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## AARE paper (refereed)

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**Title**

Use of cognitive tools as support mechanisms for adult Indigenous learners in an online mathematics unit

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Paper Presented at the AARE Annual Conference, Fremantle, 2001
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**Abstract**

(200 words)

The staff at Kurongkurl Katitjin (the School of Indigenous Australian Studies, at Edith Cowan University) design, develop and teach courses that are offered in a variety of delivery formats: on-campus, online and through traditional distance education. Many of our off-campus courses are now being delivered via the use of online learning technologies. For example, the individual units within the Indigenous University Orientation Course (IUOC) are currently being redesigned to incorporate these new learning and communication technologies. With the major components of these units being based on the internet, learning is also supported by contact with on-campus lecturers, print and multimedia learning resources.

This paper considers the instructional design, content preparation and delivery methods selected to create one particular unit of study in the IUOC course, Thinking Mathematically. The roles of the unit development team members involved in the design and production of this unit are outlined. The paper particularly focuses on the manner in which cognitive tools have been incorporated into the unit to scaffold learning opportunities, to promote positive attitudes to the topic and to identify and strengthen the link between theoretical and practical mathematics. Previous research into Indigenous students' reactions to online learning and mathematics in general informed the unit development processes and was supplemented by research from contemporary literature relating to effective online learning guidelines. Primarily, the paper reports on which cognitive tools were implemented to achieve specific learning outcomes in terms of the students' knowledge, skills and attitude development.

Full paper

**Background**

The staff at Kurongkurl Katitjin, the School of Indigenous Australian Studies at Edith Cowan University in Perth, are concerned with how to create customised online units of study for their Indigenous students. The School's past experience with creating and teaching using distance education materials has been put to good use in more recent years as the School meets the challenge to prepare innovative and accessible online education to its metropolitan and remote students. Since 1997, a number of the units taught at the school are taught online whereas other internally and externally delivered courses are incorporating both online and offline technology in their design.

This paper outlines the processes associated with the design and development of one of the units taught at the School as part of the Indigenous University Orientation Course (IUOC), particularly focusing on the use of cognitive tools to scaffold learning. One of the units within this bridging course is ABB 1114 Thinking Mathematically. It is a core unit in the course; with strong support for its existence coming from both past students and Indigenous staff members. They consider that the unit offers life skills that may be lacking due to negative experiences in mathematics in many students' educational backgrounds. Historically this unit has only been offered in print-cased external mode. The predecessor of this unit was originally written over 18 years ago, and received a minor update in 1999. Last year this print-based unit was written to replace it, and to bring it in line with current thinking in mathematics, using constructivist principles and making use of context-based situated

Paper Presented at the AARE Annual Conference, Fremantle, 2001
Australian Association for Research in Education

learning. Students were encouraged to use calculators, and from 2002, one will be supplied with the unit materials. Many of the changes came about as a result of feedback from students who were working in Regional Centres in Broome, Geraldton and Katanning.

A research project, *Indigenous Australian Adults' Perceptions and Attitudes to Mathematics and On-line Learning of Mathematics*, conducted in 1999, provided us with some valuable information about the learning preferences of the expected target audience for this unit. We found that over 50% of the students believed that on-line learning was better than the traditional (book) way of learning. 20% of the people said that an online unit would enable them to go over and over the work until they understood it. The other main advantages given were that they could go back and correct their work on-line, that it was more interesting, faster and not subjective. Interviews for this research indicated that most of the participants were aware that mathematics played an important part in their lives, but they mostly equated this with monetary and budget concerns. This had implications for the design of a new mathematics bridging unit. Also, an evaluation carried out in 2000 and 2001 of similarly designed online units at the school has suggested that the careful use of cognitive and learning support tools can greatly enhance the learning opportunities of students while at the same time increasing motivation and enjoyment levels.

