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# Information And Communication Technologies in Classrooms : Perspectives from an International Study

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# Information and communication technologies in classrooms: perspectives from an international study

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John Ainley is Deputy Director of the Australian Council for Educational Research (ACER) and head of its Policy Research Division. Since joining ACER in 1978 Dr Ainley has undertaken a number of policy-oriented research studies for Commonwealth and State education authorities and has chaired the steering committees for Commonwealth funded research projects conducted at other institutions. In the area of post-compulsory education, Dr Ainley has undertaken evaluations of a range of education and training programs, including national studies of subject choice and school retention, and currently has involvement in a program of *Longitudinal Surveys of Australian Youth* which studies the progress of cohorts of young Australians between school, post-secondary education and training, and work. He has also conducted national surveys of school-industry programs, which describe the scale and characteristics of work-based learning programs for students in Years 11 and 12 and has provided analyses and reports for the Graduate Careers Council of Australia on surveys of course experience by graduate and postgraduate students. He is currently engaged in a study of the nature of teaching in the Bachelor of Arts degree in Australian universities.

In the school programs area, Dr Ainley has conducted a range of research studies including: the definition and measurement of the socioeconomic status of school students published under the title, *(Socioeconomic Status and School Education, 1995)*; the achievements and attitudes to school of students in the primary school years *(Primary Schooling in Victoria, 1990)* with continuing involvement in research on factors that influence the quality of school life for students and the social outcomes of schooling *(Schools and the Social Development of Young Australians, 1998)*. Dr Ainley is currently National Research Coordinator for the Schools Around the World project that compiles and analyses samples of student academic work in science and mathematics from Years 4 and 8 in nine countries. He is also National Research Coordinator for Module 2 of the *Second Information Technology in Education Study*, which involves a series of case studies of innovative teaching and learning practices that use information technology.

Diana Banks is a Senior Research Fellow at the Australian Council of Education, with particular expertise in the area of educational ICT. She is currently preparing several of the case studies for Australia's participation in the Second IT in Education Study (Module 2). As well as her work with ACER, Dr Banks is an adjunct professor at the University of Canberra. She works as a consultant to Australian education systems, mostly in the area of educational ICT.

Banks has been an early childhood specialist as well as a school principal. She championed the systematic introduction of educational ICT to schools when she was an executive member of the ACT Department of Education between 1992-1996. In this role, she promulgated standards and protocols for school hardware and software, and established seed funding programs to encourage schools to take an innovative approach to ICT for learning and teaching. Her leadership at that time also led to all ACT schools being connected to the internet, the first Australian school system to do so. Later, Dr Banks became the Assistant Secretary of the Office of Government Information Technology which is an Australian Federal government agency. From 1996-1998, she managed the development and implementation of the Federal government's online service strategies.

Marianne Fleming is a Research Officer at ACER where she has contributed to several reports and articles on career development among adolescents and secondary schooling in Australia. She co-authored the two national surveys of School-Industry programs for the ASTF. Other accomplishments include her contributions to the national report on Subject Choice in Years 11 and 12, a project on the development of occupational interests among school students and the adaptation of a computer-based vocational guidance program (SIGI Plus) for use in Australia. Ms Fleming was also involved in two evaluations undertaken on School Annual Reports for the Victorian Department of Education. Most recently Ms Fleming has been working with the Catholic Education Commission of Victoria on a longitudinal study of literacy programs in the early years of schooling and a qualitative study of innovative pedagogical practices in schools using ICT.

Many countries have envisaged a significant role for information and communication technologies (ICT) in their education systems. For example, in Australia one of the goals in the declaration of the Ministerial Council on Education, Employment Training and Youth Affairs on national goals for schooling stated that students should be: confident, creative and productive users of new technologies and understand the impact of those technologies on society (MCEETYA, 1999). A national action plan, Learning in an Online World, has set three priority areas for development: making available connections of sufficient bandwidth to allow schools to integrate online services into curriculum practice; providing effective pre-service education and ongoing development for teachers; and developing high quality online content (EdNA, 2000). An information gateway provides access to relevant resource materials (Lonsdale, 2002). However, even among innovative schools there is wide variation in the ways in which ICT is utilised (Cuttance, 2001). In most countries there are a few schools that have been innovative in using ICT to change teaching practices. The IEA project, the Second International Technology in Education Study (SITES) Module 2 (M2) is a study of innovative teaching practices that are supported by the use of ICT.

