science education

Science education has a major role to play in the development of critical and informed citizens in a rapidly changing technological society. The implementation of new curricula and initiatives in science education to meet the challenge of the future has been a constant feature of the last decade. 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 are the actions and initiatives of classroom teachers. Teachers must be capable of responding effectively, not only to the changing nature of the profession, but also to the introduction of new curricular and initiatives in science education. Among these initiatives is a reconceptualisation of the purpose of science education and the role of educating children to become a scientifically literate, socially adept, and enthusiastic lifelong learners.

The concern of this paper is about preservice education strategies for teachers. Through effective preparation of teachers we hope to generate changes in science education in primary schools, which allows children to engage in processes that inculcate "habits of mind," and develop the attitudes and confidence necessary to become scientifically literate citizens. We need teachers to go beyond traditional school science teaching that focuses on "key" concepts (Eisenhart, Finkel, & Marion, 1996). We need to develop the enthusiasm, disposition and skills of teachers so they can capitalise on children's interest in science to create in these children a lifelong commitment to understanding science and its role in society. This paper describes a study of the effectiveness of an approach that attempts to develop these attitudes in preservice teachers.

Learning to teach

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 primary teachers have poor attitudes and beliefs about science and their capacity to be effective teachers of science. These beliefs and attitudes develop as a result of their science-related experiences in primary and high schools (deLaat & Watters, 1995; Watters & Ginns, 1995). 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). Science teaching in primary 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 education courses confront preservice teachers' attitude to science and motivation to teach science.

Three discrete components contribute to motivation: *values*, *expectancy* and *affect*. Certain behaviour is valued because of the need to meet intrinsic or extrinsic goals (Covington, 1993; Dweck & Leggett, 1988; Pintrich, 1989). Extrinsic motivation is instrumental in form and focuses on external rewards such as the desire to obtain grades and complete the course. Intrinsic motivation may stem from a personal goal derived from an interest in the subject area. For example, if one believes that knowledge of science is important socially, one values the task of teaching science, will attempt to learn it and feels obligated to teach it well. However, the goal orientation effects the type of learning that may ensue with more surface learning accompanying extrinsic than intrinsic motivation (Entwistle, 1998).

People behave resignedly because they acquire expectancies that they cannot affect environmental outcomes through their actions (Rotter, 1966). Self-referent expectancy systems also regulate behaviour. Self-efficacy beliefs are born out of successful or unsuccessful antecedent experiences (Bandura, 1977, 1986). Pre-service teachers who are expected to engage in teaching science in primary school hold low self-efficacy beliefs about their ability to teach science after graduation (Watters, Ginns, Enochs & Asoka, 1995; Ginns, Watters, Tulip, Lucas, 1995; Ginns & Watters, 1996). This sense of self-efficacy militates against students engaging effectively in learning science. Bandura's (1986) self-efficacy model has provided the most significant insights into the general behaviour of teachers (Ashton & Webb, 1986; Dembo & Gibson, 1985; Greenwood, Olejnik & Parkay, 1990). Therefore, self-efficacy should be an important consideration in the pre-service preparation and induction of new teachers.

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 associate these feelings with particular endeavours. 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. Although students engage in self-observation, self-judgment and self-reaction, the benchmarks against which decisions are made are socially experienced (Bandura, 1986). Developing motivation is only one component of student-centred learning.

Indeed five essential dimensions of meaningful student-centred learning can be identified and are summarised in Table 1 (Alexander & Murphy, 1998). Educational programs need to address all of these dimensions if institutions of higher learning are to provide opportunities for graduates to become truly lifelong learners with a disposition towards scholarship, ethics and leadership in the community. 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.

Table 1.
General statements relating to learner-centred principles

The knowledge base	One's existing knowledge serves as the foundation of all future learning by guiding organisation and representations, by serving as a basis of association with new information, and by colouring and filtering all new experiences.
Strategic processing and Executive control	The ability to reflect upon and regulate one's thoughts and behaviours 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.

Aims of this paper

This paper focuses on the teaching strategies in a core science education unit within a Bachelor of Education (Primary preservice) course. It considers how a collaborative learning experience that incorporated components of problem based learning was implemented and how students reacted to this approach. The paper explores how a student-centred approach enhanced students' motivation and their stated confidence and will to teach science. Data were derived from classroom observations, focus group discussions held at the conclusion of the semester and from instruments that measured science teaching self-efficacy. The study is on-going and provides a situational analysis of an 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.

