

# The Design and Development of a Simulation to Teach Water Conservation to Primary School Students

---

Lee Campbell

Flinders University [camp0182@flinders.edu.au](mailto:camp0182@flinders.edu.au)

*Information and Communications Technology (ICT) plays a dominant role in enhancing teaching and learning. Similar advances have been made in the use of multimedia in the classroom. These advances are coupled with newer developmental tools and techniques.*

*This paper examines the design and development of a simulation on water conservation. Science concepts taught through traditional methods are brought to life through animation and multimedia. The paper examines the underlying instructional design and pedagogy for developing useful simulations. It also highlights the support provided by currently available authoring tools.*

*The paper concludes with how the effectiveness of simulations can be examined, and discusses issues around the use of simulations and learning objects in the primary classroom.*

ICT, multimedia, water conservation, science education, evaluation

## RESEARCH STUDIES ON SIMULATIONS

In traditional education, the science curriculum did not encourage teachers to teach information in meaningful contexts. Instead, they were encouraged to teach in isolation, without relating new information to real-life situations (Linn et al., 2000). More recently, the value in linking information with real-life situations has become apparent and teachers are continually looking for ways to practise this in their classroom. The Warriparinga Wetlands simulation has been designed to assist teachers in this area by demonstrating a real-life example of water conservation, through the use of multimedia and animations.

## ICT in the classroom

ICT provides an opportunity for progression from the traditional method of delivery to an environment where student learning is self-directed and they can solve real-life problems. This self-directed learning allows teachers the freedom to act as a facilitator, which can give more time for them to work with individual groups and tailor their information to the requirements of individuals (Linn et al., 2000).

It is important for children to learn how to use new technology for several reasons (International Society for Technology in Education 1998). Firstly, Parents want their children to gain skills that prepare them for either the workforce or higher levels of education. Secondly, Employers want staff who are computer literate, and finally, communities want schools to teach children to be productive in a technologically advancing world.

The International society for Technology in Education (1998, p.2) states that:

The most effective learning environments meld traditional approaches and new approaches to facilitate learning of relevant content while addressing individual needs. The resulting learning environments should prepare students to:

- Communicate using a variety of media and formats
- Access and exchange information
- Compile, organise, analyse and synthesise information
- Draw conclusions and make generalisations based on information gathered
- Use information and select appropriate tools to solve problems
- Know content and be able to locate additional information as needed
- Become self-directed learners
- Collaborate and cooperate in team efforts
- Interact with others in ethical and appropriate ways.

A significant benefit of using simulations and learning objects in the classroom is that they are versatile. The Australian Education Systems Officials Committee (AESOC 2001) states that they can be used as:

...components of learning sequences or in exploration of topics, or as elements in units of study. Teachers can construct their own learning sequences, making their decisions about what works for their students as a group, in small groups or as individual learners, which suit their particular classroom situation.

