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Multimedia Resources to Bridge the Praxis Gap: Modeling Practice in Elementary Science Education

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Numerous research studies have shown that science methods courses based on constructivist approaches can enhance teacher knowledge and confidence in ways that foster more positive attitudes to the teaching of science. However, a critical part of reflective practice is the opportunity to observe competent professionals practising their craft. Opportunities to observe teachers engaging in constructivist and inquiry based practices in many undergraduate programs are limited. Our goal was to make visible the pedagogical practices and assumptions of teachers through a suite of multimedia resources that provided visual examples of professional practices. In this paper, we report on the development and use of these multimedia resources. These resources incorporated interactive CDROMs, videos and websites and supplemented an instructional program that engaged learners in a range of reflective practices.Evaluation data were derived from focus group interviews with preservice teachers, from interviews with instructors and from surveys with inservice teachers. Analysis of these data supports the value of multimedia material as a vicarious learning experience; and highlights the extent that multimedia can demystify science teaching.

Introduction

Although the importance of science in a technological society is widely endorsed, there are ongoing concerns about the quality of elementary science teaching. We propose that the use of multimedia technology can impact on preservice elementary science education to improve the quality of learning in teacher education programs. In this paper, we report on the development and use of multimedia resources to illustrate the teaching of science in elementary schools within a constructivist, inquiry-oriented framework. These learning resources, which are designed around interactive CDROMs, supplement an instructional program that engages learners in a range of inter-related ways (Watters & Ginns, 2000). The multimedia resources have been validated by experienced teachers and used within preservice elementary science teacher education programs. Through interactive engagement with the materials, students explore theoretically justified teaching practices. The evaluation of the materials indicate that preservice teachers benchmark themselves against the practices of the teachers, gain insights into science teaching ideas and see value in the resource as a reference for future practice.

Our rationale for the designing multimedia resources for the preservice science teachers' courses was based on the observation that preservice teachers returning from practicum had varied experiences of teaching science. Some had observed or taught science, whereas others had very limited exposure. Although some supervising teachers are credible mentors for preservice teachers, others themselves lack knowledge of effective science teaching (Abel & Roth, 1992; deLaat & Watters, 1995). This latter situation highlights one of the problematic aspects of mentoring (Awaya et al., 2003) or coaching (Eggers & Clark, 2000), which have been advocated as ways to enhance elementary science education. An important element of active learning underpinning successful teacher preparation is to observe experts in action. Experience in the practice of teaching provides the opportunity to generate theories about practice. This requires preservice 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 preservice teachers rarely engage with effective teachers of science in schools during practice teaching visits, and hence, they have limited shared experience to engage in reflective/critical discussion about their experiences when returning to university classes. Masingila, Ochanji, and Pfister (2004) argue that engaging students with multimedia resources incorporating teaching cases overcomes some of these recognized limitations of practice teaching experiences.

Kelly (2000) noted that science methods courses based on a holistic, constructivist approach can reform and enhance teacher knowledge, confidence, and attitudes and can lead to the adoption of effective strategies in teaching science in the elementary science classroom. Our goal was to make visible the pedagogical practices and assumptions of teachers through educative curriculum materials that encouraged inquiry and thinking about teaching (Ball & Cohen, 1996). The multimedia resources were seen as a key component in our teaching strategies which provided new perspectives on science teaching, engaged preservice teachers in discussion about science teaching and supported the construction of understanding of effective teaching practices in a student-centered environment (Watters & Ginns, 2000). This paper describes the development of the multimedia resource and its theoretical foundations and professional authenticity.

Background

The development of these materials and subsequent implementation were influenced by theoretical perspectives drawn from studies in elementary science education, and the role of technology in supporting learning. First, we discuss the major issues confronting the preparation of elementary science teachers and the role they play in fostering students' interest in science. Second, we identify the critical aspects of technology in learning and how technology can provide an effective resource for enhancing the education of preservice science teachers.

Elementary Science Teacher Education

The importance of science in the elementary school years is well established. Many have argued that scientific literacy is critical to address many major social and economic problems emerging with the development of a globalized society (Fensham, 2002). Hodson (2003), for example, has argued that:

> *Science and technology education has the responsibility of showing students the complex but intimate relationships among the technological products we consume, the processes that produce them, the values that underpin them, and the biosphere that sustains us. (p. 660)*

Children's interest in science is high in the early years of schooling, but drops markedly after 10 years of age (Murphy & Beggs, 2003). This loss of interest has been attributed to less investigative science practices in the middle years of schooling. This situation is often attributed to a lack of confidence and competence to teach science among elementary teachers (Harlen, 1997). Indeed, internationally there is concern about the quality and extent of science teaching in the elementary school and primary schools (Goodrum, Cousins, & Kinnear, 1992; Goodrum, Hackling, & Rennie, 2001; Harlen & Simon, 2001; Stevens & Wenner, 1996; Tilgner, 1990; Watters & Ginns, 1995). Clearly, teachers assume a critical role in fostering students' interest in science. The quality of teaching is seen to be central to enhancing student interest, and hence, the development of scientific literacy. For example, Batterham (2000) in a report on the status of science in Australia stated, "Excellent teachers are the key to exciting and sustaining interest in science" (p. 50).