## Methodology

### International

SITES M2 was designed to identify and describe innovative technology-based teaching practices in ways that might inform wider implementation, inform policy decisions related to ICT in schools and provide new ideas for the use of ICT in classrooms. It was conducted over the period from October 1999 through to July 2002. There were 28 countries involved in SITES M2. In total, the study generated 174 case studies. In these cases technology played a substantial

role; there was evidence of changes in the roles of teachers and students and there appeared to be positive student outcomes, where the practice was sustainable and transferable.

SITES M2 was essentially a qualitative study in which case study methods traditionally applied to small numbers were scaled up to encompass a large number of cases. In each country, common selection criteria (with the option for local modification) were used to identify innovative practices. A common set of methods was used to gather and analyse qualitative data about teaching practices, student learning the role of ICT in teaching and learning. Case studies were conducted using a common set of data collection instruments and analysis protocols. Researchers spent at least one week at each site observing classrooms, interviewing participants, conducting focus groups, gathering materials, products and documents and administering surveys. A data matrix format was used to reduce and organize the data. The matrix was then converted to a narrative account following a standard structured format. Typically a 10-page narrative for each case resulted. Finally, a number of quantitative analyses were used to identify trends and patterns in the narratives and to highlight examples that were explored in greater detail.

## National

### *Selection and data gathering*

To select cases a national panel of seven people was established. Those people provided experience in school system administration, knowledge of classroom practice and experience of research or evaluation studies related to ICT in schools. To be selected a case needed to show evidence of substantial change in student and teacher roles in pedagogy; involve a substantial role for ICT, show evidence of positive student outcomes and provide an expectation of being sustainable and transferable, and be innovative. In Australia innovative was interpreted as providing for enhanced student engagement and connections with other learning areas and contexts. Visits extending between one and two weeks were made to schools. Questionnaires were administered, interviews were conducted with school personnel and observations were made of the innovation in action. Photographic records and (in one case) videotape records were made. Table 1 contains an outline of the schools selected for study.

### *Case summaries*

*Cinderella is just-in-time: integrating English and History*. The novel *Chinese Cinderella* was the basis of a two-week integrated English/History unit for Grade 7 students at Toorak College in Victoria. Students investigated and analysed the lives of girls and women in China as they were portrayed in the novel. They were free to choose which resources to access, how to structure their approach to the task, and with whom they would work, and sought 'just-in-time' assistance from their teachers as they progressed. Students used a wide variety of ICT tools including Access Tool Box, Microsoft Front Page, MediaGram and digital cameras to develop personal e-portfolios that they stored on the school's intranet. In some instances, they were already quite adept at using the ICT as a result of their previous years at the school. However, they also used new kinds of ICT and developed new skills during this project, for example inserting sound and image files or simple programming to animate characters. Teachers designed an 'Ancient China WebQuest' which formed the preliminary support to students' research. The project was also used as a professional development programme within the school. All lessons were videotaped and documentation was available on the school's intranet.

*Using multi-media development tools to foster learning styles*. The Grange School in South Australia is a Reception to Grade 7 setting that uses ICT to emphasise growth in students' learning styles rather

| Type of school | Socioeconomic context | Grade level of innovation | Subject areas involved | Description |
|---|---|---|---|---|
| Independent K-12 | High SES | Grade 7 (ages 12-13) | History, English | Authentic learning in middle years using on-line multimedia technology |
| Government | Middle SES Primary K-7 | Grades K-7 (ages 5-13) | All subjects | Uses multimedia development tools with a focus on approaches to learning. |
| Government cluster of 49 schools | Varied | Grades 9–12 (ages 14-17) | Range of subjects | A virtual schooling service involving extending opportunities for secondary school students. |
| Government K-9 | Low to middle SES | Grades K-9 (ages 5-14) | All subjects | ICT plays a central role in school approach to teaching and learning |
| Government K-12 plus two K-6 | Low SES | Grade 6 (ages 11-12) | Not subject related | Orientation programme for primary students moving to secondary schools |

