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# **“ I need another animated gif! ”: Instructional design trends of ICT teaching resources created by pre-service science teachers**

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## **Abstract**

In this paper, we present an examination of ICT resources created by pre-service science teachers. After a great deal of modelling, use and discussion regarding ICT materials, twenty-seven pre-service science teachers created ICT resources for use in lower secondary science classrooms. These resources were submitted in a number of formats and were designed with a variety of beliefs about instruction and interaction. Trends in the designs of the resources are reported in this paper and we point out possibilities for future study.

## **Introduction**

For years, information and communication technology (ICT) has been used for teaching and learning. Worldwide, education authorities are promoting the use of ICT. In Western Australia it is expected that: “students choose between or integrate various technologies for a purpose. They adapt familiar or existing technologies to meet the demands of new tasks or situations” (Curriculum Council of Western Australia, 1998). Further, a recent report by the British Educational Communications and Technology Agency BECTA (British Educational Communications and Technology Agency, 2003) identifies that teachers must be trained in the technical and pedagogical aspects of ICT. There are also statements in the literature that teacher education programs need to incorporate training on the use of technology for teaching and learning across the curriculum (Sahin, 2003). This paper is part of an action research study addressing such training. The context is pre-service teacher education in science.

The action research study commenced in 2002 with planning, implementing and critically assessing instruction on teaching and learning with ICT (Dawson & Reid, 2003). The initiative occurred in a Graduate Diploma science education class for pre-service secondary teachers that ran for 24 hours over eight weeks. A significant component of the class was an authentic assessment where students were required to produce an ICT resource suitable for use in lower secondary science. The second phase of the study took place in 2003 with a new pre-service teacher cohort in the science education class. Consistent with the action research paradigm (Carson & Sumara, 1997), the purpose of the second phase was building on what had been learned in the first phase in order to develop further the ICT curriculum. There was also a questionnaire delivered to the pre-service teachers to measure their perceptions of their preparedness to use ICT in their teaching (Forster, Dawson, & Reid, 2005).

The main topic of this paper is the design and creation of the student created resources. First, we place their design in context by describing the theoretical views on learning that guided instruction and the scope of the ICT curriculum. Sections on construction of the resources and the analysis of the design follow.

## **Research Method**

This research study was undertaken based on a qualitative case study approach (Stake, 2000). A detailed examination and analysis of pre-service teachers’ abilities to create ICT resources for use in secondary science classes. This included scrutinizing their knowledge and understanding of the science curriculum and appropriate pedagogy, their abilities with ICT and the aptness in which they combine the two in order to enhance science education for secondary students.

## **Principles underlying the ICT curriculum**

There were four principles which underpinned the selection and implementation of learning activities for the science education unit overall. The main principle was the constructivist beliefs upon which the content was presented (Taylor, 1998). Second was that learning how to use technology for technology’s sake is not productive: instead, technology should make available knowledge or content that enhances students’ learning (Leamson, 2001; Robyler, 2003). Third, tertiary educators need to help pre-service teachers develop a clear vision in regards to how they can facilitate student learning with computers (Sahin, 2003; Wang, 2002). Finally, one of the ways this clear vision can be formed is by modelling appropriate ICT skills in tertiary education: “as pre-service teachers see technology modelled and as they are provided with more opportunities to use technology in the classroom setting,

high anxiety levels stemming from negative attitudes toward computers will be lessened” (Pope, Hare, & Howard, 2002).

### **Procedure in the class**

A number of initiatives involving ICT use were taken with the science education class. This included explaining the pre-service teachers that graduates were expected to be proficient in the use of ICT, therefore a portion of the assessed work in the class would be in the form of an electronic resource for use in a secondary science classroom. The students were split into small groups to brainstorm about the use of technology in science classrooms. The groups came up with a wide variety of examples of uses of technology in science classrooms, including: data loggers, CDs, online journals, SMS text messages, Global Positioning Satellite systems, online materials, graphics calculators, Landsat photography, radiotracking and virtual excursions.

Unlimited access to a laptop computer, a data projector and a digital camera was secured for teaching purposes for the duration of the unit that enabled the instructor (second author) to model the use of ICT. Two consecutive three hour sessions were used to familiarise students with ICT resources that are used in secondary school science including: interactive applets and simulations; the interactive CDs Biotechnology Online (Biotechnology Australia, 2001) and The Ultimate Human Body ("The Ultimate Human Body 2.0," 1996) electronic portfolios and self paced online modules; web sites for students and teachers; electronic textbooks including Heinemann's Science for Western Australia series (Cahill & Spence, 1999); data loggers for temperature, humidity and heart rate; video resources; the digital camera, data projector and laptop, and Lego Dacta. The second session was conducted in a computer laboratory. During these sessions, students were able to explore with the equipment and peer coaching was encouraged. The instructor and a technical assistant (first author) were available for advice.