Although attributing the problems of elementary science teaching to the quality of teacher education or practicum is appealing, the difficulty is in challenging entrenched practices. Teachers are prepared for their career in unique ways. As many have pointed out, teachers often spend 13 or more years in classrooms as students observing the practices of teachers

(Bryan & Abell, 1999; Lortie, 1975). Such apprenticeship produces culturally conditioned views about teaching, which often do not align with contemporary expectations (Lee & Krapfl, 2002). When experiencing their initial classroom practice teaching experiences, preservice teachers are confronted with a range of management issues, and are often encouraged to focus on the techniques and mechanics of teaching. Gale and Jackson (1997) describe this approach as "a discourse that casts the supervising teacher in the role of master and the student teacher as apprentice, with the supervisory relationship geared towards equipping preservice teachers with the techniques to put them more completely in control of the classroom" (p. 177). In this situation, preservice teachers rarely engage in critical analysis of teaching and learning situations, and hence, their experiences perpetuate the status quo. Research on beginning teachers appears to suggest that they "wobble" in their beliefs about pedagogical practices during induction (Simmons et al., 1999), and hence, at this juncture they could either adopt effective student-centered practices or conform with more traditional didactic approaches depending on the support and context (Luft & Patterson, 2002). In their formal university courses, preservice teachers are introduced to contemporary ideas and theories and often encouraged to reflect on the social, cultural issues of teaching—for example the meaning of scientific literacy and the purpose of science. These reflections are often developed in individual ways but, devoid of opportunities to examine these assumptions in practice, thus, there is superficial engagement with these ideas in a social context (Luft & Patterson, 2002). Collegial exploration of the contradictions in teaching is necessary for preservice teachers to develop sound praxis. Put simply, preservice teachers experience university courses in which messages about effective science teaching can be extensively at odds with their experiences in the classroom and which often contradict science education reform (Barnett, Harwood, Keating, & Saam, 2002; Wang & Odell, 2002; Yerrick & Hoving, 2003).

For preservice teachers, there is limited understanding of what constitutes effective science teaching despite the extensive research conducted over the last two decades, which has provided greater insights into effective teaching and learning practices in science classrooms (e.g., for a discussion of the literature see Ginns & Watters, 1999). 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 characterized 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. Clearly, teachers need to provide learning experiences that excite students, that make learning meaningful, and that provide those broad knowledge and intellectual skills that underpin scientific literacy. Unfortunately, the research cited previously reveals that the practice in many elementary schools is still dominated by a didactic mode of instruction in which teachers and students view knowledge as a commodity to be acquired largely through memorization.

Herein lies the dilemma. Ost (1989) commented that potential teachers enter the profession with well-developed sets of rules that govern teacher behaviors. These rules are well entrenched and reinforced when these preservice teachers observe practicing teachers applying didactic approaches to the teaching of science, which are often at odds with preferred practice espoused by teacher educators (Lee & Krapfl, 2002). Changing preservice teachers' attitudes about teaching science is a major challenge and responsibility of teacher educators (Mellado, Blanco, & Ruiz, 1998). Ginns and Watters (1999), drawing upon social learning theory, argued that preservice teachers needed to experience success and engage in authentic practices involving credible role models. Personal and vicarious experiences are powerful antecedents to behavior (Bandura, 1977, 1997). Lee, Dineen, McKendree, and Mayes (1999) have demonstrated substantial positive changes in attitudes and discussion behavior for students having access to vicarious learning resources. Observing episodes of effective teaching can have a powerful effect on preservice teachers entrenched beliefs about the teaching of science. We now turn briefly to considering effective ways of using technology.

Using Technology for Learning

Numerous technological innovations over the years have been promoted to reform education. Pea (1985) suggested that educational technologies can and should be used to provide opportunities to stimulate the mind to learn. This stimulation should go beyond drills and memory games to help the mind visualize, manipulate, and represent information in a new and different format. However, the true challenge is not just to put advanced technologies in our schools and universities, but to identify effective ways to design and use these new technologies to enhance learning (Henry & Clements, 1999; Jonassen, Peck, & Wilson, 1999; National Science Board, 1999; Papert, 1997). However, uptake of technology in education has been slow and attributed to a range of socio-cultural issues such as the mismatch between user-needs and the technology, and a failure to carry out usability testing in the context of meaningful social and professional contexts (Robertson, 2003).