*Table 1 Case study schools and innovations*

than to present subject matter. The catalyst for this profound shift in pedagogy came about when Grange School was selected by the South Australian government in 1999 to be a demonstration site of good practice for the integration of ICT. As a consequence, this technology rich environment enabled teachers to question current pedagogy and continually ask how it can be improved. The school has 160 computers for 650 students, all connected to a local area network. A wide variety of software is used including HyperStudio, KidPix, Inspiration and iMovie as well as the standard Microsoft applications. Digital equipment and peripherals are also used regularly. Curriculum topics are often addressed through a critical question that students are asked to investigate. Students are organised into learning teams that change according to the task at hand. The particular technologies that students use demonstrate an evolving sophistication. For example, in Grades 1/2, students make use of Websites to conduct research. They use email extensively. By Grades 6/7, students produce iMovies, preparing scripts and making and editing videos. The use of peer tutoring in the use of ICT and a 'skill register' means that there is a great deal of interactive learning between students without the direct intervention of teachers.

*Electronic distance education*. Students in Grades 9, 11 and 12 in Queensland's high schools can access six subjects entirely online through the Virtual Schooling Service (VSS) as a pilot of new distance learning strategies. A Virtual Private Network links all government schools in that state and makes the programmes possible. VSS teachers use a range of software to provide course materials and conduct the learning sessions. The key software is NetMeeting Whiteboards, Microsoft Power-Point, and interactive spreadsheets to facilitate group discussion and WebQuest to design learning tasks. Students participate in two weekly synchronous lessons with their teacher and classmates scattered around the state. They also undertake three off-line Study Room sessions each week. These online courses allow students to study subjects that are not offered at their own schools, often because they are located in rural and remote areas in Queensland where student numbers are small. Schools support their VSS students in many important ways, perhaps most critically through the nomination of a teacher as Study Coach for each subject the student undertakes. Many lessons are being learned about the consequences of electronic remote learning strategies for optimal timetabling arrangements (at the school and by the central provider), technology standards, and managing students at risk.

*Building a learning community*. Woodcrest College is a new Kindergarten-Grade 9 school that has been able to plan the integration of ICT into programmes from the outset. Students are grouped into four multi-age bands, and the curriculum is organised around themes. Teachers work in teams and students are involved in collaborative learning. There is a Learning and Development Centre for Technology at the school providing professional development for teachers. The school has 300 computers for a student population of 1,100, all connected to a local area network. Software holdings are extensive including Microsoft Office, AppleWorks, KidPix Studio, and iMovie Digital Video together with a variety of digital technologies such as Lego Robolab. Teaching is based around broadly defined themes. Students share ideas about what they would like to learn within these themes and teachers take these ideas to flesh out the learning programmes each term, assisted by two ICT experts at the school who suggest how ICT might best be incorporated into the proposed programmes. Students work in groups but develop electronic portfolios of their own work that are the basis of assessment by teachers and used to showcase their work to parents. Each term, teachers move from being instructional designers and facilitators, to becoming advisors and mentors. Teachers new to the school experience a period of adjustment to Woodcrest College's deeply embedded philosophy of ICT-across-the curriculum approach.

*The Virtual Bridge: an online orientation programme*. St Mary's District High School in Tasmania uses a process of sustained electronic communication as part of its orientation programme for the Grade 6 students in three small, remote feeder primary schools. After an open day at St Mary's for all prospective students and their parents, the Grade 7 coordinator at the high school establishes personal contact with each of the prospective students using the Virtual Bridge facility. The Tasmanian government has a Virtual Private Network linking all government agencies, including its schools. The Virtual Bridge relies on this network for secure transmissions between the students and the Grade 7 coordinator. The fundamental software is WebQuest. Contact between participants is in the form of email, and through chat rooms. The Grade 7 coordinator engages in a series of quite informal communications with individual students and, by so doing, learns a great deal about them, their interests, and concerns about and expectations of high school. The information that flows helps in the decision making about suitable groupings of students in their first year at high school. Grade 6 students in the three primary schools are also encouraged to email each other and, as a consequence, they make new friends and get to know about their prospective classmates. The skills that Grade 6 students practice using the Virtual Bridge stand them in good stead for their learning at St Mary's, where parts of, if not entire, courses are provided online. Teachers in these schools have also realised that this simple model based on WebQuest offers an almost unlimited range of possibilities for online learning through shared teaching resources between themselves and other Tasmanian schools.