Students then exchanged ideas in small and later lecturer facilitated large groups regarding the advantages, disadvantages and issues associated with using ICT resources in secondary science. This student discussion was guided by open ended questions and articles by Przywolnik (2002) and Tebbutt (2000) which describe factors to consider when using ICT in secondary science classes. Advantages that were presented included: ICT can be useful for one to one interactive learning, remediation, revision, visual learners and lateral thinkers. Disadvantages included: technical issues and access within schools. Other issues that were discussed included: ICT use must add to educational outcomes for students; use of ICT must suit teachers' and students' comfort levels; and content of ICT resources must suit students' interests and ability levels. In addition, the instructor raised the issue of copyright in relation to ICT resources as the Year 11 and 12 science syllabus documents for Western Australia on a CD. They were told that copyright permission had been obtained for reproduction of the documents and that copyright requirements need to be addressed with any reproduction and use of web resources in the classroom.

### **Scope and assessment of the resources**

Each student in the class was required to develop a teaching resource based on the years 8 – 10 science curriculum of Western Australia. The resource was to be designed so that it required the use of ICT by lower secondary science students. There are four themes in the Western Australian science learning area for students to base their resources on. These themes were: “*Earth and Beyond*,” “*Energy and Change*,” “*Life and Living*” and “*Natural and Processed Materials*” (p. 220).

The resource was evaluated for the class and later for the study. The allocation of marks was based on creativity, accuracy of content and pedagogy rather than ICT skills. The allocation was an attempt to encourage and not disadvantage pre-service teachers with limited technical skills. Due to the diversity of technical skills, they were given a choice of information, multimedia and submission formats. Students were provided with an outcomes based rubric at the outset that was used to assess their resource. When the resources were examined, the designed inquiry was viewed through the lens of Bloom's Taxonomy (Bloom, 1956). The usability of the resource was also explored based on the ease of navigation, the appropriateness of the content for the target audience and the interactivity designed into the tasks in the resource. Trends from the study are discussed below under the headings ‘Design of inquiry’ and ‘Design of interaction.’

### **Design of inquiry**

The initial analysis of the 27 resources was based on the cognitive requirements placed upon the learner by the tasks presented in the resources. Figure 1 shows the number of resources that included interaction with the content at each level of Bloom's Taxonomy. Examples of each level of required cognitive skill follow Figure 1.

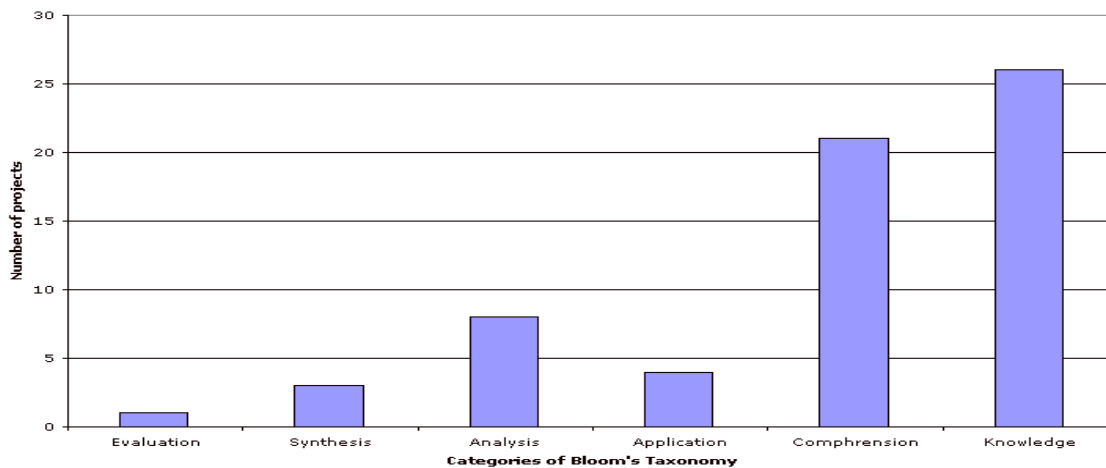


Figure 1: Levels of designed cognitive skills

The majority of the content included the lowest levels of cognitive skills in their design according to Bloom's Taxonomy. All but one of the resources included knowledge questions involving the presented content. The next level of cognitive skills, comprehension, was evident in over three quarters of the resources.