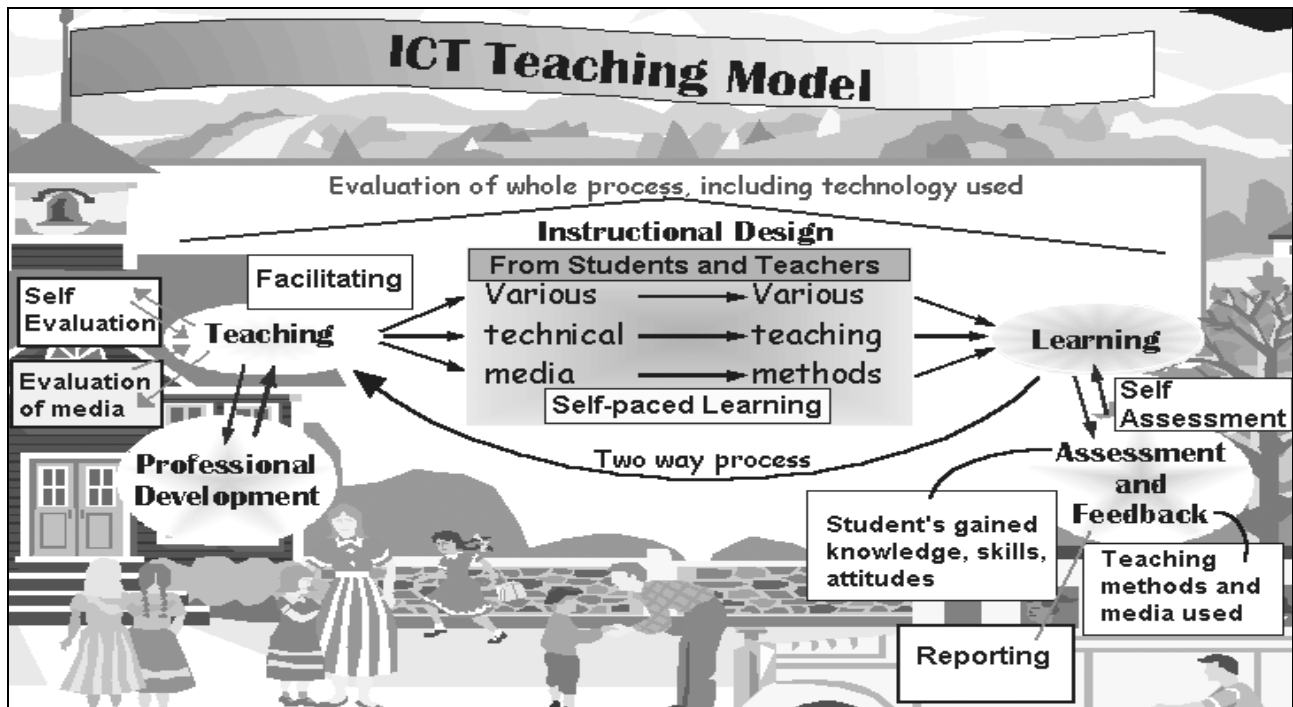
Rather than being taught in isolation, technology should be used as an integral tool for student learning within the existing curriculum (International Society for Technology in Education 1998). According to the BJP Consulting (2003) web site, there are three stages of ICT infusion. The first is the initial use of technology: computing is separated from other learning and is usually taught in computer labs by specialists. The pedagogy of learning is about teaching technology. The second is the integration of technology: technology is integrated into the curriculum, however its use is optional. It is taught with traditional tasks and the pedagogy of learning is about teaching the same tasks with new tools. The third is infusion of technology: this is where technology is seamlessly infused into the curriculum. It involves both student and teacher initiated activities, using ICT. Tasks are impossible without technology and students work collaboratively on self-directed learning, complex thinking and communication. The teaching pedagogy is about student-centred learning using new methods with new tools.

Figure 1 shows a model depicting the dynamics of ICT in education as a two way process between teaching and learning. Instructional design is initiated by both teachers and students and involves various teaching media and methods. Learning is self-paced and is assessed by both teachers and students. Evaluation of teaching methods and media used is done by students and teachers and can be used for assessment, reporting and for teachers to evaluate their own needs in professional development.

There is a government initiative designed to integrate learning objects into the classroom called The Learning Federation (AESOC 2001). The Initiative's aim is to develop interactive curriculum content online. This content is delivered to students in the form of learning objects designed to support teachers in enhancing student learning, specifically for Australian and New Zealand schools. The framework applied in the development and evaluation of learning objects for use by the Initiative, only gives consideration to some parts of the above model. It concentrates on curriculum content, teaching, learning and technical standards. However, it is missing the elements of instructional design, assessment, evaluation, feedback and professional development.

The Warriparinga Wetlands simulation aims to cover all of the elements in the ICT Teaching Model. It is a tool for student-centred learning, allowing the teacher to become a facilitator, free to

observe students' activities and provide individualised assistance. Students are empowered by having control over their own learning and can be given the opportunity to come up with their own educational activities stemming from the research conducted while completing the simulation. Students submit their answers to research questions contained within the simulation to a database through an online questionnaire (see Description for more detail). Questions can be added to the questionnaire and teachers can use the resulting database to assess students' knowledge, skills and attitudes towards the environment. The database can also be used to provide feedback to students and parents. The whole package lends itself to provide professional development to teachers on many facets of ICT infusion in the classroom, including how to teach topics using learning objects and simulations, what activities can be used in conjunction with learning objects and simulations, how to create movies, and use databases.