## Case analysis

### *Framework*

One framework that was used to analyse the cases focused on two dimensions. The first of these dimensions concerned how technologies were used. The technologies that were being used were examined and the uses that were made of them were coded using a classification of technology applications in education based on a proposal by Rubin (1996). Rubin's tool category entails 12 ways in which the computer could be used in the classroom as a means of enhancing student learning. The 12 categories identified by Rubin were initially condensed to four broad categories*. The categories were information resource tools, authoring tools, knowledge construction tools and knowledge reinforcement tools. The distinction between authoring and knowledge construction is not always clear because authoring involves some knowledge construction. For this investigation, where the emphasis was on the process of investigation in order to establish patterns, trends or generalisation, it was classified as knowledge construction. Where the emphasis was on organising material for the purpose of communicating to others, the activity was classified as authoring. Thus the categories were:

- *Computers as information resource tools* – Computers provide access to a greater and constantly expanding information base through the Internet, the World Wide Web and CD-ROMs.
- *Computers as authoring tools* – The computer and associated software provide students with the tools to work with and present information in different and creative ways. Examples include word processors, spreadsheets, presentation packages, graphics, multimedia and virtual classrooms.
- *Computers as knowledge construction tools* – A variety of software is available that allows students to explore knowledge and learn by constructing their own knowledge. Such software includes MicroWorlds, Inspiration, Lego LOGO and Tabletop.
- *Computers as knowledge reinforcement tools* – Computers may be used for drill and practice activities to reinforce basic skills and the learning of factual information. Typing programs such as SuccessMaker, and educational games such as 'Where in the World is Carmen San Diego?' are examples of these.

The second dimension of the framework concerned the teaching and learning processes that were involved. To begin, student and teacher activity during the period when our observers were in the school was summarised. From those descriptions of activities the nature of the teaching and learning processes that were involved were inferred. Teaching and learning processes were coded using the taxonomy for learning, teaching and assessing proposed by Anderson and Krathwohl (2000). This taxonomy is based on levels of complexity on two dimensions: a knowledge dimension and a cognitive processing dimension. The knowledge dimension encompasses the following aspects:

- factual knowledge – the basic information required for a subject, unit or theme;
- conceptual knowledge – the way in which basic information connects with other more complex systems (such as theories and classifications);
- procedural knowledge – methods for doing something and the knowledge of the criteria used for these (such as procedures for conducting a science experiment or methods used to produce a graph); and
- metacognitive knowledge – knowledge about cognition as such and also self-awareness about one's learning.

The aspects for the cognitive processing dimension include:

- remembering – which includes recognition and recall;
- understanding – constructing meaning from a range of information (may be demonstrated by summarising, comparing or classifying, for example);
- applying – carrying out or using a procedure in particular situations;
- analysing – investigating material or information;
- evaluating – assessing a product, process, etc using specified criteria; and
- creating – which may involve producing a product, planning or designing a product or procedure or generating hypotheses.

The classification does not explicitly refer to social knowledge or social learning. Anderson and Krathwohl (2000, p. 41) emphasise the perspective that knowledge is domain specific and contextualised and that it should reflect 'the role that social experiences and context play in the construction and development of knowledge'. Despite this recognition, the emphasis in the taxonomy is on the interaction of the person with content, rather than between people and content. Some aspects of social learning involving ICT in the case studies were captured even though they were not explicitly part of the taxonomy.

