
Reimagining Primary Science Education at Griffith University

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Largely as a result of unfortunate or inadequate experiences with science during their compulsory school years many students enter the first of two core primary science education courses at Mt Gravatt and Logan Campuses of Griffith University with trepidation. Attempts to develop in these students a positive attitude towards science and the teaching of science have not been helped by inadequate university funding, which has forced all universities into mass teaching and other approaches that are "efficient" in terms of staff student ratios. Working within these attitudinal and funding constraints, Griffith University educators in the two courses have experimented with a range of different teaching, learning and assessment methods. In close consultation with students they have refined those ideas that are rated as effective and discarded those that are rated as ineffective, resulting in two courses that are now highly rated by students and regarded as beneficial. This paper discusses a range of different methodologies that have been employed to help overcome negative attitudes and the isolating and impersonal influences of large group instruction. Techniques discussed include teaching styles in mass lectures, engaging students during mass lectures, small group learning projects, effective assessment, student support, flexible learning and delivery ideas, and the primacy of reflective student feedback to achieving student satisfaction.

Introduction

The world is becoming increasingly dependent on science and technology and greater responsibility to produce scientifically literate citizens must inevitably fall on teachers of students in their formal years of schooling. However the essential ingredient for this to happen in schools, namely competent and confident teachers of science, is missing. This is of particular concern in primary schools where students' natural curiosity and enthusiasm for science needs to be nurtured. By and large, however, primary teachers throughout Australia are under-confident about teaching science and many try to minimise the amount of science that they teach. Indeed, one report (Speedy, Annice, & Fensham, 1989) noted that science teaching in primary schools was in a state of crisis and questioned whether science should continue to be taught by generalist primary teachers.

Unfortunately this gloomy assessment has not improved. Science teaching in primary schools is still rated as ineffective and inadequate preparation of teachers at university is frequently cited as the principal reason for this. For the past 15 years changing government ideologies and approaches to higher education funding have had dramatic effects on Australian universities, academics and tertiary students. The most obvious

manifestation of policy change has been a large increase in student numbers accompanied by a decline in per capita university funding. A recent AVCC report noted that the national ratio has climbed between 1990 and 2000, from 12.9 to 18.8 students per teacher. This has forced universities to place great emphasis on teaching modes that are "efficient" in terms of cost and human resources. Some researchers have highlighted structural problems associated with inadequate resourcing of university teaching as likely to cause on-going problems for the effective preparation of good primary and secondary science teachers. For example, Goodrum, Hackling and Rennie (2001) observed that university science teacher education programs are under-resourced and close to crisis, with a great deal of the associated teaching failing to model best practice. Similarly, Dobson and Caledron (1999) related the problem to universities' enforced adoption of low cost, mass lecture and tutorial methods, which fail to produce science teachers with the requisite skills and knowledge required by modern, innovative curricula.

The context of compulsory primary science education courses at Griffith University

Primary Science Education 1 is the first of two compulsory science education courses for approximately 350 students who are enrolled in the Bachelor of Education (Primary) (BEd) program on the Mt Gravatt and Logan Campuses (MG-L) of Griffith University. This introductory course provides the students' first exposure to the content and methodology of science education and it takes place during semester three of the 8-semester BEd program. Students enter the course with a wide variety of science backgrounds ranging from junior high school to tertiary level science education. A small number, mainly mature students, have no secondary science experience at all. Regardless of their backgrounds, many enter the course with considerable apprehension and negative attitudes towards science and their future roles as teachers of science in primary schools. Each week the group of about 350 students receives two mass lectures plus one laboratory session and one workshop (comprising small group self-paced study). Swindell, Richmond and Parkinson teach all the mass lectures on both campuses and most of the laboratory sessions on the Mt Gravatt Campus. Sessional staff members teach the remaining laboratory sessions at Mt Gravatt and Logan. Apart from the obvious purpose of providing students with the opportunity to develop hands-on skills, the laboratories provide an opportunity for the teachers to get to know many of the students personally and to provide individual assistance as needed. The workshops are flexible learning sessions in which the students are assigned unsupervised group work to be carried out at a time of their choosing, each week. The workshops serve the purpose of promoting peer teaching, group work and reflective discussion as well as moving students towards taking personal control of their own learning in science. Weekly meetings take place between all involved staff to ensure that all content and pacing is identical.