**Development of the unit**

Instead of applying a faculty designed or a commercially available courseware or template for course design, the team of staff responsible for creating this unit have opted to design the unit in a more customised manner. That is, the online version of this unit is based upon a specifically designed structure and interface. These designs were created as a result of consultation amongst all members of the online development team (project manager, instructional designer, computer programmer and multimedia developer) in conjunction with the academic staff member (the content expert) responsible for creating and teaching the unit.

This "do-it-yourself approach allows for maximum freedom for design and delivery" as each "instructional website can be highly individualised" . The advantages of this design method include the ability to more accurately meet the needs of the target student audience. The use of simulations and tutorial exercises have enabled us to ensure a direct link between theory and practice and by providing users with plenty of control, feedback and opportunity for both remediation and fast-tracking, the unit attempts to meet student needs more succinctly .

By providing the unit to students in online website format and a static CD-ROM as a backup when online access is not possible, the flexible nature of the unit is guaranteed . This prevents the traditional problems associated with slow download times due to non-ideal modem connections, slow bandwidth speeds and competition to use available telephone lines. Use of hyperlinks within the unit have been designed with Hall's recommendations (Hall, 1999, cited in in mind who recommends a restrained but informed use of such functions. Since many of the cognitive tools used in this unit incorporate elements of hypertext, this design feature is particularly important as we didn't want to overuse the affordances of hyperlinks so as to prevent confusion, distraction and cognitive overload. For example, the general hyperlinked environment of the unit fosters an awareness of the relationship between various mathematical concepts as well as allowing users a higher level of control than is possible in the print based version of this unit.

Paper Presented at the AARE Annual Conference, Fremantle, 2001
Australian Association for Research in Education

**Design and selection of cognitive tools**

A selection of cognitive tools have been designed and incorporated into this unit. The purpose of using them is to enhance the students' learning experience by providing meaningful ways in which to interact with the mathematical content. Since the unit takes the form of a website, the tools used were primarily based on computer technology but also integrated hand held (calculator) and print (workbook) technology. The choice of medium of each tool has been driven by a desire to create an authentic learning environment where students skills and knowledge could be meaningfully situated . give a definition of computer-based cognitive tools which is relevant here in regards to their function and form:

> Computer-based cognitive tools have been intentionally adapted or developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning. Examples of cognitive tools include: databases, spreadsheets, semantic networks, expert systems, communications software such as teleconferencing programs, online collaborative knowledge construction environments, multimedia/hypermedia construction software, and computer programming languages.

, while using the term "mindtools" refers to their role in supporting mental processes "supporting those functions, mental and computational, that directly impact on cognition." Jonassen suggests that cognitive tools can be used as ways to assist learners to expand their thinking as well as encourage them to construct knowledge instead of merely replicating knowledge. He also considers that cognitive tools can help learners to complete complex tasks while also gaining a wider understanding of the specific subject domain.

The above aspects of cognitive tools in general fits in well with our intentions to create a unit in which students could not only complete mathematical tasks in authentic contexts, but we also wanted to design a unit where practical thinking tools were provided to assist students' learning processes. Across the board, the use of cognitive tools relies heavily on the students' use of language, whether it be represented in verbal speech, inner thought or written language. Vygotsky considered language to be the most important tool of all and suggested that the interplay between thought and language use had huge effects on the manner in which students learn . describe language as the "tool of tools" but also stress that there is no one tool for every situation. This advice was heeded in the design of Thinking Mathematically where we attempt to provide the right tool for the right task as well as allowing some element of choice for students in relation to when and how each tool was used. suggest that "flipping" between different media representations, ensures that links are made between various contexts.

