Windows into a science classroom: Making science relevant through multimedia resourcing

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Abstract

In the Australian context much effort and expenditure is being devoted to enhancing the quality of science teaching. In part, this is in recognition of the need to develop a populace that is scientifically literate, thereby, raising public awareness of the role and importance of science and technology in creating a sustainable future. It is also in response to the ever-increasing rate at which new knowledge is being generated. It is impossible for teachers to keep abreast of new developments, and hence, new ways need to be developed to enhance student interest in science and to encourage talented students to pursue a scientific career. Teacher knowledge is fundamental to the achievement of quality teaching and learning. This paper focuses on the use of a multimedia resource that was developed to enhance pre-service and in-service teachers' knowledge of science and ways to teach inquiry-based science. Through inquiry, students come to understand the importance of the practices of science as much as developing content knowledge. This resource comprised two CD-ROMs, which enabled students to interactively explore a model for the teaching of inquiry-based science supplemented with video vignettes of teachers implementing specific strategies at different year levels. A six-component model, which highlighted the role of: working scientifically, student learning, learning in science, teaching strategies, learning environment and content, was developed to guide the production of the multimedia materials. Complementing the resource was a web site. The paper draws upon three contexts for data analysis for the impact of this material: (a) a group of early childhood and primary student teachers and their lecturers, (b) a 100 senior teachers responsible for the professional development of colleagues throughout a region who were participants in a professional development program that used the material, and (c) a cohort of 300 pre-service primary science teachers undertaking a science methods course. Data were collected through surveys, focus groups, and analysis of online interactions. The findings of this study revealed the value of the multimedia material as a vicarious learning experience; the extent that multimedia can demystify science teaching; and the impact on learning outcomes of a multimedia-supported strategy. Here, we will explore those aspects of the multimedia design which enhanced learning and discuss the strategies that can be used in teacher education which support the growth of teacher knowledge.

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Introduction

This paper reports on a teacher education and professional development initiative based on the use of multimedia resources. The purpose of these resources was to enhance the learning experiences of primary preservice and inservice teachers. Although a multimedia-supported approach affords a range of benefits, the quality of learning is influenced by the content provided. The focus of this paper therefore is on the design of content needed to support contemporary approaches to learning and teaching. Details of the development of the multimedia program have been presented elsewhere (Diezmann & Watters, 2002b). In deciding on the content, it was necessary to reconcile the different perspectives on the knowledge necessary to teach science, the purpose of teaching science and the motivational characteristics of preservice and inservice teachers towards the teaching of science.

Importance of science education in a global society

A recent review by the Australian Chief Scientist (Batterham, 2000) highlighted the importance of science, engineering and technology to Australia's future as "a thriving, cultured and responsible community". He emphasised the essential knowledge base of science in fostering a viable economy. Although there is substantial funding being provided to ensure the fostering of innovation through science, policy makers must be cautious that such development does not lead to undesirable economic, environmental, and social consequences. Sustainability is achieved when we ensure development meets the needs of the present without compromising the ability of future generations to live productive and enjoyable lives (cf. Brundtland, 1990). Science is undoubtedly an important tool for all citizens to use to ensure a viable future. Becoming scientifically literate is critical in a society confronting major social and economic problems. Indeed, in a review of science education in Australia, Goodrum, Hackling, and Rennie (2001) emphasized the importance of science to the individual arguing that educators should be attempting:

> to develop scientific literacy which is a high priority for all citizens, helping them to be interested in, and understand the world around them, to engage in the discourses of and about science, to be skeptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being. (p. 10)

This proposition emerges in the context of major concerns about the quality of science teaching. Several major reports have highlighted a crisis in the teaching of science in Australia (Australian Science Technology and Engineering Council, 1997; Goodrum, Hackling, & Rennie, 2001) and elsewhere (Glenn, 2000; Osborne & Collins, 2000; National Science Board, 1999; Royal Society, 2002), which suggest that students are becoming disenchanted with science and the most talented are not pursuing science-related careers.

Although many students and teachers within the field of science might hold these sentiments, such ideas are often substantially at odds with the views of others in the community who are overawed by science. As Kyle (1999) has commented, many have experienced a science education which "serves to disenfranchise learners from coming to know the world and universe" (p. 257). Experiences in school have given students little hope that science is capable of providing the knowledge and skills necessary for meaningful lives. Lowe (2002) argues that there is "widespread community alienation from science and technology, especially among disadvantaged groups; (and) those with limited formal education are obviously more likely to feel that advances in science and technology are too hard for them to understand" (p. 2). The challenge is to ensure that science teaching does empower all citizens to participate in a rapidly changing technological society.