Why the current team teaching approach was developed

The team teaching approaches that underpin primary science education at MG-L can be traced to two defining events. At an Australian science education conference in the mid-

1980s, Roger Osborne, a science education researcher, revealed the alarming finding that conventional science teaching, for the most part, was largely ineffective. Osborne and Freyberg's (1985) research initiated a worldwide move towards constructivist teaching methods that today inform all modern teaching practices. Osborne's revelation was the defining moment that steered us from our former content-driven science teaching to the development of processes that place constructivist learning at the focus of all our teaching. The second defining event occurred as a result of the restructuring of the tertiary education sector. In the 1970s and early 1980s Swindell and Richmond were members of a group of 12 primary and secondary science educators who taught all science courses exclusively by small group teaching. These courses were highly rated by students. Therefore, given a choice, it is likely that all 12 teachers would have strongly resisted any move to introduce mass lecturing. However, retirement and non-replacement of ten of these colleagues and the emerging emphasis on new teaching, learning and assessment approaches required us to think creatively about different teaching/learning methods. More than fifteen years ago Swindell and Richmond took the decision to work as a team and to entirely restructure the course along constructivist learning principles that might work effectively despite the perceived limitations of mass instruction.

How the current team teaching approach has developed

An extensive literature relating to the theory and practice of large class teaching has developed over recent years as academics have struggled to find solutions to the dilemma of doing more and better with less. Although the practices described in this paper can be rationalized post facto as falling within a number of sound teaching/learning theoretical frameworks, they were in fact based largely on a combination of personal experience and intuition rather than being grounded in any particular theory.

Regular student feedback is an explicit cornerstone of effective practice regardless of class size. Within both of our courses student evaluations have been, and remain fundamental to the ongoing evolution of our team teaching approach and course structure. For more than 15 years, at the end of each semester, all students have been asked to complete an anonymous questionnaire that asks them to rate each component of the course on a 5-point likert scale. The questionnaire also asks for written comments or suggestions for change to any aspect of the course. A summary of all student responses for recent years, to two global questions relating to student satisfaction with their initial science education course is shown in Table 1.

Table 1

Levels of students' satisfaction with their introductory core science education course*

QUESTIONS	1997	1998	1999	2000	2001	2002	2003
Overall, I was satisfied with the quality of instruction provided by the lecturers	99.3%	100%	99.0%	100%	98.1%	97.9%	99.0%
Overall, I was satisfied with the quality of the course	100%	99.5%	97.9%	100%	99.0%	98.7%	98.0%

* Responding numbers vary from year to year. Generally numbers range between 150–250 students

It would be easy to become convinced by quantitative data such as that shown in Table 1 that a course requires little in the way of fine-tuning. However, in 1996, the Deputy Dean Teaching and Learning noted that reflective feedback obtained by student discussion is frequently of greater value in unlocking student perceptions of a course than tick a box responses provided during "end-of-semester euphoria". This idea was adopted and since 1996 qualitative data obtained through in-depth discussion with students about their perceived needs as future teachers of primary science, and how the course could better meet these needs, have comprised a fundamental component of our course evaluation. In brief, after completing the anonymous questionnaire, which usually takes about 10 minutes, the remaining 40 minutes of the final laboratory session is devoted to a "round table" discussion about anything related to the course. During this session students and lecturer sit in an open circle, with the lecturer acting in the role of moderator and recorder. Apart from one or two initial lead questions and occasional probes for further elaboration from the lecturer the students are in charge of the session. Initially, comments tend to be stilted, tentative and focused on the positives but once the group perceives that they, rather than the lecturer, "own the agenda" the more confident members or those with "burning issues" take over. Within the first 10 minutes most students are usually fully engaged in the discussion. Deep insights about the course and its presentation are obtained through this technique and the discussion sometimes becomes very animated as differing points of view are aired. In essence, the session might be described as a negotiated curriculum (Hanrahan, 1997), albeit a post facto one with variations. Students reach consensus on what their colleagues in the following year should do and how the teaching team could better facilitate quality teaching and learning experiences for future intakes. When there is wide support for change, the teaching team discusses how (not whether) to implement that change. Almost without exception, suggested changes are introduced in the following year and, in turn, students subject these modifications or innovations to the same process of reflective analysis. The major advantage of this "post facto negotiation" is that by the end of course students have also gained brief experience of life in primary schools via their initial school visits and are in a relatively sound position to critically weigh up the many components of the course. Most importantly, their negotiations are less likely to reflect hidden agenda than if the negotiations had taken place during the semester, because future groups rather than the discussants are the ones to benefit from their suggestions. Every semester this group reflection produces ideas for change, which over the years has resulted in substantial modifications that may not have occurred to us had we relied solely on quantitative feedback. Several of these changes are discussed later.