The cognitive tools included in this unit support the initial intended learning outcomes, that is to encourage mathematical skill development, increase confidence as well as acknowledging students' prior knowledge levels. The cognitive tools selected for use in this unit included the following:

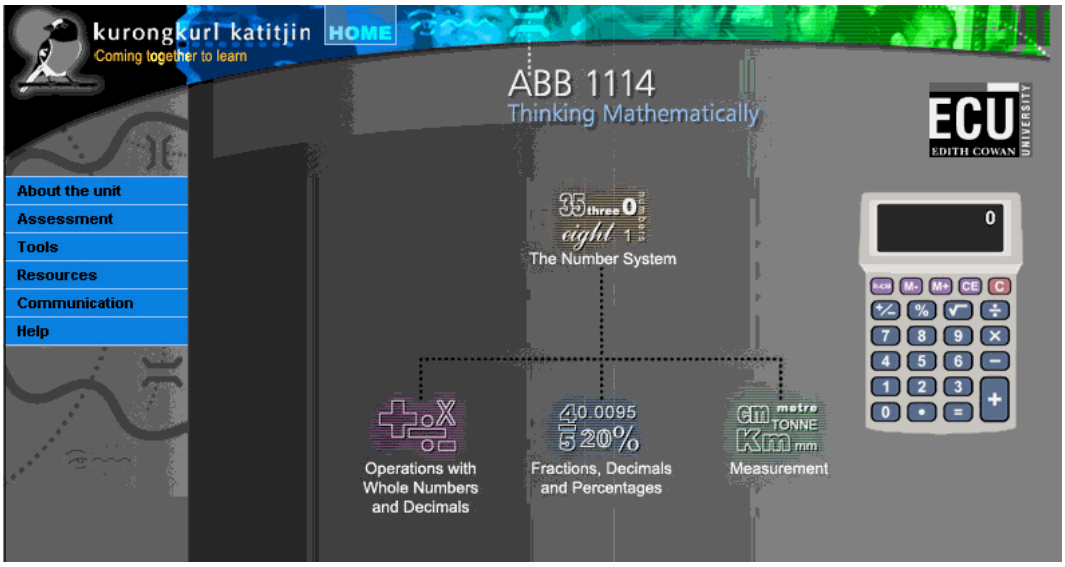
***Online, floating calculator and hand-held calculator***

The online calculator has limited functions, and has been adapted to the course content. For example, the concept of square root is not in the unit, therefore this key is not functional on the online calculator. It has been labelled a "floating" calculator to describe its moveable nature. The calculator, created with *Flash* software, is located in a separate window and is therefore able to be moved around the screen by the learner.

Paper Presented at the AARE Annual Conference, Fremantle, 2001
Australian Association for Research in Education

This dual presentation (online, hand-held) means that the calculator that the students use is exactly the same as the online version. We have found that some adult students are not comfortable using calculators, even believing that they are 'cheating' by using them. By including a number of activities where they have to use them, and by providing some step-by-step demonstrations of their use, students should become more comfortable with using them. This streamline design has the online environment reflecting real life.

The availability of the calculator is contextual, but also perpetually accessible from 'Resources' menu. Where the use of a calculator is the central focus of an activity, it will appear on the screen without the need to access the 'Resources' menu.




***Paper-based workbook***

Because of the difficulty of students writing mathematical symbols online, we aim to get students to write their answers in a paper-base workbook. This is provided with their unit materials, but is also be available in the 'Resources' menu to be downloaded if required. It serves to integrate the online content with the paper-based, as in a real life situation, and to reduce confusion about typing in mathematical symbols.

The workbook also has a section where students record their progress. This serves a metacognitive function.

***Online glossary***

This is an important tool in helping students come to terms with the specific 'language' of mathematics. This mathematical language is often seen as an invisible barrier to students' understanding of mathematical concepts. By including an easily-accessible glossary of terms used in the unit, we hope to overcome this particular obstacle that students perceive with mathematics. Sinitsa, K, Mizoguchi, R., & Serdjuk, M. (1992) describe a Glossary as a cognitive tool for:

- "helping capture the conceptual structure of the domain;

Paper Presented at the AARE Annual Conference, Fremantle, 2001
Australian Association for Research in Education

- facilitating in-depth understanding of concepts by tracing concepts related to the chosen ones; …
- assisting in search for glossary entries that correspond to or are related to the user's concept;
- displaying terms' explanations and definitions at appropriate level of details;
- providing convenient and friendly interface."