### *Information and communication technology tools*

In all the case studies, the use of the tools varied from lesson to lesson and from activity to activity. However, Table 2 contains a summary of the main emphases in each of the cases. The general classification is elaborated through examples of the use of ICT tools in each of the categories.

| Case | Information resource | Authoring | Knowledge construction |
|---|---|---|---|
| 1 | Students sought and obtained information from intranet and Internet; interact with consultant and author. | Students used a range of ways to construct and present their information. PowerPoint and Word were used for multimedia presentations. | 'Inspiration' was used to visually organise thinking during a brain-storming session and explore ideas. |
| 2 | Students used the Internet to find information. | Students used a variety of software to present and work with information. | Inspiration was used for mind mapping exercises and planning and analysis processes. |
| 3 | WebQuest used in economics. | Audiographic conferencing Electronic whiteboards as a tool to facilitate discussions. | |
| 4 | Year 3/4 class used the Internet to research aspects of Earth and Space. | Students used a video camera, then imported the video into a computer to be edited. Procedures and materials (of the science experiment) were then added. A range of software is available at the school. | Students used MicroWorlds to program and create 2D patterns involving revolving shapes such as circles and squares (eventually the aim will be to produce an animation of an astronomical concept); Inspiration is used for concept mapping. Lego Robolab and Control Laboratory are available. |
| 5 | Students to obtain information about high school and students who would be their peers. It also enabled the coordinator to obtain information about the incoming students. | | |

*Table 2 Use of ICT as tools in case study schools*

### *Information resource*

In Case 3, information technology tools are used as both an information resource and for authoring in varied ways depending on the subject. ICT is used to receive and retrieve information and also to prepare material that is then submitted through the network to the instructor. In Case 5 the tool was used primarily as an information resource. All Grade 6 students in the three innovation schools regularly logged on to the *Virtual Bridge*, to send emails to their e-pals at the other schools and to participate in chat rooms with other Grade 6 students. They also emailed their Grade 7 coordinator, asking questions and responding to questions from the coordinator. Most teachers in the innovation schools have laptops that attach to the school network, and all classrooms have several PCs and peripherals.

### *Authoring*

There was widespread use of the tools for authoring. In Case 1 students set up e-portfolios on the school's intranet. They created an electronic illustrated timeline of Chinese history showing key events and Dynasties using the Access Tool Box to retrieve the data chart and using the copy/paste tool to record information from the Net into their own document. Students utilised search engines to help find the relevant information and undertook a library catalogue search online. They downloaded illustrations from sites into their document and participated in a WebQuest activity. Students used a bulletin board to communicate and collate questions within the classroom that were then posted to the Chinese curriculum consultant. To share their learning and understanding with others, students created a multimedia presentation. In Case 2, ICT applications include a number of software products designed for school age users, software used as standard applications in business and the development tools used by multimedia and Web developers. However, students in the focus group observed that 'we don't use them for the multimedia high-tech stuff, we just use them for typing stories, poems, wordprocessing, graphics'.

### *Knowledge construction*

In Case 4, students work on units of work and focus on producing a quality product each term that illustrates what they've learnt from the unit that has been undertaken. Each term the project progresses through phases, including: researching the project or problem; designing the process for reaching a solution; accessing and organising the information needed; reflecting on what is being done; and producing the quality product. For example, in one of the observations the Grade 4/5 classes were studying the unit 'Earth and Space'. Two groups performed science experiments with student teachers. One experiment was conducted outside in a sandpit. Students made a

slope out of sand and poured buckets of water onto the slope. Students observed how valleys formed and answered questions about the experiment. The other group used the digital video camera to record 'making rain indoors' using ice in a saucepan over heat. The video was imported into the computer and edited, and procedures and materials added to show how to conduct an experiment. Another group used the Internet to research aspects of earth and space and to begin thinking of an experiment to conduct for the Science Fair (the Quality Product for the term). The fourth group read a book about laboratory experiments together with one of the teachers and discussed this.

### *Knowledge reinforcement*

One of the general observations is that these tools were not used for knowledge reinforcement in an obvious or noticeable way in any of the cases. The use of ICT tools in the forms that is found in integrated learning systems is not typically nominated as innovative, even though it has often been found to be effective when used for that purpose.