Although a number of sessional staff teach parts of the course, to date we have been fortunate in avoiding pitfalls that could be associated with the hiring of inexperienced (and inexpensive) sessional staff by convincing the Head of School that specialist science teachers are fundamental to retaining satisfactory feedback from "fee-paying clients". Our sessional staff colleagues are generally retired specialist science teachers and their experience and ideas have led to many useful course refinements. We meet regularly as a team to discuss the upcoming week's teaching and to share ideas about how various activities might be most effectively related to the primary classroom. Their teaching

content and pacing directly mirrors ours. All members of this wider teaching team carry out identical assessment items and these are marked according to prescribed criteria. All members of the team meet to moderate the final grades in order to ensure that any idiosyncrasies do not advantage or disadvantage any student group.

Guiding principles

Our team teaching approach has been guided by three complementary objectives that are aimed at producing graduates who are confident, competent and effective teachers of science in primary schools.

Objective 1: To develop in students a positive attitude towards science and teaching science in schools

Our overarching teaching philosophy is based on the belief that students must leave our course with a positive view of science and the conviction that they can be, and most importantly want to be, effective primary science teachers. However, before any effective learning can take place students must engage with their learning (Cambourne, 1988). In order to effect engagement with our course, we have devised a diverse range of teaching and learning methods and flexible assessment practices that are designed to help students to recognise that they can succeed regardless of their prior science backgrounds or attitudes. In the preliminary step towards removing student trepidation about the course, the introductory mass lecture makes clear that success in the course is not rationed. Students are shown grade distributions for previous years indicating that about 95% of their predecessors passed the course at their first attempt. They are also provided with written materials that clearly show in considerable detail what they need to do in order to gain the maximum benefit from each section of the course and that allied assessment items are based on tightly specified written objectives that closely relate to the lecture, laboratory and workshop content. Although these procedures may sound mechanical and routine, students frequently state that this initial orientation lecture is the single most important action that we take in removing their anxiety about our course.

The lecturers are motivating and the content is contextualised which makes it very relevant. I was concerned about my scientific knowledge prior to this course, but am now confident of my ability to teach science—and look forward to doing so.

Objective 2: To arouse curiosity and stimulate independent learning and critical thought

Constructivist learning theory informs our teaching. This theory suggests that students learn best when they are allowed to work out explanations for themselves over time and through a variety of learning experiences. Our students are involved in a wide variety of learning experiences. These include: conventional face-to-face lecturing; supervised laboratory activities; excursions to the Museum, Science Centre and Planetarium; independent and group activities carried out on the Web and by CD Rom; and flexibly timetabled workshop activities in which small groups of students engage in peer teaching and learning, and learn to manage assigned work to fit into their preferred schedules. All assignments entail group work, because working in groups is believed to enrich the learning environment by allowing students to share their experiences, critically evaluate different points of view and cooperatively work towards developing solutions to specific tasks (Primary Investigations 1994).

My early years of teaching were modelled very closely on their expertise in integrating in-depth understandings covered in lectures with hands-on activities in lab-based tutorials, self-directed learning activities, and team-learning tasks. As well as learning to teach, I must say I 'learned how to learn' (Former student and current Education Consultant in Higher Education).

Objective 3: To situate science content in a real world context

During their two semesters of science education, beginning teachers must come to grips with some of the key ideas of the five main areas of Life, Energy, Matter, Earth and Space, and how to teach these effectively. There are no suitable commercial materials that are wholly suitable for this task. Portions of several good commercial texts could have been adapted to cover some of the requisite content and methodology, but the cost for these books would have been several hundreds of dollars. More importantly, commercial materials do not have a direct relationship to the Queensland syllabus. We believe that constantly relating our teaching to the realities of the classroom is a vital part of helping students, who know very little about the primary school system, to understand the fundamental underpinnings of their chosen career.

We have written all text materials for the course so that they relate to the Queensland syllabus. This was a demanding task that resulted in over 500 printed pages covering the entire mass lecture content and laboratory and workshop activities in six books. (We have done the same for the second course.) Apart from having a specific syllabus focus, throughout the books we have attempted to address the frequent criticism that science is boring and unrelated to the real world. We have related many of the scientific concepts in our books to real world problems, such as global climate change and ozone depletion. Students have a passion for the environment and most are quite receptive to learning about the more arcane and seemingly unrelated concepts of science provided that the ideas are presented in a meaningful framework that they care about (Fien, 1993).