There was a nearly inverse relationship between the level of higher order cognitive components and the number of resources that included them in the design. "Diet plan for Bibbulmun track" was the only resource that included all six levels of cognitive skills in its design. There was one resource entitled "NASA ICT Worksheet" which did not include any levels of cognitive inquiry as there was no designed inquiry built into the resource. This resource gave students a list of links and instructed them to view the latest images on the NASA website and record what they saw, particularly colours.

An example of typical Knowledge level inquiry that were present throughout the majority of the resources can be found in the resource called "Dieback Webquest." This resource focused on questions such as "What is a keystone species?" and "What is the scientific name for the fungus responsible for Dieback

An example of typical Comprehension level inquiry that were present throughout the majority of the resources can be found in the resource called "Which energy is for you?." This resource had the learner act as a power consultant for the federal government to report on the different types of power that can be used to supply the population.

An example of typical Application level inquiry that were present in four of the resources could be found in the resource called "A Webquest on Organic Food" which focused on the pros and cons of eating organic food. The resource was based within a fictional setting where the learner must apply knowledge and understanding about organic food shopping for a domestic living arrangement.

An example of typical Analysis level inquiry that was present in eight of the resources can be found in the resource called "Ningaloo Coast Webquest." This resource had the learner explore the issues and motives of the various groups about the use of the area around Ningaloo Reef in Western Australia.

An example of typical Synthesis level inquiry that was present in three of the resources can be found in the resource called "Water Conservation." The learner was required to construct a plan to help Western Australia deal with its current water shortage.

An example of the Evaluation level inquiry that was present in the sole resource with this level of inquiry can be found in the resource called "Diet plan for Bibbulmun track." The learner was required to examine the diet they would need to trek on the Bibbulmun Track, a very long walking track. The learner would have to prioritize the food decisions based on criteria such as physical exertion of carrying the food, nutrient and energy value of foods chosen, refrigeration concerns, budget, food preparation, and quantity of food consumed per day.

## Design of interaction

There were five distinct formats used by the pre-service teachers to present content in the resources. These methods included text, graphics, sound, video and hyperlinks. Text-based content was provided by every resource. Many of the resources were text intensive with over a third of the resources only using text to present information. Presentation of the text-based information varied from large blocks of text to short phrases that accompanied another form of information, which was most often figures. Similar results were observed regarding the primary locus of information being a mixture shared presentation between text and figure (Iding, Klemm, Crosby, & Speitel, 2002).

Over half of the resources used graphics to present content which consisted of photographs, animated gifs and diagrams. Photographs were used to present authentic information such as what animals look like in the wild and organs of the body. A number of animated gifs were used including a beating heart that demonstrated blood flow. Diagrams were often used to present conceptual information like food pyramids and the structure of DNA. Charts of information were also used to present seasonal rainfall in an area. Diagram 1 presents a diagram of the periodic table of elements that was used to present conceptual information that was linked through the resource from Chem4kids.com (Rader, 2003).

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|----|
| H  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  | He |
| Li | Be |    |    |    |    |    |    |    |    |    |    | B  | C  | N  | O  | F  | Ne |  |    |
| Na | Mg |    |    |    |    |    |    |    |    |    |    | Al | Si | P  | S  | Cl | Ar |  |    |
| K  | Ca | Sc | Ti | V  | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |  |    |
| Rb | Sr | Y  | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I  | Xe |  |    |
| Cs | Ba | La | Hf | Ta | W  | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |  |    |

Diagram 1: The periodic table of elements diagram with conceptual information

The graphics used did not always present content information as some were used for aesthetic reasons or to be visual cues to aid navigation. There were several examples of graphics being used for layout purposes that did not directly contribute to the content. The use of layout graphics increased the visual attractiveness of the resources in ways that could encourage student attentiveness to the resource. The graphics were also used to entertain and to emote feelings of warm and empathy in the learner. An example of this was the gif in “Energy & Change” shown in Diagram 2.



Diagram 2: The animated gif of a basketball player

Sound was present in roughly one fifth of the resources and was used to supplement text and graphics by assisting in environment creation, motivation and to emphasize other information sources. Environmental sounds included seagulls cawing and explosions while motivators were the clapping sound that was used to celebrate a correct answer. Generally, unlike the use of text and graphics, sound was not used to present content information.

Very few resources included video components. However, in the three resources where it was included, it presented content information and assisted environment creation. It was used to show chemical reactions and historical events. It was also used as an introductory tool to present a science lab rather than taking pictures or writing a description.

Twenty-five of the resources included Internet hyperlinks that were essential to many resources as the tasks required obtaining more information than was provided in the resource. These were usually used to allow learners to access to more information and required the computer to be connected to the Internet. Many of these hyperlinks were to organizations such as Landcare (<http://www.landcareaustralia.com.au/>) and the International Rivers Network ([www.irn.org](http://www.irn.org)). A few were links to interactive web resources such as <http://school.discovery.com/> which could take the learner to interactive puzzles and knowledge games which were based on the content of the resource.