### *Teaching and learning approaches*

Examining the teaching and learning approaches involved in each of the cases was a high-inference activity. Moreover, the cases were schools and the emphases differed across units of work being undertaken. In all the case studies the objectives varied from lesson to lesson and from activity to activity. Table 3 indicates the interactions of the knowledge and cognitive process dimensions that were used to guide the analysis of what happened in the cases. It contains very brief illustrations of aspects that were observed in the cases.

### *Knowledge objectives*

In Case 1 the innovation teachers designed an integrated 'History and English' unit of study. The students read the novel *Chinese Cinderella* then investigated and analysed how the lives of girls and women in China are governed by the structures of history. Students resolved essential questions focused on examining their understanding of the lives of women in other cultures and how they compare to the lives of women in their own culture and timeframe. However, the focus was on the student researching, processing and analysing information as well as reflecting and collating what they had learnt. The use of information technology was fundamental to student access and response to unit material and collaboration with the other students. Teachers used an e-learning lesson planner matrix with the Anderson cognitive dimension placed on one axis and Gardner's Multiple Intelligence categories (Gardner, 1993) on the other. Students were involved in online discussion activities, for example with the Chinese Curriculum Consultant.

| | Type of knowledge | | | |
|---|---|---|---|---|
| **Cognitive process** | **Factual** | **Conceptual** | **Procedural** | **Metacognitive** |
| Remembering | Used the Internet to research aspects of Earth and Space | | | |
| Understanding | Used software to communicate their understanding | | | |
| Applying | | | Conducted science experiment and included findings in an ICT presentation | |
| Analysing | | Analysed how the lives of girls and women in China are governed by the structures of history | Self-assessment tasks that encouraged students to reflect on their learning process | |
| Evaluating | | | Panels of students assessed ICT presentation using a rubric that the class had agreed | Assessment based on students being engaged in monitoring their own progress |
| Creating | | Students created an electronic illustrated timeline of Chinese history | | |

*Table 3 Classification of teaching and learning categories with examples*

In Case 2, teacher–student interactions frequently demonstrate a belief in the ability of students to make critical decisions about their own learning. The school has instituted systems that formally recognise the ability of students to play a leading role in the teaching of others. Assessment practices combine self-assessment, peer-assessment and teacher-assessment and the form of assessment as well as the curriculum objectives are negotiated between student and teacher. The structure of the learning activities, the nature, content and length of the activities are all seen as opportunities for students to be engaged in decision making about their own learning. Working on projects also provides opportunity for reflective journal writing about the conduct of the project. In a Grade 1/2 class, students were observed investigating Websites while researching the concept of space. The lesson began with the class seated on the floor of their classroom while their teacher explained the range of activities, all linked to the concept of space, that they could use during the lesson. After the explanation the students then began on various tasks. Some students were looking at a box of books determining whether any of them suited the category of space, others resumed a writing task they had been doing previously, and one group used the computers located in the room. Their teacher had identified suitable Websites relevant for the topic and the URLs of those Websites were written on small strips of card that the students selected. When the students located pictures in the Websites that they thought would be useful for the class' topic of space, they printed them on a colour laser printer. In that situation, Internet access was used as an information resource in the same way that books and other resources in the classroom were also being used. This Grade 1/2 class has also used email extensively and students have used their email address to communicate with parents during the day.

Similarly, in Case 4, students are not only learners but also teachers. With multi-age classes made up of students with differing experiences in using technology, there are opportunities for students to teach their peers and even their teachers. In the Micro Worlds class, students often asked advice from others in the class. In one Grade 2/3 class students were involved in a variety of mathematics activities. One group of students selected a theme ('camping') and drew a scene on the computer depicting this with shapes such as a triangle for a tent. The shapes were then labelled. Another group used plasticine and straws to make 2D shapes such as a square, then turn it into a 3D shape. Some went further and made a house. Students experienced a range of technology through the curriculum programme. In this way they developed a good understanding of what technology can do for them. Students were also engaged in using a range of software creatively by applying their knowledge to complete authentic tasks. Outcomes are achieved over the two-year cycle of eight units of study. Through the many varied activities and the two-year cycle, students are able to demonstrate the achievement of the outcomes in a variety of ways. Students are involved in monitoring their own progress so they are aware of what they need to find out or learn.