Teacher Education

In a recent review of teaching, teacher education has been targeted as a major issue underpinning the quality of science, technology and mathematics teaching in schools (Commonwealth of Australia, 2003). That review highlighted the important role played by teacher educators in ensuring that teachers are effectively educated to teach science. The need to prioritise science, mathematics and technology in primary schools was particularly highlighted. Educators need to enhance children's interest in science and to make science relevant to their perceptions of what is important in contemporary society. Batterham (2000), in his review, stated, "Excellent teachers are the key to exciting and sustaining interest in science" (p. 50). Extensive research over the last two decades has provided greater insights into effective teaching and learning practices in science classrooms. Educational research has painted a portrait of the successful learner as active, mindful, inquiring, and self-monitoring. That image is clear enough to require an equally sharp picture of the settings that foster deep learning (Alexander & Murphy, 1998). These settings are characterised by complex situations in which students engage in inquiry-based learning that draws upon interdisciplinary knowledge and contributes to the development of critical and creative thinking.

Implementing these approaches in the science classroom has required teachers to reflect seriously on their assumptions about learning and teaching, and to adopt approaches that in many situations are personally challenging. Excellence in teaching is hard to define but clearly teachers need to provide learning experiences that enthuse children, that make learning meaningful, and that provide those broad knowledge and intellectual skills that underpin "scientific literacy". What knowledge do teachers need to achieve these goals? This was an important question that needed to be answered before we could develop a multimedia resource.

Teacher Knowledge

The question that we were faced with is what constitutes core knowledge for beginning practitioners and experienced teachers. Research in this area, summarised for example by Munby, Russell and Martin (2002), suggest teacher knowledge is difficult to identify and describe. They argue that consensus does not exist about what constitutes professional knowledge and even "how to conceptualise knowledge" (p. 878). On one hand, attempts have been made to define teaching in propositional terms (e.g., Shulman, 1987; Grossman, Wilson, & Shulman, 1989). This assumes that at least the individual teacher can articulate a set of guiding principles, or analogies of models to describe his or her practice. In contrast, others believe that knowledge is manifested in the actions of practice (Brown, Collins, & Duguid, 1989; Roth, 1998). Polanyi (1983), however, saw knowledge in terms of a tool used to act on phenomena in focus. The individual is unaware of his or her knowledge, and thus, it is personal and cannot be articulated (Stenmark, 2002). Such views acknowledge the contextual nature of teacher wisdom and the role of tacit understanding or craft knowledge. These two extremes remain unresolved with debates continuing to extol each position (Duncan, 1998; Wortham, 1998). As teacher educators, we are concerned with the need to provide students with opportunities to gain sufficient knowledge to be competent beginning practitioners, and to support experienced teachers to continue to improve their practice.

Attitudes towards the teaching of science

Substantial research has shown that primary teachers and preservice students find the teaching of science a stressful experience (deLaat & Watters, 1995; Goodrum, Cousins, & Kinnear, 1992; Stevens & Wenner, 1996; Watters & Ginns, 1995). Reasons are many, but a significant one is that most primary teachers have not studied science much beyond junior high school and in many situations where they have the experience has been unsuccessful. Their pre-service program offers the only opportunity for many to acquire any grounding in science and how to teach science. Most pre-service curricular are crowded and time and opportunity for a substantial engagement in learning to teach science is limited. Additionally, many students report that they rarely see effective teachers engaged in teaching science during practice teaching. An important element of active learning underpinning successful teacher preparation is the opportunity to observe experts in action. Experience in the practice of teaching provides the opportunity to generate theories about practice. This requires opportunities for student teachers and inservice teachers to engage in discussion and deconstruction of teaching practices (Northfield, 1998). Although practice teaching is the primary activity that purports to achieve this, anecdotal evidence suggests students rarely have opportunities to engage with effective teachers of science in schools during practice teaching visits. Hence, vicarious experiences become particularly important. These contribute significantly to changes in teachers' sense of self-efficacy (e.g., Bandura, 1977; 1997), which is claimed to be one of the most important attributes underlying change (Wolfolk & Hoy, 1990).

Thus, this project was designed to lead to a more effective approach to primary teacher education in science. Specifically, the main aims of the project were to produce an interactive CDROM based resource that enabled preservice students and practising teachers to observe, reflect on, and discuss an exemplary range of teaching practices for classrooms.