A common application of computers and multimedia particularly in schools and universities has been the development of online technologies as a resource to foster collaborative knowledge construction, to move learners away from focusing on procedures toward high level cognitive processing and knowledge generation (Jacobson & Jacobson, 1998; Reeves, 1998). The use of online technology as "mindresources" has been well researched in the fields of science and mathematics in particular (Jonassen, Carr, & Yueh, 1998). Mindresources offer students the opportunity to engage in critical thinking and cognitive amplification of what they already know (Glaserfeld, 1996; Wilson, 1996). The research supports online integrated, investigatory-based long-term projects (e.g., Krajcik & Starr, 2001; Linn & Hsi, 2000; Roschelle & DiGiano, 2002). Another application of technology includes the range of usual software such as Word Processors, Spreadsheets and presentation packages as well as simulation software, communication facilities and CD-ROM based databases (Rodrigues, 1997). A further technology application is in the form of simulations, virtual reality and case-studies that open up new forms of experience, discourse, and reflection. This latter approach increases the potential for meaningful interaction which occurs when the outside world is brought into the classroom via multimedia technology allowing learners virtual experiences they could not have in real life (Debski, 1997). The fundamental educational advantage of multimedia, for example CDROMs, videos, and websites, is that through virtual experiences these resources provide integrated visually and linguistically rich sensory input that enhance the users' learning experiences (Mayer, 1997). We have adopted the latter approach.

Developing Multimedia Resources

The implications for the design and use of educational multimedia resources are that the resources need to promote active engagement in students and avoid being simply information repositories (Grabe & Grabe, 1998). Hence, educators need to be vigilant that the technologically based learning environments that they design have instructional integrity. Mayer (1997) has proposed explanations for learning in multimedia environments through his generative theory of multimedia learning:

> *In a generative theory of multimedia learning, the learner is viewed as a knowledge constructor who actively selects and connects pieces of visual and verbal knowledge. The basic theme of generative theory of multimedia learning is that the design of multimedia instruction affects the degree to which learners engage in the cognitive processes required for meaningful learning within the visual and verbal information processing systems. (p. 4)*

Mayer's (1997) theory is based on a theory of meaningful learning, which draws on Wittrock and others' work on generative theory and Paivio and others' work on dual coding theory. Generative theory contributes the understanding that "meaningful learning occurs when learners *select* relevant information from what is presented, *organize* the pieces of information into a coherent mental representation, and *integrate* the newly constructed representation with others" (Mayer, 1997, p. 4). Dual coding theory explains that "cognitive processes occur within two separate information processing systems: a *visual* system for processing visual knowledge and a *verbal* system for processing verbal knowledge (Mayer, 1997, p. 4). The elements of generative theory and dual coding theory are evident in the graphic representation of Mayer's theory of meaningful learning in a multimedia environment in Figure 1. According to Mayer, meaningful learning in a multimedia environment consists of the learners "selecting words and selecting images from the presented material, organizing words and organizing images into coherent mental representations, and integrating the resulting verbal and visual representations with one another" (p. 4).

The generative learning theory (Mayer, 1997) has been well supported in an extensive series of experiments with various materials. While Mayer's work provides some insight into learning via instructional multimedia, he also acknowledges that technology is advancing faster than knowledge of how people learn from the technology. Stemler (1997) distinguishes between the learning process and the technology in multimedia arguing that interactive multimedia should be viewed as a process rather than a product that alone will provide learners with new learning potential. Thus, to capitalize on the technology, multimedia resources need to be used effectively. Laurillard (1999) also emphasizes the need to ensure that multimedia products are interactive in that preservice teachers are required to attend and discuss information, thereby, generating a stimulating education experience. Mayer's model illustrates the sensitivity of the learner to the external environment—how specific information is represented and structured, and the ease with which it can be retrieved and organized externally. Video-based information represents a form of mediated information (Kozma, 1991) characterized by a pictorial symbolic system accompanied by audio and dynamic presentation. It is manipulable in so far as the user can scan through, stop, rewind or and freeze frames at will. Such dynamic presentation of information in which video elements, script elements (transcriptions), and interactive questioning should provide cues that help the user develop rich mental models of the situation depicted. This richness emerges from the considerable computational efficiency in the processing of visual information (Larkin & Simon, 1987).

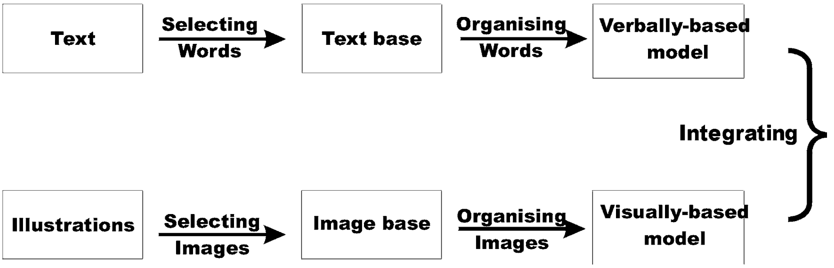


Figure 1. *A generative model of multimedia learning (Mayer, 1997, p. 5).*

The implications for designers of instructional multimedia are that the learning process should be foremost in the design process, and the technology should be used selectively to enhance the learning process. According to Stemler (1997), successful instructional multimedia: (a) gets the learner's attention, (b) helps the learner to find and organize pertinent information, and (c) helps the learner to integrate information into his or her knowledge base. These processes of attending, organizing, and integrating which Stemler derived from the literature is closely aligned with Mayer's model of select, organize, and attend. Stemler argues that multimedia supports these processes through five features of multimedia: (a) screen design (visual elements: color, text, graphics, and animation), (b) learner control and navigation, (c) use of feedback, (d) students' interactivity, and (e) video and audio elements (p. 349). His literature review provides extensive guidelines for the design of various types of instructional multimedia using these features. The main principles identified by Stemler are shown in Table 1.