***Cognitive processing objectives***

When the pattern of cognitive processing objectives is examined it becomes evident that few of the processing objectives involve remembering. There is a strong emphasis on understanding and on creating. Students reported that they were fascinated to find out more about Chinese culture, they liked working in groups and being able to pool their discoveries. The students thought it was a quick way to get a lot of information and to get other people's opinions besides their own. They also liked posting questions to real people such as the Chinese Curriculum Consultant and the authors. They felt that this was an excellent way of getting answers to questions that interested them. The students felt that they had learnt more in two weeks than a whole term of history.

In Case 4, students produce each term a quality product that illustrates what they've learnt from the unit of study that had been undertaken. The Grade 4/5 students studied the unit 'well-being' in the term previous to the project team's visit. The quality product that celebrated their learning was a short video clip that illustrated an aspect of health and safety. It was produced using HyperStudio and QuickTime. Students wrote their own skits, made clay figurines and objects to illustrate them, and then took still photos depicting important stages of their messages. QuickTime was used to produce animations, and music and voiceovers were added. A presentation and awards night (the 'Clogies') was held to celebrate the learning the students had engaged in over the term. Groups of students presented their movies (clay animations) and talked about it to a large audience of parents and siblings.

## Discussion

Australian education has identified as priority areas for information technology: a greater understanding of the interdependence of conditions which facilitate success in improving both student and teacher learning outcomes with the use of ICT; the identification and operationalisation of the role of school education in the context of a knowledge society; the need for equity to both access and effective use of ICT; the need to bridge the gap between the potential of ICT and its actual implementation in the classroom; and national monitoring of teacher and student competencies, resources and learning outcomes.

Although progress in relation to these objectives has been made, much still needs to be done in supporting teachers and school systems in transforming the learning environment of the classroom into one that fully captures the potential of using ICT to improve student learning.

One aspect of the use of ICT in schools and classrooms focuses on competencies in using the technologies. Developing those competencies is important and many of the schools that were studied in this investigation recognised that importance. In Australia, several states have implemented assessment programmes to monitor the ICT competencies of students. The OECD Programme for International Student Assessment (PISA) indicates that Australian students are above the international average for comfort, ability, usage and experience with computers (OECD, 2001). However, most of the schools included in this set of case studies were also concerned with using ICT to develop student knowledge and cognitive processing capacities. Several of the schools were in school systems that had established methods for improving the ICT skills of teachers so that they could work more effectively with their students to use ICT to develop broader intellectual skills.

Embedding ICT into classroom practice requires teachers to work in quite different ways than previously, and expects students to learn new things in quite different ways. Much literature refers to the use of ICT to foster students' higher order thinking skills, even though these skills may be conceptualised in a variety of ways. Several of the case study schools in this report describe using learning taxonomies and schema as important aids to planning for higher order outcomes. For instance, Grange School and Toorak College developed rubrics to assess student outcomes and those rubrics specified higher order skills such as problem solving. The Quality Product that marks the completion of a student's unit of work at Woodcrest College has an underlying rubric.

In these schools it is accepted that technological literacy is not necessarily a goal in itself but a means to improving learning outcomes. The development of analytical and higher order cognitive skills has always been viewed as empowering thinking and problem-solving ability. Now, it is recognised that ICT can facilitate the programmes and approaches that develop these abilities. However, the pursuit of this goal is dependent not only on the technology available but also on the capacity of teachers to implement programmes that are challenging, diverse and actively engage students. It is important to attend to other aspects of learning environments rather than assume that the introduction of technologies alone will result in changes. These case studies show how schools in different settings can establish appropriate technology infrastructure and develop teaching practices that enhance technology skills and a range of broader skills.

Pouring resources into IT infrastructure does not necessarily reflect the actual implementation of the technology in schools. Fluck (2001, p 156) describes the phases in the uptake and use of computers in education: providing computers, establishment of frameworks for student and teacher competencies for using ICT across the curriculum, content changes in all curriculum areas and flexible school learning through the use of ICT. Fluck argues that although many are focused on the second phase there are examples of the third 'where the computer changes the way in which education is conducted'.

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