They go on to suggest that the glossary should be "available via Internet, have a friendly and clear interface, allow for different types of search, and provide explanations at the appropriate level." When creating the glossary, the design team wanted to allow it to reflect the human cognitive process. As explained by Sinitsa, et al (1992) an online glossary should allow the user the opportunity to incorporate new concepts while establishing links to current knowledge. Since our students are first year bridging course students with minimal exposure to online learning, there is the added need to design it with an ‘ease of use’ principle in mind. Hence by designing the glossary as such, the development team created a comfortable means of understanding the function or workings of the tool. The team built the glossary to be, as with the total feel of the unit, a non-confrontational environment.

Essentially, the glossary for this unit can be accessed by several methods: from the ‘Resources’ key in an alphabetical format; by scrolling over call out boxes rather than jumping to a completely different window where a student may get lost in bad navigation; and by scrolling over a hyperlinked word within a hyperlinked word for further explanation. This should result in students being provided with incidental mathematical knowledge in the context of the required definitions. An example of this is where the student comes across the term ‘denominator’ as part of the work on fractions. If the student is not familiar with this term, s/he would scroll on the word, which hyperlinks to the Glossary. The call-up box shows the word ‘Denominator’ with a definition, "The bottom number written in a fraction. It tells how many parts there are in the whole." There is also a diagram and example of this, eg "In this fraction, the rectangle is divided into 4 equal parts, three of which are shaded. This represents the fraction 3/4. There are 4 parts, so the denominator is 4, and 3 of these are shaded, so the numerator is 3."

Although one of the key elements of a web-based environment is the function of hyperlinking the design team attempted to limit hyperlinks in the online unit for several reasons. First, considering that many of the students were first time users of online learning it was avoided so as not to confuse students. Secondly, it was also important to ensure that the students remained focussed on the task on screen. Therefore by designing glossary explanations in small ‘call out’ boxes, the learner would then be able to see the context in which the term in used and the remain on the screen they are reading rather than jumping to a new screen.

***Online workload planner/calendar***

Due to time constraints these particular tools were not incorporated into this version of the Thinking Mathematically online unit. However with further revision the development team see immense value in providing such tools as integral components of online units for bridging course students. As discussed, the students which are enrolled in this unit may have had limited exposure to online delivery modes and in addition, taken the orientation course after a lengthy absence of formal educational experience. With this in mind, the design team will build a web-based workload planner and calendar to provide assistance to the student. This will be provided online as a Word document that students download and customise to their own needs. This will support the students’ recommendation for integration of online and paper media in accordance with finding of Marshall et al (2000).

Paper Presented at the AARE Annual Conference, Fremantle, 2001
Australian Association for Research in Education

### *Summary of cognitive tools*

As is obvious from the above description, not all of the cognitive tools used in this online unit were in fact presented online. However, in the case of the calculator, this is provided in both an online and a hand-held version. This high level of customisation has been consciously adopted by the staff involved in the development of this unit to ensure the cognitive tools are contextually appropriate and were not just included in the unit for novelty value. Each has been designed with a clear purpose in mind.

## Further application

When this online version of the unit is taught to students in future semesters, evaluation will be collected as to how the students use the cognitive tools provided. It is hoped that the tools will be used quite incidentally, in an almost "transparent" way. Our future research goals include those related to observing and documenting the use of these tools. It is planned to collect this data at various stages of the semester so as to ascertain if there is a pattern of use associated with the tools and how the use of the cognitive tools is connected to the unit's original learning outcomes. More research is also needed to ascertain which tools work best and, subsequently, which ones require adjustment. Furthermore, each tool should be evaluated in terms of how well they enable some level of scaffolding.

Further online unit development at the School is expected to continue in the next few years. As such, the experience gained from the development of customised cognitive tools within this unit, Thinking Mathematically, will ideally be transferred to the development processes associated with other units in other courses at the school. The value of the cognitive tools used in this unit is that they are quite applicable to other contexts and discipline areas. With small amounts of adjustment to their functional processes and visual appearances, the cognitive tools used in this bridging course unit will undoubtedly be used in other contexts where computer technology is used as part of the course components.

## References