**Figure 1. ICT Teaching Model**

The Warriparinga Wetlands simulation can be infused with many educational activities on water conservation and ICT. For Society and Environment, students could create their own movies on some aspect of the environment and go on an excursion to the Warriparinga Wetlands (or some other environmental outing), taking digital photos of the main features for use in their own project or movie. In English, they could write a script for their movies and keep a digital journal of their learning and creations. In the Arts, they could make their own graphics for their movies and journals, create a storyboard for their movies, practise acting techniques and produce their own background music. In Health, they could look at how the issue of water pollution effects the health of the community. Extension activities could entail a whole class commitment to a Water Watch project (South Australia Central 2001), a project using HyperStudio on a river of their choice, an animation using Kid Pix or PowerPoint.

## DESIGN

When designing the simulation, several considerations needed to be taken into account. The first was to create something which would be interactive so that students could control their own learning and teachers could become facilitators of that learning. With this in mind, questions were incorporated into the project so that student learning would be directed in the area of water

pollution. Students typed their answers into an online questionnaire and submitted this to a database for the teacher to assess their understanding of the topic. Later, to aid in interactivity, the simulation was interfaced with PowerPoint so that students could control the pace of their learning (see Description of Warriparinga Wetlands Simulation for more detail).

Secondly, the video footage of the processes involved in water conservation at the Warriparinga Wetlands needed to be explained to students. In order to give a powerful visual demonstration of this, Macromedia Flash animations were integrated. These animations gave simple explanations and demonstrated the flow of water and filtering out of pollutants. Macromedia Flash was used to create these animations because it was attractive, compelling and widely available for most ICT users (Macromedia 2000). The design capabilities of Flash are unlimited – novices can use it to create simple animations and experts can produce high quality publications.

Thirdly, it was important to create interest for students in order to increase their motivation to watch the simulation. Various visual stimuli were introduced to assist with this. Written information was integrated with Macromedia Flash animations and Video footage. In the animations, the character of a water droplet was created to appeal to students. Sound was also included to create ambiance and add interest.

Fourthly, the information needed to be presented in a logical sequence. The two questions focused on the issue of water pollution and what students could do to assist with this issue. The movie then built on this gained knowledge by showing the Warriparinga Wetlands as an example of what the community doing to protect our waterways.

Lastly, in order to make this simulation a highly useful classroom resource, it needed to be adaptable. This is another reason it was interfaced with PowerPoint as teachers are able to adapt the PowerPoint slides to give different instructions if desired. They can also add slides with extra activities for students.

## **DEVELOPMENT**

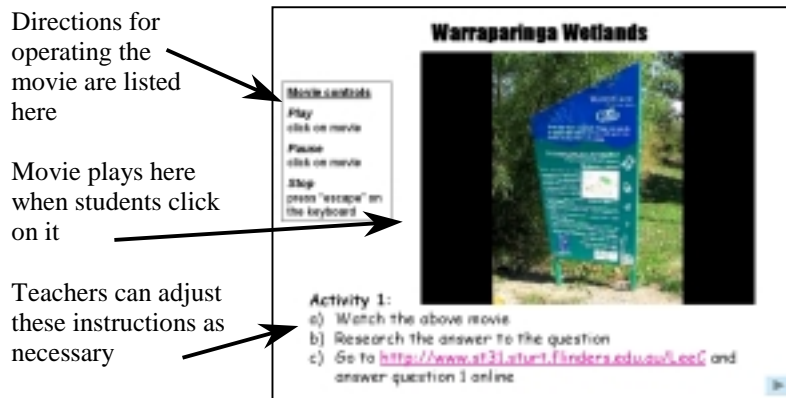
In the development of the Warriparinga Wetlands simulation, several software programs were used. To put the whole thing together into Quicktime Movie format, iMovie was used. This program was very easy to use and all transitions, music, sound effects and titles were inserted using it. Microsoft PowerPoint provided the means for including written information and as mentioned previously, Macromedia Flash was used to create the animations.