### **Resource format**

The resources created by the pre-service science teachers were grouped into three distinct categories: PowerPoint presentations, webquests and html web pages. Out of the 27 resources, 15 were webquests, 9 were based in PowerPoint and 3 were html web pages.

Webquests made up the majority of resources created by the pre-service teachers. As part of the sessions on using ICT, the pre-service teachers were provided with a webquest template and an example webquest and this might have led to students favouring this format of resource. These webquests followed a standard format that included an introduction to the content, a task to be completed and hyperlinks to pertinent web sites that contained information to fulfil the task. Many webquests also included focus questions and group work which was designed to be used in as a whole class lesson. The webquests were the least interactive of the three formats. They also contained the least multimedia content as none contained sound or video components.

PowerPoint created a structure in the resources that did not exist in the other two formats. There was a sequential navigation that dominated resources in this format. Information was presented in discrete portions and learners were required to view the content based on the order set down by the resource designer. This format used a great deal of visual and aural cues as well as graphics to supplement the text-based information.

The greatest amount of learner control was in html web pages as it allowed learners to have many activity paths to pursue. The web pages had a typical html structure and opened using an Internet browser so this was the easiest format to use hyperlinks in. These resources also used a great deal of visual and aural cues as well as graphics to supplement the text-based information.

### **Instructional design format**

The analysis of the design of the resources was considered in terms of the directions provided for the learner by the lecturer, the organization of the resource, the evaluation in the resources for grading purposes, and the extent to which the pre-service teachers followed the assignment guidelines.

There was much variety in the instructions provided in the resources. Twelve resources were very straightforward and easy to follow such as the "Captivity Webquest," where learners were instructed "to form an opinion based on factual evidence" and the steps to make this happen were well defined with learners having a choice of roles to play within a group. There were six resources that had directions that were very vague and confusing such as "Do you have the *guts*?" The instructions ramble on for a long paragraph and most of the text deals with aliens keeping humans as pets. The task is then presented again in another paragraph and finally the focus questions are dot-pointed in a third paragraph. All three sections have a different emphasis that might be confusing to a learner. The resources with vague directions tended to be the resources that gave learner more choice even though these imprecise instructions were seen in all three resource formats.

Along with the instructions, the quality of the organization of the resources varied greatly. The layout of three resources hindered access to material through the poor use of applications. An example of this was the interactive PowerPoint quizzes that had learners jumping to a slide informing them if they were correct or incorrect. On occasion, navigating back to the quiz was difficult. The resources submitted as web pages also suffered from poor navigation with the learner not having a direct route to follow to get to the next task. Eleven of the fifteen webquests were very clear and well organized as learners could only take one path to complete the task.

Throughout the review of the resources, the design of emphasis and evaluation was noteworthy. There was a distinct lack of evaluation built in to these resources. The evaluation that was present did not have strong links to the intended learning outcomes. The tasks were often opinion pieces asking "What do you think?" The format of the task was usually clear but there were no marking criteria included. There were electronic quizzes integrated within some resources but they did not record results so they could not be used in any summative evaluation, but they were motivational and formative in nature. Other formative assessment included requests to answer questions on a piece of paper but this was not always the case.

Finally, some of the pre-service teachers needed to follow the assignment instructions more closely. The resources were to be designed for use by lower secondary science students (12 – 15 year olds). Some of the resources were not appropriate as the complexity of the tasks were too much for the target age group. Also, there was a great deal

of variance in the length of the resources. Several were quite short while others were very long. This difference in length had the nature of the resources ranging from a short lesson to a multi-lesson unit. This variance in resource length was not unexpected as there was no length specified in the directions given for this task to the students.

### Conclusion

The main trends discovered in the design of the ICT resources created by this cohort of pre-service science teachers were: the focus on lower level thinking skills; the primary format was text-based webquests, with graphics augmented PowerPoint the second most submitted format; and most resources were well organized with clear instructions. The major limitations were the absence of calls for higher thinking skills, and the absence of navigation that allowed some choices for learners. In the future, having a similar cohort of pre-service teachers focus discussion on levels of thinking skills and evaluation of learning as well as navigation and organization may alleviate these issues. As well, discussion on the benefits of different formats of presentation could be beneficial.

Arenas for future research include a number of areas of interest arising out of this study involving pre-service teachers. These include the examination of presentation formats and including more templates and examples from a range of formats, the format of interaction of designed tasks, the availability of science education audio and video resources and exploring how to improve educational task creation requiring higher order thinking skills.

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