To address the need for an effective learning experience for preservice elementary science teacher, a technology-based approach was implemented. The aim of this project was to generate technological resources that afforded opportunities to reflect upon the practices of experienced teachers engaged in inquiry-based science.

Multimedia Resource Development

The development of the multimedia resource occurred in four phases: *Developmental Phase, Technical Phase, Authentification Phase*, and *Implementation Phase*. The first phase of this project required the identification of appropriate content guided by a theoretical framework. The second phase comprised the technical design, preparation, and trialling of multimedia resource. The third phase involved practicing teachers and educational experts reviewing the resources and providing credible criticism (Flinders & Eisner, 1994). The final phase was the implementation of the multimedia resource with a cohort of preservice teachers. These phases and the associated evaluation are now described.

Phase 1: Identifying Content

A situational analysis (e.g., Print, 1993) involving 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, which is compatible with curriculum directions at state, national, and international levels, emphasizes an interactive, inquiry approach to science. Six key components were identified to guide preservice teachers in planning and implementing effective science in the primary school. These components addressed the following themes: "Working Scientifically"; "Children As Learners"; "Learning Science"; "Teaching Strategies"; the

Table 1

Features of Multimedia and Associated Design Principles

Features	Principles
1. Screen Design (Stemler, 1997)	Focus the learner's attention Develop and maintain interest Promote processing Promote engagement between the learner and lesson content Help learners find and organize information Facilitate lesson navigation
2. Interaction (Orr, Golas, & Yao as cited in Stemler, 1997)	Provide opportunities for interaction Chunk the content and build in questions and summaries Ask questions but avoid interrupting the instructional flow Use rhetorical questions to get students' to think about content and to stimulate curiosity Provide for active exploration in the program rather than a linear sequence
3. Feedback (Orr, Golas, & Yao as cited in Stemler, 1997)	Keep feedback on the same screen as the response Provide feedback immediately following a response Provide feedback to verify correctness Tailor feedback to the individual Provide encouraging feedback Allow students' to print feedback
4. Navigation (Stemler, 1997)	Clearly defined procedures for navigation and support Consistency in screen structure and location of keys Use of familiar icons on control panels Progress map or chart to show location within a program Help segments with additional information to allow a learner to follow interests and construct his or her own learning experiences
5. Learner control (Jones as cited in Stemler, 1997)	Provide selectable areas for users to access information Allow users to access information in a user-determined order Provide maps so students can find their locations and allow students to jump to locations Provide feedback if there are to be time delays on accessing information Arrange information so users are not overwhelmed by the quantity of information Provide visual effects and give visual feedback

Table 1

Continued

Features	Principles
6. Color (Stemler, 1997)	Use sparingly and consistently with a maximum of 3–6 colors per screen Use brightest colors for most important information Use neutral colors for backgrounds and dark colors on a light background for text Avoid combining complementary colors (e.g., red/green) Use commonly accepted colors for particular actions (red for stop) Avoid hot colors on the screen as they appear to pulsate
7. Graphics (Stemler, 1997)	Graphics include photos and scanned pictures Icons and photos enhance menu screens Information is better understood and retained when supplemented with graphics Avoid graphics for decoration or for effect Use graphics to indicate choices (e.g., left/right arrows)
8. Animation (Stemler, 1997)	Can be motivational and attention getting Useful for the explanation of dynamic processes Subtle benefits by highlighting key information, heightening interesting, and facilitating recall
9. Audio elements (Orr, Golas, & Yao as cited in Stemler, 1997)	Use audio when the message is short but audio rather than text for long passages Do not let audio compete with text or video presentation Provide headphones Tell students what is relevant and chunk the message with other instructional activities
10. Video elements (Stemler, 1997)	Use video as an advance organizer or a summation Synchronize video with content, and reinforce/repeat the concepts being presented