Design of Resources

A multifaceted approach was necessary to address the need for an effective learning experience for students in this context. Hence, this project involved the design, preparation and implementation of a flexible teaching strategy supported by multimedia resources in the form of a CD-ROM learning package. The strategy provides preservice and practising teachers students with insights into authentic learning experiences (Flinders & Eisner, 1994) that should enable them to develop the content knowledge, pedagogical knowledge and confidence to teach science effectively to children.

Multimedia resources: The development of multimedia resources was achieved in a number of stages. The multimedia resources finally developed included three Videos (Diezmann & Watters, 2001a, 2002a; Watters & Diezmann, 2001a), two interactive CD-ROMs depicting teaching episodes illustrative of effective science teaching (Diezmann & Watters, 2001b; Watters & Diezmann, 2001b), and a Web Site linked to resources (Watters & Diezmann, 2002). The CDROMs were developed to encourage students to engage more deeply with the theoretical ideas of contemporary science education than they otherwise would through traditional print-based materials. Thus, the CDROMs were designed to show theory in practice. The website was designed to provide students with ready access to a range of science resources and to encourage students to explore further. Underpinning all the multimedia resources were principles of effective educational multimedia design. Details of the preparation and structure of the material is provided elsewhere (Diezmann & Watters, 2002b).

Developing a model or theoretical framework for guiding the instructional design: An extensive literature review on effective teaching and learning in science preceded the development of a model that identified key domains of teacher knowledge. The model, shown in Figure 1, identifies six key components to guide students in planning and implementing effective science in the primary school.

Figure 1. Components of effective science teaching

These components represented our beliefs about what science is and why students need to learn science, how students learn in general and in science in particular, effective teaching strategies and the environment of the classroom or situation where learning will occur. These components are compatible with curriculum directions at state, national and international levels and emphasise an interactive, inquiry approach to science. Each of these components will now be discussed.

Working Scientifically

More recent syllabus developments in Australia have adopted the notion of "working scientifically" to describe the way that students should approach the learning of science (Australian Education Council, 1994). Working scientifically suggests that effective learning of science involves identifying problems and investigating these problems in ways that involve inquiry, hypothesising, data collection and reconciliation of evidence and hypothesis. The outcomes of scientific endeavour may seem to conflict with everyday understandings, but they are accepted as viable, explained by current evidence and scientific argument. Science is taught as a 'way of knowing' in which knowledge is seen at tentative and acquired through human endeavour involving debate, consensus and dissent. Working scientifically is illustrated in the CDROM by a selection of subcomponents identified as: *Problem Finding*, *Investigating, Collecting Data, Recording Data, Interpreting Data, Evaluating Findings,* and finally, *Applying Knowledge.* Each of these subcomponents is supported by video episodes of teachers interacting with children and with Internet links through the Website. The same approach is used for each of the six components.

Children as Learners

This component addresses general theories and strategies that guide the learner and provide insights into children's learning within a constructivist framework. Theories about children as learners are numerous with no less than fifty relevant to teaching (Kearsley, 2002). Given that the central role of teaching is to enable the child to become a learner (Fenstermacher, 1986), this component focuses on ways an effective learning experience can be generated. This component draws attention to the need to consider generic issues in learning. Six subcomponents are illustrated with video episodes. These address issues such as: *Active Engagement*, *Child-Centred Learning, Children's Explanations, Individual Differences, Reporting Ideas,* and *Social Learning.*

Learning Science
Knowing how to explain scientific concepts in ways that help students understand is a key teaching skill that has been described by Schulman (1986) as pedagogical content knowledge. Knowing the types of ideas that students have concerning particular concepts, knowing where students have difficulty in understanding concepts and knowing how to relate new scientific concepts to existing knowledge is the most important skill of a good teacher. Pedagogical content knowledge is as important as the actual content knowledge that teachers should have (Osborne & Simon, 1996). Conceptual change teaching (e.g., Hewson, Beeth, & Thorley, 1998) challenges preservice and practising teachers to encourage children to articulate their initial, naïve beliefs or even misconceptions and to provide experiences that challenge these beliefs. Thus, conceptual change teaching attempts to generate conflict as a means of helping children to recognise that their prior ideas may be inappropriate. Video episodes were provided to demonstrate strategies such as: *Connecting Ideas, Prior Knowledge, Real-World Links*, and *Reconciling Ideas.*