While it was highly useful to be able to include all of these programs with iMovie, they were not all compatible. Therefore, problems occurred while converting some of the formats so that they could be used with iMovie. Microsoft PowerPoint did not present any problems as slides could be converted to JPEG format, which was compatible with iMovie. However, the Macromedia Flash animations needed to be converted to DV format using Quicktime Pro. This proved to be more difficult, but with the support of Len Szablinski (the technician at Flinders University), was quite easily achieved. Len provided all the technical support necessary and with his help, all of the considerations mentioned in the design phase were able to be realised. Len taught me how to use all the equipment needed such as techniques for using the video camera and tripod, recording the sound effects (eg bird sounds), and using iMovie.

## **DESCRIPTION**

The Warriparinga Wetlands simulation was interfaced with PowerPoint. This is useful because slides could be set up with instructions for students so that learning could be student-directed and self-paced. Teachers were then free to act as facilitators. The other benefit of presenting the

simulation in this way was that teachers could alter the instructions listed underneath the movie and add in any questions for students, as shown in Figure 2.



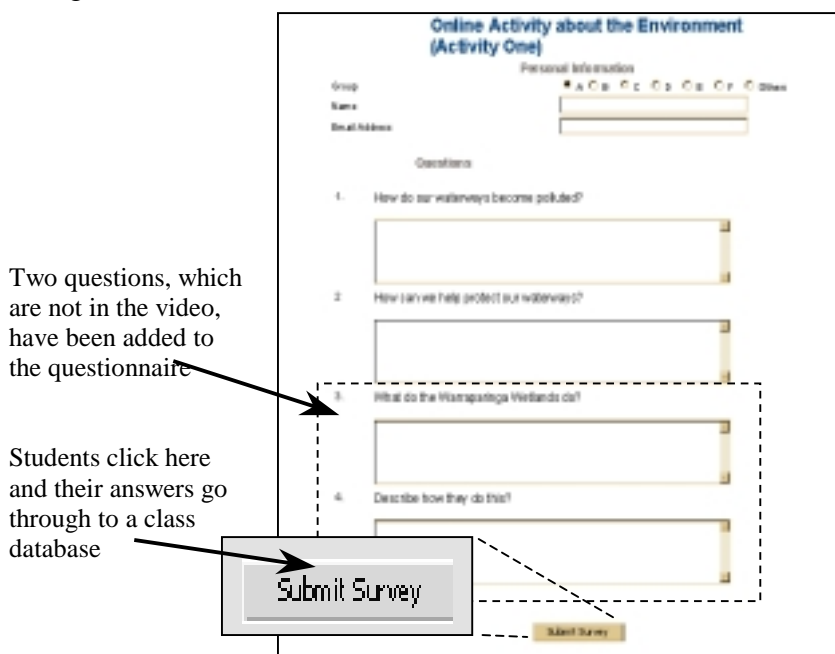
**Figure 2.** The Warraparanga Wetlands movie is displayed in the centre of the slide with instructions underneath and on the left hand side

The simulation was split into three parts. The first part presented the titles and various photos taken at the Warraparanga Wetlands. Then the first question was displayed in Figure 3.



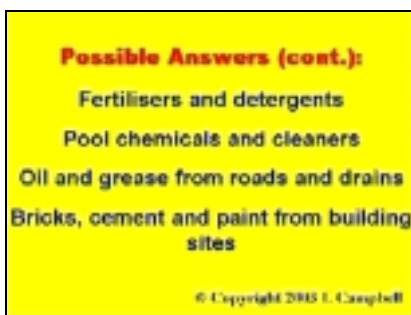
**Figure 3.** Question number one: PowerPoint was used to create this effect

Students can research the answers to this question on the Internet and record them in an online questionnaire, which is submitted to a class database. The questionnaire can be altered and extra questions added as shown in Figure 4. The database created provides an opportunity for a whole class discussion of the research results, feedback to students and parents and assessment of learning.