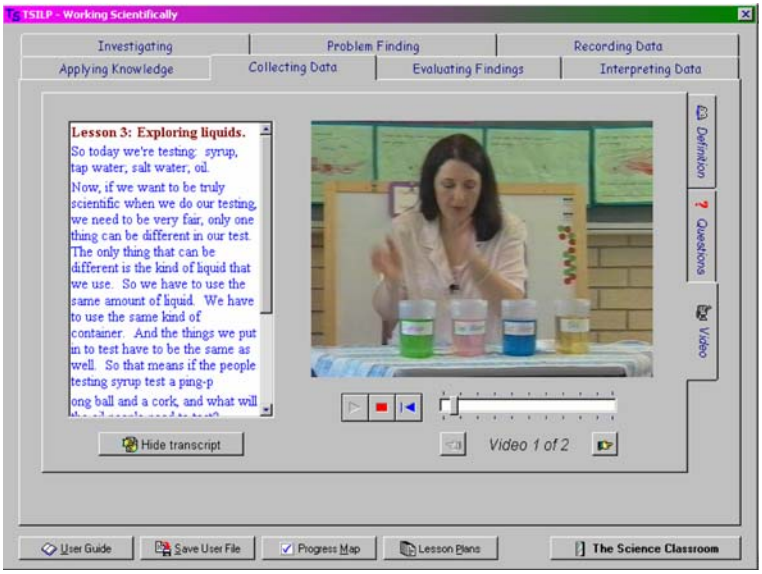
"Learning Environment" and "Content." As shown in Figure 2, these six components were used as the theoretical framework for the CDROMs and underpinned instruction depicted in the associated videos. The literature review examined a broad range of published research and curriculum documents. The key issues and themes emerging from the literature were pooled and organized into these components and sub-components. We invited colleagues and other science educators to critique the model and provide suggestions which were subsequently incorporated. Each component is briefly

Figure 2. *The science classroom.*

described. The development of these multimedia resources is described in Phase 2.

Working Scientifically. More recent syllabus developments 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, hypothesizing, data collection and reconciliation of evidence and hypothesis. Working scientifically is illustrated in the CDROM by a selection of sub-components identified as: ‘‘Problem Finding,’’ ‘‘Investigating,’’ ‘‘Collecting Data,’’ ‘‘Recording Data,’’ ‘‘Interpreting Data,’’ ‘‘Evaluating Findings’’ and finally ‘‘Applying Knowledge’’ as shown on Figure 3 on the horizontal tabs of the screen. Each of these processes is supported by video episodes of teachers interacting with children and with Internet Links to appropriate readings through the Website. The same approach was used for each component.

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 50 relevant to teaching (Kearsley, n.d.). 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. Six sub-components are illustrated with video episodes. These address issues such as: ‘‘Active Engagement,’’



Lesson 3: Exploring liquids.

So today we're testing: syrup, tap water, salt water, oil.

Now, if we want to be truly scientific when we do our testing, we need to be very fair, only one thing can be different in our test. The only thing that can be different is the kind of liquid that we use. So we have to use the same amount of liquid. We have to use the same kind of container. And the things we put in to test have to be the same as well. So that means if the people testing syrup test a ping-p

ong ball and a cork, and what will

Figure 3. *The sub-component menu for working scientifically.*

"Child-Centered Learning," "Children's Explanations," "Individual Differences," "Reporting Ideas," and "Social Learning."

Learning Science. Knowing how to explain scientific concepts in ways that help preservice teachers to understand is an extra 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). Some ways of addressing these issues in learning science follow: "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). Although there are numerous teaching strategies that facilitate this process, some 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 resources and information resources in their guided pursuit of learning. Episodes depicting a range of issues include a focus on: "Classroom Climate," "Classroom Organization," "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 Approach."

Phase 2: Technical Design

The multimedia resources were designed to provide integrated visually and linguistically rich sensory input that enabled approximately 20 early childhood and primary preservice teachers to view, analyze, and discuss the practices of two teachers. These materials included interactive CDROMs, videoed lessons and a website. These six components discussed in Phase 1 provided the framework for each of these resources.

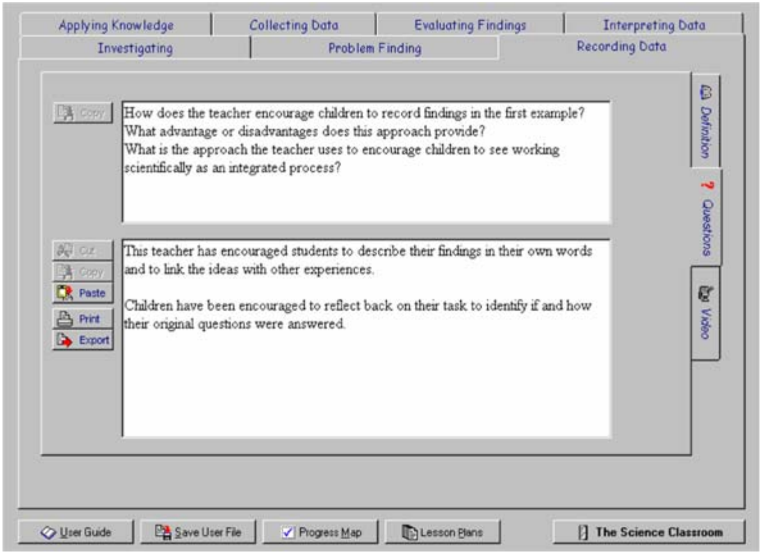
Videos. Two videos were produced from the filming of a series of three lessons in lower and upper elementary classes to provide explicit and authentic examples of classroom science teaching. The lower elementary video focused on the topic of "Floating and Sinking" (90 min) (Diezmann & Watters, 2001a) and the upper elementary video on "Finding out about the past" (60 min) (Watters & Diezmann, 2001a). A further shortened video was produced to highlight critical elements of teaching science (Diezmann & Watters, 2002a). The authors and teachers collaboratively planned these lesson to ensure that six component-model of science teaching was explicated.