Some approaches to large group teaching

A number of educational researchers have described different approaches that have been used to make large class teaching a successful and manageable experience (see for example Biggs 1999; McKeachie 1999). Some of these approaches include: stimulating active learning and higher order thinking; maintaining interest and varying teaching strategies; selecting the appropriate pace and content for lectures; performing rather than lecturing; developing valid and reliable assessment that is also manageable; coordinating and managing assessment and feedback

We have incorporated many of these ideas into our courses in an effort to develop learning experiences that are interesting, fair and challenging for everyone, despite the very diverse science backgrounds that were described earlier in this paper.

I took engineering (2 years) in Uni. If I had had a better understanding of the basics, which I received in this course, a lot of the material would have made more sense for me.

I was never any good at science at school; however, this course has taught me more in 14 weeks than I learnt at school. My attitude toward science is now relaxed and I enjoy it.

Maintaining interest and varying teaching strategies

Mass teaching/lecturing remains a most efficient way of exposing large groups of students to substantial amounts of new information within a restricted time frame. In order to help maintain student concentration and interest during their two mass lectures a week, we use many different delivery techniques. These include:

- Videotaped demonstrations. Several years ago close up video recordings were made of several dozen of our demonstrations of fundamental science concepts. Each of these segments varies in length from about 15 seconds to several minutes. The advantages of this technique are: the demonstrations always work ☺; we can stop the demonstration at any time during our live commentary to reinforce a particular point; a demonstration can be quickly repeated for emphasis; and students can clearly see demonstrations from any point in the lecture theatre.
- Group participation. For example, in one lecture during which we discuss experimentation and graphing, three student volunteers (a fit male, fit female and sedentary female) pedal at the same rate for five minutes on an exercise bike and heart rate data are recorded every 30 seconds. All students are simultaneously involved in plotting their own graphs and considering the implications of the emerging data.
- Mass teaching. For example, in order to model a constructivist teaching session, students are asked what happens to the weight of chewing gum when it is chewed. To test their ideas volunteer group leaders weigh different brands of chewing gum and distribute their brand to 10 students per group. Every student in the lecture theatre can participate in a group. At the end of 5 minutes the leaders collect the chewed gum and wrappers and reweigh. Students present graphical results for each brand on the overhead projector and these are discussed.
- Much teaching in primary schools takes place around various themes that integrate several different teaching disciplines. Where appropriate, we attempt to model similar approaches in our mass lectures. For example, we might draw on students' experience of playing the recorder in music to help demonstrate how sound travels in waves. Alternatively, it may be appropriate to briefly dress up to demonstrate how a science enquiry could be stimulated through drama.

It's good that these lecturers actually practice what they preach. They use constructivist principles to teach and not just talk about it. They seem to really put a lot of effort into delivery and it is really appreciated because it makes the subject interesting. There is no mystery in this subject. The teaching of concepts is done very well. Very explicit.

Some suggestions that evolved from "round table" critiques

During course evaluations, which are held for the full 50 minutes of the final laboratory session for every group, students have suggested many innovations and modifications that have been successfully introduced into the courses. These probably would not have been considered had we relied solely on course feedback obtained by questionnaire. Some of these include:

- Videotaping lectures. Our lab attendant videotapes all lectures and demonstrations in their entirety. Students may borrow these for review at home or in their small groups at university.
- Visiting speakers. Occasional visiting speakers from primary schools and Education Queensland are invited to reinforce the relevance of our course content to the primary school curriculum.
- Reducing content. A frequent criticism of both courses relates to our covering too much in too short a time. We can do nothing about increasing teaching time so we have responded by rewriting materials and excising formerly revered portions of content from lectures and from the "required for study" section of the book and publishing these as "optional extra" appendices. We have retained these as appendices because feedback from our graduates, who continue to use our books as references for their classroom teaching, rate the entire content as useful.
- Lecture visual materials. Copies of all PowerPoint slides and copies of all overhead transparency materials that are used in mass lectures are compiled before each semester begins into a single booklet that students may purchase from the bookstore. This requires considerable forward planning and discussion with all members of the teaching team to ensure that all visuals are modified long before the semester begins. Almost without exception students elect to purchase this material. This simple innovation is very highly rated by students because it enables them to concentrate on important lecture detail rather than on the trivial task of transcribing information.

The lecture visual materials are fantastic—in other subjects I'm so busy writing down notes that I don't hear what the lecturer is saying.