**Figure 4.** Questionnaire where students record their answers to the research questions in the video and any other questions the teacher might like to add

After recording their research findings, students return to the simulation, which lists possible answers to the question and shows video footage illustrating these points. These are presented in Figures 5, 6 and 7.



**Figures 5 and 6.**

**List of possible answers to question one**

**Figure 7.**

**Video footage of a building site**

Next the simulation displays question two, which is, “How can we help to protect our rivers and lakes?” The simulation stops here and students research this question and record their answers in the same format as before. The possible answers and video footage are displayed as seen in Figures 8 and 9.



**Figure 8. List of possible answers to question number two**

**Figure 9. Video footage demonstrating proper disposal of lawn clippings**

The next part of the simulation is about how the Warriparinga Wetlands work to clean the water from the Sturt River. Macromedia Flash animations demonstrate the various processes involved in filtering out pollutants in the water. Each animation then flows into actual footage of the Warriparinga Wetlands. Following is a brief description of the process.

The water flows down the Sturt River and is diverted through a tunnel and into the Warriparinga Wetlands through a large fallen log (Figures 10 and 11). The water passes through nets, which trap debris and litter (Figures 12 and 13). It then flows out into four ponds. Water moves very slowly through the ponds and finer pollutants settle out into the clay at the bottom (Figure 14 and 15). Finally, the water passes over a rock riffle and then flows back out into the Sturt River (Figures 16 and 17).

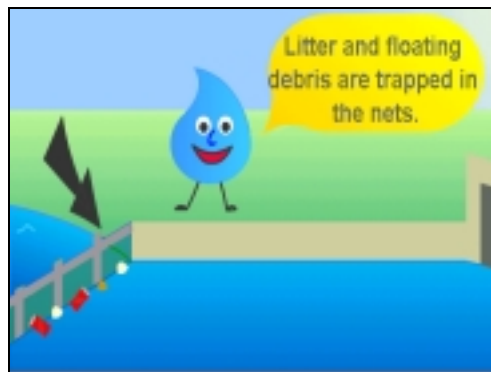




**Figure 10. Animation demonstrating the water being diverted into the Wetlands**



**Figure 11. Transition from animation to footage of the process**



**Figure 12. Animation demonstrating the nets which trap litter and debris**



**Figure 13. Transition to video footage of the nets shown in the animation**



**Figure 14. Animation depicting finer pollutants settling out of the water in the ponds**



**Figure 15. Transition to footage of ponds demonstrated in the animation**



**Figure 16. Animation depicting water flowing over the rock riffle**



**Figure 17. Transition to footage of the rock riffle demonstrated in the animation**

## EVALUATING MULTIMEDIA SIMULATIONS AND ANIMATIONS

Teachers know that the wise use of technology can enrich learning environments and enable students to achieve marketable skills. It is still critical that educators analyse the potential benefits of technology for learning and employ it appropriately (International Society for Technology in Education 1998, p.2).

According to Dowle (nd) and Perry (2000) there are several categories that need to be looked at when evaluating multimedia for use in the classroom.

- Teachers need to consider several factors about the **content** of the program. Is the content current and accurate? Does it include a sufficient amount of information to educate students? Does it enhance the delivery of the topic?
- We need to think about the **instructional design** of the program. Is information presented in a logical sequence? Are the learning activities and instructions clear and easy to understand? Is the program easy for students to use? Is the way in which information is delivered interesting and/or innovative?
- Consideration should be given to student **motivation** from the program. Does the program create interest and engage the student through novelty, humour or surprise? Are learners shown how the topic relates to real world situations?
- Teachers need to examine the use of **media** in the program. Is the media varied (eg video, animation, music, narration, sound effects, and special visual effects) and does it effectively illustrate the concepts and content being taught? Does the various media used complement rather than compete with each other?
- We need to look at the *tone* and **aesthetics** of the program. Is the educational material aimed at the appropriate level for the intended audience? Is the appearance easy to look at (eg no bright colours, can text be easily read)? Does the sound create ambiance or is it too loud?
- Teachers should consider **interactivity** and **navigation**. Do students interact with the program and have the opportunity to input information? Does the program encourage problem solving and do the activities teach by questioning the students? Is navigation easy for students? Are the instructions provided on activities clear?