CDROMs. The core elements in the multimedia package were two interactive CDROMs. One CDROM focused on lower elementary content (Diezmann & Watters, 2001b) and the other on upper elementary content (Watters & Diezmann, 2001b). These CDROMs were designed in accord with theory on multimedia learning (Kozma, 1991; Laurillard, 1999; Mayer, 1997; Stemler, 1997). Thus, these CDROMs were designed to support preservice teachers to interactively engage with visual images, theoretical explanations of strategies, and to identify underlying structures that frame effective teaching. The CDROMs show key theoretical ideas in practice by using video examples from the lower (Diezmann & Watters, 2001b) or upper elementary videos. The structure of the CDROMs is identical. However, the content varies according to whether it is a CDROM to illustrate lower or upper elementary teaching. Full lesson plans are available on the CDs to provide a context for the video excerpts. A hypertext arrangement of information contributed to the construction of a multimedia environment in which visual and textual elements were combined with interactive question-response options.

The layout of the lower elementary CDROM has been shown in Figures 2 and 3 with the major components and sub-component menus. The main menu on the CDROMs was the *Science Classroom*. This screen presents the six component framework (Figure 2) that was described earlier. This menu allows the user to select various options. The visually symmetrical layout emphasizes a non-hierarchical structure. When a user selects one of these components he or she is presented with a sub-component menu that provides a range of choices designed to analyze and deconstruct a particular component within the lessons. For example, if the user selected "Working Scientifically" he or she may then further select an aspect of working scientifically, such as "Collecting Data" (Figure 3). These sub-component screens feature video and transcript information.

There are two additional screens associated with each sub-component screen that can be accessed from the vertical tabs on the right-hand side of the screen. One screen provides a succinct description of the sub-component for those who may be unfamiliar with the terminology. The other screen provides a stimulus question about the video excerpt to support users' analysis of episodes for meaning and to facilitate reflection on how they might react in a similar situation (Figure 4). A question response section is also included on this screen. These responses can be saved, exported to a word processor, or printed. Users can also copy from this screen or the definition screen to construct reports or imbed into assignment work. The opportunity for users to examine the video episodes and respond to particular focus questions facilitates interactivity.

There is also a *Progress Map* on the CDROM, which provides an overview of the components and sub-components (Figure 5). This progress map automatically updates as users view videos or respond to questions. The map is "hotlinked" so users can quickly connect to any sub-component in

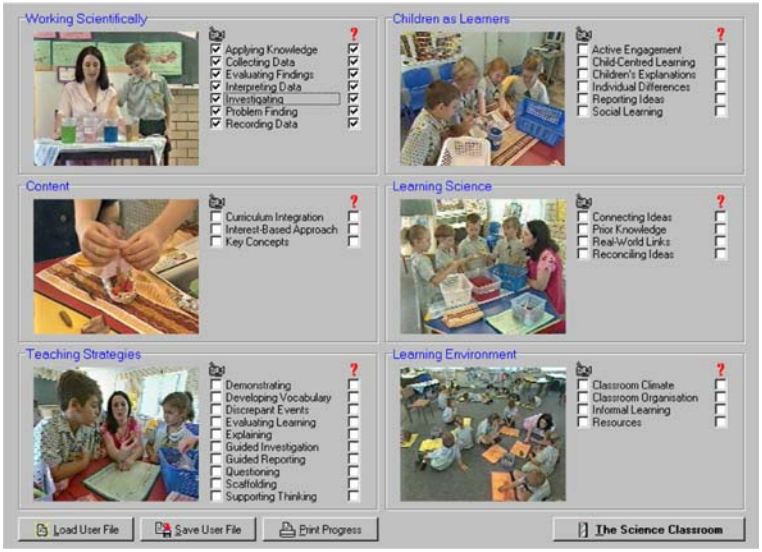


How does the teacher encourage children to record findings in the first example?
What advantage or disadvantages does this approach provide?
What is the approach the teacher uses to encourage children to see working scientifically as an integrated process?

This teacher has encouraged students to describe their findings in their own words and to link the ideas with other experiences.

Children have been encouraged to reflect back on their task to identify if and how their original questions were answered.