The salient instructional strategies adopted of 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.* Each team implemented a number of collaborative learning strategies 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 critically evaluated 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 key conceptual areas, namely, energy, matter, earth and weather, life science, and space. For example, students would explore strategies such as concept mapping to investigate prior knowledge of children related to matter or space.

Problem oriented assignment work 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 develop appropriate 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 conclusion of the first stage before the preparation of the unit of work. Each group presented their unit of work to the 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 students 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, records and reflections about their learning. 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 expectations are 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 strategies also attempted to recognise 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 endeavours albeit guided by a supportive teacher.

In summary, the instructional strategies incorporated:

- Authentic learning environments simulating real life practices of diagnosis, planning and teaching
- Collaborative learning
- Personal reflection on learning.

Methods adopted for data collection

Participants

The participants in this study were enrolled in a four year preservice Bachelor of Education (Primary) program in 1997. All students completed a core science content unit (Science Foundations) in the first year of the preservice program and a core science curriculum unit (Science Education) in the third year of the program. At the beginning and end of the unit 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 unit was structured with two lectures per week and a two-hour workshop described before. Workshops were facilitated by one or other of the authors or by a part-time tutor who had been instructed on the strategies and whose workshop was regularly monitored by the researchers.

Procedures

Both qualitative and quantitative data were collected. Quantitative data were obtained through survey instruments. For example, 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 focus group sessions and through analysis of workshop notebooks and the reflective journals kept by the students.

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 unit facilitated the focus sessions. Students were encouraged to reflect on their experiences with limited input from the research assistant. 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 assignment (Stage 1). Some of these issues may have been addressed in the open conversation but if not they were explicitly explored and a summary of all participants' feelings was made to close the focus session.

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 behaviour and students' assertions and concerns.

Results

A summary of the quantitative data is presented in Table 2. Only individuals whose comments are included in the qualitative data section of this paper are given. There were significant changes in PSTE overall for group ($p = 0.008$). Implementation of the end of unit 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, sd 6.8). 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 indicative of a substantial improvement in a personal belief that they will be able to effectively teach science (Howell, 1985). STOE scores were more variable. An increased sense of self-efficacy implies a greater confidence in their ability to effectively teach science. The changes in STOE indicate that students are 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 2
Changes in PSTE and STOE scores on self-efficacy scale

Student	PrePSTE	Post PSTE	Effect Size	PreSTOE	PostSTOE	Effect size
Jill⁜	36	50	2.56	42	38	-0.9
Bev	31	33	0.37	33	33	0
Colleen	44	49	0.92	37	30	-1.6
Katherine	30	51	3.85	37	33	-0.9
Whole group✦	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 analysed to obtain insights into how student's perceptions of the course and their capability to teach science changed. The format of the focus sessions or conversational interviews allowed students spontaneously to generate claims, issues or concerns about their experiences. The focus leader provided a general introduction to the sessions with the general statement: “What Jim and Ian want to do is look at the effectiveness of the science curriculum course that you’ve recently done in relation to you 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 sessions proceeded to reflect on their experiences in these terms. The major issues identified in the transcripts will be described and interpreted in terms of the strategies implemented by the teaching team.

Confidence

The students in this unit of study had, in their first year of the preservice course, studied the unit Science Foundations that focussed 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 to entry into the course and for many the foundation science unit was a major challenge. The focus on content in that course was remarked upon my many students in negative terms. The following response from Jill is typical of the feelings of the students:

> I really didn’t like the first one 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 Foundation Science unit and the Science Education unit in terms of how the latter unit impacted on their confidence and competence. Bev for example stated:

> Because first year was really scary and I got freaked by all that theory, and all that sort of stuff. Like I’m not going to be able to do this! And then like (in) the semester just passed and we got onto a little bit more hands on stuff. … I could see, I could see like how I could use some of those experiments that we were doing in the classroom.

The Science Education unit was acknowledged as more useful in developing understanding rather confidence to teach. Even the most anxious or “sciencephobic” student noted the unit helped her understand some of the concepts she did not understand in high school science: “Science Foundations sort of cleared everything of that up for me.”

Colleen expressed a common assertion about changes in student confidence as a result of engagement in the Science Education unit when she stated:

> 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.

Explanations and Qualifications

Confidence was attributed to a range of initiatives such as “hands-on” activities, more relevant content that was suited to primary school, access to resources but also several key components of the unit’s instructional strategy were identified. For example, collaboration and the nature of the assignment were singled out for comment by students. For example one student commented when describing 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,

and another student reflected:

> 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.