### Evaluation of the effectiveness of the Warriparinga Wetlands simulation

The simulation is currently undergoing evaluation. During this process, the following aspects of student learning will be considered.

#### *Intrinsic motivation*

It is generally accepted that there are two categories of motivation: extrinsic, which stems from external rewards and intrinsic, which comes from within the students. Intrinsic motivation is the most effective way to learn because students complete activities because they want to, rather than feeling like they have to (Jenkins and Visser, date unknown). As one of the reasons for using ICT, like the Warriparinga Wetlands simulation, in the classroom is to create interest for learning, it is important to evaluate the effect the simulation has on this aspect. The tool to be used for assessing students' intrinsic motivation is the Intrinsic Motivation Inventory (IMI). This is a collection of questions that aim to assess students' experiences relating to a particular activity (Deci and Ryan 2003).



### ***Multiple Intelligences***

There are a broad variety of theories on how the human brain functions and the consequential preferred methods of learning. Gardner of Harvard University discusses this in terms of multiple intelligences and states that there are many that he has not yet identified. He has, to date, identified nine different types of intelligence. They are Visual/Spatial, Verbal/Linguistic, Logical/Mathematical, Musical/Rhythmic, Intrapersonal, Interpersonal, Naturalist, Kinesthetic and Existentialist. The intelligences are of substantial importance when designing educational programs because teachers can accommodate individual students more successfully if they can target each intelligence (McKenzie 1999). Students will be given a questionnaire prior to completing the activities in the simulation. This questionnaire will be adapted from an example found online (Como Secondary College 2002). After completing the simulation, students will be tested on their knowledge and comparisons will be made with their preferred multiple intelligences.

### ***Higher-order learning***

After completing the activities in the simulation, students will be tested on their knowledge. The questions will be based on Bloom's Taxonomy and the categories in the cognitive domain. In particular, the focus will be on whether students have gained knowledge in the higher categories of analysis, synthesis and evaluation. According to Hoffman (1994-2003) and Krumme (2001) analysis is where information is broken down into its component parts and examined to develop conclusions, synthesis is where students combine the information they have learned in order to create a new whole and evaluation is where students make judgments on the value of the information they have learned, based on certain criteria.

## **IMPLICATIONS FOR RESEARCH**

This study should contribute significantly to several areas of knowledge. First, it will provide useful information about factors to be taken into account when designing software, simulations and learning objects. Secondly, it will give insights as to how to optimise the use of learning objects in the classroom, taking into account Gardner's Multiple Intelligences and higher-order learning. Thirdly, the study will give details on how to enhance and support all learner types through the Multiple Intelligences. Fourthly, it demonstrates that simulations and learning objects can provide authentic experiences for learning, where real-life situations are not available. Fifthly, it will provide useful information on how intrinsic motivation can be achieved using learning objects in the classroom.

Feedback from this study will be used to readdress the ICT Teaching Model and the design of the Warriparinga Wetlands simulation. Evaluations completed by teachers will be used to look at the appropriateness of the content for the year level, its correlation with the science curriculum, the appropriateness of the research questions asked, the tests conducted for assessment of knowledge gained by students and the overall appeal to students. This evaluation will be used to modify the simulation if necessary.

The use of the simulation in the classroom will be examined for whether it allows the teacher to act as a facilitator of learning, whether the answers given in the database provide sufficient feedback to teachers on student learning, whether students found learning more interesting using the technology, whether they felt they had control over their own learning and whether teachers can use it for professional development. Both the simulation and ICT Teaching Model may need to be modified according to evaluations completed by teachers and the students' reaction to and learning from the simulation.

## CONCLUSION

The simulation and database have been designed with the ICT Teaching Model in mind. Students and teachers learn together about ICT and water conservation, using the simulation and associated Internet research. The elements of facilitation, student-directed learning, assessment, evaluation and professional development have all been considered during the design phase of the simulation.