Figure 4. *Question screen with response section.*



Working Scientifically
☑ Applying Knowledge ☑
☑ Collecting Data ☑
☑ Evaluating Findings ☑
☑ Interpreting Data ☑
☑ Investigating ☑
☑ Problem Finding ☑
☑ Recording Data ☑

Children as Learners
☐ Active Engagement ☐
☐ Child-Centred Learning ☐
☐ Children's Explanations ☐
☐ Individual Differences ☐
☐ Reporting Ideas ☐
☐ Social Learning ☐

Content
☐ Curriculum Integration ☐
☐ Interest-Based Approach ☐
☐ Key Concepts ☐

Learning Science
☐ Connecting Ideas ☐
☐ Prior Knowledge ☐
☐ Real-World Links ☐
☐ Reconciling Ideas ☐

Teaching Strategies
☐ Demonstrating ☐
☐ Developing Vocabulary ☐
☐ Discrepant Events ☐
☐ Evaluating Learning ☐
☐ Explaining ☐
☐ Guided Investigation ☐
☐ Guided Reporting ☐
☐ Questioning ☐
☐ Scaffolding ☐
☐ Supporting Thinking ☐

Learning Environment
☐ Classroom Climate ☐
☐ Classroom Organisation ☐
☐ Informal Learning ☐
☐ Resources ☐

Figure 5. *Progress map.*

the CDROM. The Progress Map also enables users to save a record of their progress that can be retrieved in subsequent sessions. This feature allows multiple users to work from the same CDROM.

Website. The Website is titled Teaching Science in the Primary Years (Watters & Diezmann, 2002) and has four main sections. The "Teaching Science" web page links to web-based information about six components of effective science teaching: "Working Scientifically," "Children as Learners," "Content," "Learning Science," "Teaching Strategies," and "Learning Environment." The "Science Education" Sites links to various Websites including Children's Sites, Curriculum Sites, Science Museums and Science Teachers' Associations. The "Classroom Examples" links to example Lesson Plans featured on videos/CDs for lower and upper primary students, Background Resources for these lesson topics, and students' Work Samples from these lessons. The "Science Curriculum Units" links to other science education courses at our University.

Evaluation of technical and pedagogical issues associated with the multimedia resource was undertaken by approximately 20 volunteer preservice teachers from both Early Childhood courses and Primary Science Education courses. Groups of 2–3 students responded to a series of questions on an open-ended evaluation form that probed both the technical and pedagogical usefulness of the multimedia resource and its strengths or limitations. These preservice teachers were monitored using a "Genlock" facility, which synchronises video signals from the computer monitor and a video camera. Hence we were able to record both students' physical response to the software (e.g., nodding, discussions) and the corresponding screen image that they were viewing and track their movement through the software.

Analysis of the video recordings of students' interactions with the multimedia resource revealed that students focused on viewing videos segments with intermittent use of other options in the CDROMs. This information provided an insight into students' patterns of use of the CDROM. The students' written responses endorsed the relevance and applicability of the content of the CDROM and its presentation format. The following feedback is representative of the endorsement provided by these students.

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

Feedback from Science education staff in both early childhood and primary courses was also obtained. Consistent with the students, the staff endorsed the educational value of this resource.

- 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 feedback from staff and students resulted in minor programing changes and informed the development of an accompanying guidebook for instructors.

Phase 3: Authentification

The endorsement of the multimedia resources by the profession was also critical because these products are designed to assist individuals to become members of the professional community and need to be authenticated as representative models of practice (Flinders & Eisner, 1994). Thus, the resources were evaluated by practicing teachers. Approximately 100 highly experienced teachers, who were responsible for professional development within their schools or districts, viewed one of the videos and explored the CDROMs during a professional development program. The sessions were led by one of the authors (CMD) who drew upon the resource as a stimulus for supporting effective science teaching. Feedback from these teachers was obtained by a formal survey incorporating open-ended questions.

The teachers' responses were exceptionally positive and they indicated that they would be sharing these resources with their colleagues. Although there was little commentary on the framework of the components, there was general consensus that the video clips 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 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.

Phase 4: Implementation

The implementation of the multimedia resources coincided with major redevelopments in the Science Education (methods) subject. Changes were implemented as part of a longer standing program of reflection, evaluation, and revision. In keeping with the focus on technological multimedia resourcing and student-centered learning a number of new initiatives were developed including online website support, collaborative learning (Watters & Ginns, 2000), and global learning strategies (Watters et al., 2004). The science education subject was structured over a 9-week period with one 1-hr lecture per week, a 2-hr workshop in which students explored strategies in teaching science, and a 1-hr tutorial session in which they used and discussed the multimedia resource. This subject was undertaken by approximately 300 preservice teachers as part of either a 4-year preservice Bachelor of Education (Primary) program or a 2-year graduate Bachelor of Education Program (Primary) course. Eighty-five percent of the preservice teachers were female with almost 50% in excess of 25 years of age.