Teaching Strategies
Effective teaching involves establishing learning environments and situations that enable learners to engage with the content (e.g., Collins, Brown, & Holum, 1991; Ciardiello, 1998; Gattis, 1998). While there are numerous teaching strategies that facilitate this process, some important strategies predominate in science teaching. Video episodes are included in which the teachers engage in strategies such as: *Demonstrating, Developing Vocabulary, Discrepant Events, Evaluating Learning, Explaining*, *Guided Investigation, Guided Reporting, Questioning, Scaffolding,* and *Supporting Thinking.*

The Learning Environment
Effective learning environments permit and encourage children to engage in reflective experiences in which they work together and support each other. There are opportunities to discuss ideas, undertake investigations and use a variety of tools and information resources in their guided pursuit of learning. Characteristic of the environments emphasised in the video segments were the teacher-student relationships which challenged traditional teacher centred classroom environments. Episodes depicting a range of issues include a focus on: *Classroom Climate, Classroom Organisation, Informal Learning* and the use of a range of *Resources.*

Content
Scientific literacy is an awareness of the key ideas, conventions and methods of science so that a scientifically literate person has access to scientific knowledge, is able to use that knowledge as a citizen and contribute to decision-making in a technological and scientific society (Bybee, 1997). Scientific knowledge is burgeoning at a tremendous rate and new disciplines are forming which draw upon basic scientific ideas in new and integrated ways. Teachers must be able to introduce students to science that is relevant and meaningful in their lives. Hence, several features related to the identification of content are: *Curriculum Integration, Interest-Based Approach,* and *Key Concepts*

Evaluation

Evaluation of the materials and approach were undertaken in both a clinical and a naturalistic setting. Although specific groups were approached for evaluation, feedback from potential users was sought throughout the production of the multimedia resources. Professional feedback included responses from science lecturers, science curriculum officers, and feedback from teachers. The endorsement of the multimedia resources by the profession was critical because these products are designed to assist students to become members of the professional community and need to be authenticated as representative models of practice (Flinders & Eisner, 1994). Specifically, evaluation occurred in three phases.

First, during development of the resources we worked with preservice students to explore technical issues. CDROMs were distributed towards the end of Semester 2 2001 to approximately 20 students who worked in groups to evaluate the program for both technical quality and educational usefulness. The students were selected from both Early Childhood courses and Primary Science Education courses. These students were monitored using a "Genlock" facility through which their physical use of the CDROM could be monitored. They also responded to a series of questions that probed both the technical and pedagogical usefulness. While students were evaluating the material, feedback from Science education staff in both early childhood and primary courses was also obtained. Data sources included video recordings of student interactions, responses to a series of questions that probed the strengths and limitations of the material and follow up interviews with selected students.

Second, the resource was evaluated through application with inservice teachers. Approximately 100 senior teachers, who were responsible for professional development within their schools or districts, attended a professional development workshop. The sessions were led by one of the authors (CMD) who drew upon the resource as stimulus. Feedback from these teachers was obtained by formal survey incorporating a single open-ended question requesting participants to identify the most effective strategy used during the workshop.

Third, the final product material was piloted with a group of preservice primary teachers as part of their regular course. The four staff responsible for teaching in the target preservice course were briefed on the material and provided with guidance concerning its purpose and use. The material was introduced to students early in semester and each week a 30-minute session was conducted in which students explored a particular aspect of materials. Focus group sessions were held with two groups of students and interviews were conducted with teaching staff.

Results

In phase 1, students provided detailed feedback on both technical and content issues. The intent was to establish the ease of use of the resource as well as to monitor how students used the material. Feedback from students was also of particular importance to ensure that the resources were appealing and were easily usable. Feedback from students also enabled the refinement of some technical features of the program. Students also responded to a series of questions that probed pedagogical usefulness.

Patterns of use indicated students focussed on viewing videos segments with intermittent use of other options, which assisted in understanding the theme being illustrated. At the end of the session, they completed an open-ended evaluation form. The following feedback is representative of the endorsement provided by a group of 20 students in both early childhood and primary courses.

- *Early childhood student teacher:* Made me think about how to engage the children. The video excerpts are excellent.
- *Early childhood student:* Really enjoyed looking at it (CD) (and) will look forward to sharing it with others in the future.
- *Primary student teacher:* (The CD) was very useful. Being able to learn from a visual stimulus enabled me to see the application of teaching strategies.
- *Primary student teacher:* Videos were very useful in getting a grasp on how to teach science in an effective way.

Comments from two of the lecturers involved in teaching these students complemented the students.