While developing the simulation, there was a lot for me to learn about the software programs I was using. However, this experience was made easier by the ability to find solutions both within the software programs and on the Internet. For example, to learn how to use Macromedia Flash, I used a tutorial built into the program as well as tutorials available on the Internet. With some of the difficulties I had in converting between formats, I was able to find the answers on the Internet – in fact, there are many downloadable free programs available for converting between formats.

The software programs used in the development of the Warriparinga Wetlands simulation are easy to use, flexible, available across platforms and allow interactivity for both students and teachers. As a result of this, other teachers can create their own learning objects and simulations using these programs and can use the Warriparinga Wetlands simulation in their classrooms.

Simulations and learning objects such as the Warriparinga Wetlands are a useful tool in the classroom. They allow the students to learn at their own pace and the teacher to facilitate learning. The Warriparinga Wetlands simulation raises the bar for learning by teaching students to be informed and effective learners. This is facilitated through self-paced learning, teaching students how to research information themselves and giving students the opportunity to work in groups, helping each other to learn.

ICT is an important tool for student learning and should be integrated with all subjects within the existing curriculum. Its use in education is as a two way process between teaching and learning, whereby instructional design is initiated by both teachers and students. ICT should be seamlessly infused into the curriculum, giving students the opportunity to work collaboratively on self-directed learning, complex thinking and problem solving.

## REFERENCES

- AESOC (Australian Education Systems Officials Committee) (2001) *The Learning Federation homepage*. [Online] <http://www.thelearningfederation.edu.au/tlf/newcms/d2.asp> [2003, December 4].
- Como Secondary College (2002) *Multiple Intelligences Questionnaire*. [Online] [http://www.como.wa.edu.au/external/LA/learning\\_tools/mi/MI\\_ques.html](http://www.como.wa.edu.au/external/LA/learning_tools/mi/MI_ques.html) [2003, Sept 25].
- Deci, E. and Ryan, R. (2003) *Intrinsic Motivation Inventory*. University of Rochester. [Online] <http://www.psych.rochester.edu/SDT/measures/intrins.html> [2003, October 6].
- Dowle, S. (nd) *Multimedia Evaluation*. University of Alberta. [Online] <http://www.ualberta.ca/~sdowie/multimedia.htm> [2003, December 7].
- Hoffman, B. (editor) (1994-2003) *Encyclopaedia of Educational Technology*. [Online] <http://coe.sdsu.edu/eet> [2003, October 24].
- International Society for Technology in Education (June 1998) *National Educational Technology Standards for Students*. Eugene, USA.
- Jenkins, J. and Visser, G. (Unknown) *Make Learning Fun*. [Online] <http://www.imaginal.nl/learningFun.htm> [2003, October 24].

- Krumme, G. (2001) *Major categories in the taxonomy of educational objectives*. University of Washington. [Online] <http://faculty.washington.edu/krumme/guides/bloom.html> [2003, October 24].
- Linn, MC. Kessel, C. Lee, K. Levenson, J. Spitulnik, M. Slotta, J (2000) *Teaching and learning K-8 mathematics and science through inquiry: Program reviews and recommendations*. EnGauge Resources. USA. [Online] <http://www.ncrel.org/engage/resource/techno/k8.htm>. [2003, September 8].
- Macromedia (2000) *Flash Player for developers and publishers*. [Online] <http://www.neostudios.com/WhyFlash.pdf> [2003, December 11].
- McKenzie, Walter (1999) *It's not how smart you are – it's how you are smart: Howard Gardner's Theory of Multiple Intelligences*. [Online] <http://surfaquarium.com/mi.htm> [2003, October 24].
- Perry, Terrell L (2000) *Evaluating Multimedia*. Coastal Training Technologies Corp. [Online] [http://www.coastal.com/WhatsNew/online\\_multimedia.html](http://www.coastal.com/WhatsNew/online_multimedia.html) [2003, December 7].
- Porter, B (2003) *Bernajean Porter Consulting: Organising Technology for Student Results*. [Online] <http://www.bjpconsulting.com> [2003, September 8].
- South Australia Central (2001) *Waterwatch SA*. [Online] <http://www.sa.waterwatch.org.au> [2003, November 5].