Stimulating active learning and higher order thinking

We have introduced a number of innovations into our assessment that are in line with the University's emphasis on flexible delivery and learning. In keeping with constructivist learning principles, all five assignments across the two courses are carried out in small groups that require students to interact with specific content and reflect deeply on the implications of their findings. For example, in their first course, students study the environmental and monetary cost of using "clean" electricity in their home. Each student reads the electricity meter at home for 10 consecutive days and records in a daily diary events in the home that have contributed to each day's hot water and general electricity readings (e.g., use of dryer, air conditioner, extra guests, heater, number of baths/showers etc). The dollar cost is found from current commercial charges. The environmental cost is found by knowing that each unit of electricity recorded on the electricity meters "costs" the environment, because one kilogram of carbon dioxide has been released into the air at the coal burning power station. Their calculations show that each household is responsible for the emission of several tonnes annually of global climate change gases. They compare their data and diaries with those of other students and submit for assessment a group paper with a lesson plan explaining how school children could be taught to reduce electricity use in the home with little or no loss of quality of life or convenience.

In their second course students, in groups of three, engage deeply with their learning when they are asked to fully evaluate a unit of the recently developed "Primary Investigations" program. Students are advised that during one of the assessable stages of the assignment they will have a maximum of 10 minutes to present a poster session to the rest of the class that details the teaching implications of their particular unit. They are advised that their audience (the other members of the class who know nothing about their particular unit) should be treated like a group of busy teachers at a conference who have only a very limited time to hear about their innovation. Thus the emphasis is on evaluation, links with the new syllabus, links with different curriculum resources, classroom management, effectiveness at helping children learn, etc. It is not about teaching of the unit per se. This is a highly rated assignment that allows students to draw on a wide repertoire of communication skills (for example music, drama, art etc.) to get their message across in the limited time.

Coordinating and managing assessment and feedback

Assessment is usually a stressful experience for many students. In order for students to become convinced that they can be successful science teachers we believe that they must themselves experience success in their science education studies. Accordingly we use a variety of small-medium assessment items, including mid-semester and final exams and group projects. Written objectives very clearly specify what students need to do in order to succeed at each task and students are explicitly told that success is not rationed. We make a point of providing students with very rapid feedback. On all but the final exam, all assessment items are marked and returned in the following laboratory session, at which time they are discussed to ensure that students learn from the assessment process.

As shown in Table 2, students regard our assessment items as fair and appropriate.

Table 2

Students' reactions to assessment items*

QUESTION (STRONGLY AGREE/AGREE RESPONSES)	1997	1998	1999	2000	2001	2002
I believe the assessment items for this course have been appropriate and fair	97.3%	97.9%	93.7%	100%	95.2%	98.1%

*Responding numbers vary from year to year. Generally numbers range between 150–250 students

The assessment items were excellent, each one wasn't worth too much but they were interesting too.

New directions

The Internet is poised to bring about a paradigm shift in the way people teach and learn. Interactive materials presented via the WWW are radically changing access to knowledge and how learning is carried out (Ortega, 1997) and have high motivational potential for the new generation of students who have grown up with computer technology. Papert (1993) called the computer the "children's machine" because many students have grown up in a world of computers and online technology is an integral part of their world. They

play, are entertained and learn with the computer and tend to be more visual learners than previous generations because their world is rich in visual stimuli and they thrive on interacting with the technological tools. Computers are able to present conceptually difficult information in a widely varied combination of textual and graphical ways.

Proctor, Baturo, and Cooper (2002) have developed a number of learning objects that they speculate may assist students to develop abstract understandings in mathematics. Their findings are based on the idea that highly complex ideas can be broken down into a number of discrete computer-based learning objects that children can master independently. Subsequently, with the assistance of an effective teacher, the learning objects can be assembled into an appropriate learning sequence that allows students to build on the new knowledge that was gained through the individual learning objects.

Similar ideas may hold true in primary science, which is based on the transformation of concrete experiences into appropriate abstract understandings. Much of our research and developmental activity is currently focused on the preparation of new interactive Web-based teaching/learning materials for our BEd science education students and for upper primary and lower secondary school students. The idea of developing materials that are suitable both for teacher trainees and school students comes from our belief that many existing problems associated with poor primary science teaching, such as lack of equipment, and overworked and under-confident teachers, can be inexpensively addressed once good science teaching/learning materials are widely available through the Internet.