- *Lecturer 1:* The video excerpts are good examples of the principles being presented: A valuable and useful resource.
- *Lecturer 2:* I believe that it has very good potential to be used with preservice primary and early childhood students. I would certainly make use of it in my teaching as I thought it has great potential.

Feedback from teachers in phase 2 was exceptionally positive and teachers indicated that they would be sharing these resources with their colleagues. Although there was little discussion of the framework of components, there was general consensus that the video excepts in the CDROM provided highly credible vicarious experiences of teaching science. The comments ranged in scope including the value as a resource that provides a supportive and credible resource to encourage teachers to implement science. The following comments are representative of the range of expressed opinions.

- Provides an excellent resource for all staff members to use. Both CDROMs were non-threatening and therefore would engage even the most reluctant science teacher.
- Very helpful for our graduate teacher and our non-science oriented staff member.
- An insight into what "Science' looks like in a classroom. An insight into "how easy" Science can be. An inspiration to non-Science teachers.
- It will engender INTEREST, which has been lacking.
- Show a clearer way of implementing the science syllabus.
- Will be used as part of the Professional Development program for the cluster on Pupil Free Day – Term 2.
- I will conduct 3 or 4 sessions with my staff on the CD and Video Resources.
- The video excerpts are good examples of the principles being presented. A valuable and useful resource.
- I believe that it has very good potential to be used with preservice primary and early childhood students. I would certainly make use of it in my teaching as I thought it has great potential.

The focus group sessions conducted in the third phase of the evaluation identified three general responses to the use of the CDROM as a stimulus for discussion. These themes were held approximately equally by the students. One response identified the material as a source of ideas related to teaching science. This response – the 'ideas approach' – was typified by the following comment:

> I'm hopeless at remembering things but it's divided into the different you know like working scientifically and things so I was able to look at that and think to myself oh that's an idea I could do it that way, it just makes me feel a bit more comfortable about ways that I could implement them and things like that

In related comments, other students discussed the strategies used by the teachers in the video. In particular, there approach in interacting with students, their teaching plans (which are incorporated into the CD and website resources) and details of the topics being taught.

In the second type of response, students described the resource material as a useful benchmark to map their performance or the performance of their practice teaching supervisors:

> *The lesson was good for me because it gave me some sort of a benchmark.* I wasn't completely sure how well or how effectively I was teaching science, so looking at that, and we actually, in our tutorial, we did like (sic) critiques about how they were teaching science, and I often thought well, you know, I could model my teaching or assess or critique my teaching based on what we were presented.

The third group of responses were related to the future value of the resource and were typified by the following comment:

> It's a good resource and probably in the next couple of months, preparing for teaching, it's something that I will go back to, looking at science.

Students making this type of comment were concerned that the activities involving the use of the resource materials were not being directly assessed. They were highly goal focussed on only those activities that were assessable. Hence, they argued that the resource would be more valuable when they actually started teaching. Indeed, one student commented that his practice teaching supervisor employed the resource to demonstrate to colleagues some issues in teaching.

The four instructors in the course related quite similar experiences. They were strongly aware that the students valued the opportunity to examine the practices of the teachers in action. A comment that captured the common sense of how the CDROM impacted was expressed by one instructor who stated: "(We) talk and talk about constructivist teaching and they (students) never see it".

A final comment relates to the use of the material by one part-time instructor, who was herself a full-time classroom teacher and her school's science coordinator. She related in an interview the alacrity with which teachers in her school engaged in analysis and discussion of the teaching in the CDROM video episodes. She noted in particular, that in the absence of assessment pressures, the inservice teachers were highly motivated by the videos and developed teaching strategies based on the resource material for implementation in their own classrooms.

Conclusion

In this paper, we have described the development of a theoretical framework and a multimedia-based resource for use in preservice and inservice teacher education. Although the focus and motivation was to develop a resource for preservice teacher education as a response to the long standing deficiency in opportunities to see effective models of primary science teaching on practicum experiences, the material also provided a powerful resource for inservice teachers. Feedback from students, teachers and university academics has highlighted the extent to which this resource addresses a major deficiency in teacher education. Vicarious learning through the study of credible and quality teaching has the potential to impact on teacher confidence and provide insights to a range of strategies. The use of an organising framework, in this case six themes, provides a structure for beginning teachers and experienced teachers to deconstruct teaching practices. A feature of this study to be pursued relates to the way in which students and teachers used the framework to analyse the teaching episodes. In conclusion, the study supports the value of multimedia material as a vicarious learning experience; and highlights the extent that multimedia can demystify science teaching.

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