The four staff responsible for teaching in the science education subject were briefed on the material and provided with guidance concerning its purpose and use. In particular, teaching staff were encouraged to engage the students in discussion of episodes, unpacking the teachers' assumptions, comparing practices with their own practicum experiences, and to describe how practices could be adapted to their own situations. That is, to view the CDROM episodes as "prototypes that exemplify theoretical principles; precedents that capture and convey principles of practice; and parables that explore norms of practice" (Merseth & Lacey, 1993 p. 288). The material was introduced to students early in semester with an overview of the lessons depicted on video. Then each week a 30-min session was conducted in which preservice teachers discussed a particular strategy or practice exemplified in the CDROMs. For example, class discussions on the use of "Questioning Strategies" were followed up by explorations of the CDROMs for episodes depicting questioning. Preservice teachers were encouraged to critique and suggest ways the activity or episode reflected on the strategy being highlighted and how these strategies might be modified for implementation in their own assigned lesson plans. Students were encouraged to utilize the website throughout the semester to extend their reading on topics.

Feedback on this resource was sought from both students and their tutors. Two focus group sessions were conducted with, 12 volunteer students at the conclusion of the semester. Students in these groups were asked to discuss the educational value of the multimedia resources for their learning. These sessions were audio-taped, transcribed, and analyzed for themes. Three themes emerged from the analysis.

The first theme emphasized 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 preservice teachers 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.

The second theme was preservice teachers' use of the resource material as a teaching 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.*

Thus, these materials provide preservice teachers' with exemplars of effective practice, which allow them to evaluate their own practice against a professional standard. This constitutes the authentic feedback necessary for individuals to set goals, and monitor their progress and success through which they develop a realistic sense of self-efficacy.

The third theme that emerged was preservice teachers' perception of the future value of the resource and was 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.*

Preservice teachers 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 focused and only those activities that were assessable received any attention in the course. Hence, they argued that the resource would be more valuable when they actually started teaching. Indeed, one preservice teacher commented that his practice teaching supervisor employed the resource to demonstrate to colleagues some issues in teaching.

Interviews with the four teaching staff in the course revealed quite similar perceptions of student learning. Tutors were strongly aware that the preservice teachers 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 staff member who stated: "(We) talk and talk about constructivist teaching and they (preservice teachers) never see it (during their practicums)."

One of these tutors who worked in the preservice course was 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 when shown the materials. She noted in particular, that in the absence of assessment pressures, the practicing teachers were highly motivated by the videos and developed teaching strategies based on the multimedia resource material for implementation in their own classrooms. This feedback was consistent with that of the teachers in Phase 3.

Conclusions

In this paper, we have described the development of a multimedia-based resource for use in preservice teacher education. The materials were designed to provide insights into both classroom teachers' thinking and their students' thinking, which was displayed through their actions and interactions during the science lessons. Analysis by preservice teachers of these classroom interactions is important for developing effective practice (Borko, Bellamy, & Sanders, 1992). This resource provided a shared experience to reflect upon, discuss, and model. Feedback from preservice teachers, practicing teachers and university teaching staff has highlighted the extent to which this resource addresses a major deficiency, namely a lack of credible models of effective elementary science teaching. 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 organizing framework, in this case six thematic components, provides a structure for preservice teachers to deconstruct teaching practices.

Although the focus and motivation was to develop a resource to support preservice science teacher education, the material also provided a powerful resource for practicing teachers. The materials enabled preservice teachers and practicing teachers to examine their assumptions about teaching and to engage in reflective discussions about their assumptions. These outcomes were achieved because the multimedia materials enhance interest in science teaching by providing visual and verbal renditions of other teachers' classrooms. The technology incorporates exemplars, provides links to theoretical ideas, and affords opportunities for revisiting teaching episodes. Additionally, the multimedia materials provide a common reference point for discussions of science teaching by preservice and practicing teachers. Furthermore, these materials familiarize individuals with the language that is typically used in the science curriculum and research literature, which they can appropriate as a common language. Thus, the study supports the value of multimedia material as a vicarious learning experience; and highlights the extent that multimedia can demystify science teaching. The educative role of these multimedia resources is illustrative of how carefully designed curriculum materials have the potential to be agents for instructional improvement (Ball & Cohen, 1996).

These multimedia resources offer two further advantages. First, the multimedia resources can readily be used by learners at a distance and are relatively cost effective. Thus, these materials can be coupled with online learning, incorporated into off campus courses, or be used in on site professional development. Second, multimedia materials provide individuals with opportunities to develop experience and expertise in the use of technology in its own right. This potentially familiarizes them with the power of technology and a willingness to adopt technology within their own classroom. Ideally, this would result in technology being used as a learning resource—"a mind resource" in education (Jonassen et al., 1998). Through their own experiences in using the technology preservice teachers should come to value the practices embedded in online technologies.

In summary, this project has provided a window into classrooms in an environment supportive of discussion, debate and reflection. The material appears to be a promising approach to complement preservice elementary science teachers' experiences of teaching and learning. Initial set-up costs for the multimedia production were substantial; however, continued development and refinement are possible at minimal costs and reproduction costs are low. Our future direction in this project is to explore the impact on preservice and practicing teachers' practices attributable to their engagement with these materials. An avenue to be pursued relates to the way in which preservice teachers and practicing teachers use the framework to analyze the teaching episodes provided and their own teaching.

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