Other students made similar comments about the authenticity of the assignment and how it contributed to a sense of social learning.

When confidence was discussed in the focus sessions, a number of qualifiers and issues arose. Although the confidence of most students increased during the unit, 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. Those who had taught science on practice teaching experiences were much more confident of their ability to implement effective science programs.

Knowledge of content was a common but not exclusive concern, especially if implementing activities that do not apparently work as Katherine 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.

However, others were prepared to capitalise on such events or review content themselves believing that they could cope knowing effective strategies:

> 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 organise 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 attitudes. There was a common acknowledgment that unless it was fun it was not worth teaching. Indeed one student 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 only pressure I found in the course was getting everything done in the workshop. Otherwise I found it really fun, enjoyable, you could sit there you could talk (about the experiment.)

The same student also described the important role that the lecturer played in scaffolding the group's interaction and learning by probing questioning and reinforcement. The strategies used by the lecturer 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 lecturers as modelling practices that would be important for the students to use themselves in their future teaching.

Assignment as a focus for learning

The assignment was designed with principles of problem based learning in mind. The task was to work with a child and identify his or her understandings of a concept and then to develop a program to teach that concept. 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 attested the effectiveness of this process, for example one student stated:

> 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.

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 course on the strategy of maintaining a reflective diary. Student reaction to the journal identified tow issues. Firstly, keeping a journal that would be used for assessment was problematic but acknowledged as a worthwhile strategy to monitor childen's thining. For example one student who expressed concern about having to write the journal made this acknowledgment:

> 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.

However, there was some amelioration of this conflict between reflection and assessment. 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.

Others acknowledged the metacognitive value of the journal:

> The journals actually really helped, … the more I wrote down things the more it helped me, and the more I thought, you know, I also thought this could be a really good idea to do in the classroom having your own journals.

Although many saw the keeping of journals as tiresome, the quality of journal writing demonstrated deep thinking about the content and processes adopted in the unit and about the students' learning.

Conclusions

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 associated with a student's sense of self-efficacy in teaching science (Watters & Ginns, 1996). Students' science teaching self-efficacy was enhanced in situations where firstly, their previous experiences in school science were positive and teachers provided recognition of the student's interests in science. Secondly, when science experiences were fun, interest and enjoyment provided intrinsic rewards and positive feedback. Thirdly, self-efficacy was enhanced when there was opportunity for discussion and interaction, which promoted the maintenance or improvement of self-efficacy and provided an environment where risk taking was encouraged. It was also evident that students were driven by both internal and external motivation. Desire to finish courses and graduate was a powerful motivator that in some instances outweighed feelings of anxiety about science. Finally, direct experience with teaching children science enhanced their outcome expectancy for the teaching of science. This study has provided further evidence in support of those assertions. Motivation in terms of value, expectancy and affect were enhanced through the instructional practices. 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 enjoyment and fun through the activities.

The analysis has shown that attitudes towards the teaching of science can change through appropriate student centred strategies. Students acknowledged learning occurred during the implementation of a number of specific strategies. A commitment to learning and improved understanding was evident in the reflections of students. The modelling of strategies by lecturers in the workshops, the problem based nature of the assignment and the interactions with peers in workshops were acknowledged as valued experiences. The assignments 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.

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 unit content. The most significant issue to emerge from the study was the impact of the unit on enhanced motivation. While changes may have been moderate, in all cases students indicated a preparedness to implement science programs in schools. Underpinning this enhanced motivation was revision of their view of science in so far as a more inquiry based approach was valued and an acceptance of the tentative nature of scientific knowledge.

Within the context of a unit with in excess of 170 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 in the assignment with different children, the variation in individual children's knowledge and capabilities and hence became sensitised to these issues. Finally, the social environment facilitated discussion and debate. The workshops were structured around groups in which students were free to elaborate their ideas and which were supported by lecturers. 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; to move from authoritative to facilitative discourse played a major role in the instructional strategies.

Table 3
Implementation of student centred 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 Activities in workshops 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

The primary objective in the instructional strategies of this unit was to implement a culture of learning involving discourse in a risk-free environment. 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, and develop curiosity and to seek support when needed and share experiences with teacher and peers. Effective teaching requires a deliberate communication of strategies to students to afford them the sense of empowerment to be active contributors and hence life-long learners with awareness of themselves as creative problem solvers.

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