Our first set of Web-based materials dealt with the conceptually difficult area of current electricity. The modules allow students to observe electron flow in circuits and to progressively study the effect of changing the number of batteries and varying the resistance in series and parallel circuits. Our interactive science materials development team has been substantially strengthened recently by the addition of Jamieson-Proctor, who has a strong theoretical and practical background in instructional design for interactive multimedia. She noted that the existing electricity modules are "too linear and too long" and suggested that better quality learning would occur if the modules were restructured into discrete learning objects. This work, as well as the development of other novel science learning objects, will be carried out by groups of Griffith University multimedia students as their major project required to fulfill part of their course requirements.

At the time of writing, four multimedia students are in the process of working with us to develop a series of linked learning objects that will help students aged in the 10–15 year old range to understand the abstract ideas related to the Kinetic Theory of Matter. The learning objects involve a cartoon character named Moly-Cool who can shrink to the size of a water molecule in order to study the energy changes involved in changes of state between ice, water and vapour as heat is added or removed. The evaluation stage of the module will ask students to explain the water cycle in terms of the internal energy of molecules. Challenging young students to think about the states of water in terms of what is believed to be happening at the molecular level is an ambitious idea and it will be interesting to find out how successful this is. The package will be tested with students in

primary and secondary schools and subsequently refined to reflect student feedback. In addition, teaching notes will be prepared and BEd students and experienced classroom teachers will evaluate the whole package for its teaching/learning potential. The intention is to make all science modules that have been developed by multimedia student groups freely available through the Internet, to primary and secondary school teachers. This will help to further reinforce the close links that we strive to maintain between our science education courses and classroom practice.

For the past three years we have also been developing web-based interactive materials that promote understanding of science and social issues relating to global climate change. We regard global climate change as the most serious of all environmental issues and believe that essential social change must begin immediately if the problem is to be contained. Social change is likely to be successful and lasting if new generations of voters have a good understanding of the many interlocking facets of society's dependence on fossil fuels. Stage one of the Global Climate Change project was completed in 2002 and four of the interactive modules are available for BEd students on the primary science website. To the best of our knowledge there are no similar teaching materials on the Internet.

Preliminary indications are that teachers will welcome the climate change package. In 2002, BEd Primary students on the Mt Gravatt and Logan Campuses were asked to evaluate four of the web-based interactives. Of 196 students who submitted an evaluation, 59% strongly agreed and an additional 37% agreed with the statement "I/we believe that these modules could be a useful teaching tool in the upper primary school". Classroom teachers also rate these materials highly. A prototype CD of the completed modules was sent to 43 primary and secondary teachers for comment. They provided a range of constructive suggestions for additions and modifications and many of the suggestions have since been incorporated into the revised materials.

Having just completed this unit I rate this CD Rom highly. It fully and capably fulfils the requirements of an outcomes based syllabus. In the classroom activities we used VERY basic resources, so it was good to see the presentation using technology—a must for children in low socio-economic areas such as the one I teach in (Year 6 Teacher, Browns Plains State School 2002).

Presentation is excellent. I like the way the activities are presented especially the experiments. They are simple and easy to achieve for teachers in a lesson. Plus the use of graphs is an excellent teaching tool. Lower secondary would be an appropriate level, even some senior geography students would benefit from the clear explanations. (Jacobs Well Environmental Education Centre).

The project will be completed in 2005 and will contain many learning objects that are integrated into the full package of climate change modules. A former primary science adviser has joined the project team to write a comprehensive on-line teacher's guide. "For the teacher" will feature additional learning materials, extension ideas, teaching hints and links with various Australian and overseas syllabi.

Conclusion

Schafer (2001) observed that, generally, team teaching encourages members of the team to perform exceptionally well. We have found that frequent contact with lively and critical students, and with colleagues who share a passion for teaching, is a constant reminder to us of the importance of university teaching in shaping the critical thinkers and leaders of tomorrow. Certainly our collegial interactions keep us "on the ball" and drive us to continue to look for new ways of getting the message across, particularly in large group teaching. And regular meetings between team members, involving critical reflection on the strengths and weaknesses of aspects of the course and "brain-storming" of ideas relating to innovative materials and practices, help to reinforce enthusiasm for, and commitment to, our various teaching approaches. However, of the widely varied approaches that we have experimented with over the years, we regard the consultative and reflective "round table" critiques by students as the single most important innovation that has led our students to suggest that we are achieving our overarching objective of developing in them a positive attitude towards science and teaching science in schools. Our next important step is to find out how persistent these positive attitudes really are after a few years at the "chalkface".

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