2006

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Abstract: The mutability of contemporary work practice requires graduates who can continue to develop in self-regulated ways. This paper describes research into design and evaluation of a product to assist learners in engaging in the metacognitive processes inherent in the domain of reading comprehension. Findings identified strengths of the product and a number of features that could be improved, as well as contextual factors that may impact on the implementation of such learning environments.

Keywords: self-regulated learning, metacognition, reading comprehension

Introduction

Reich (1983) argues that we are now part of a post-industrial society and the work force of the future will have to be far more highly skilled and adaptable than the work force of the past. This requires a high level of self-regulation that must be developed by the time learners enter their professions. In the end, students must be responsible for their own learning. After all, 'learning is not something that happens to students; it is something that happens by students,' (Zimmerman 1989, p. 21). However, it is unreasonable to assume that students will be coming into a course with the skills to regulate their own learning. While increased flexibility and the impetus for the use of technology as a learning medium may have many learning benefits, particularly with regard to on-line learning, with studies as far back as the late 1980s touting its benefits to learners (Harasim 1989; Crook 1994; McAteer, Tolmie et al. 1997), there are many issues associated with this, not least of these being a high drop-out rate for students with poor study skills when they venture on-line (Loomis 2000). Brooks (1997, p. 135)

One important use of the Internet is as a means of accessing course readings, either in the form of Web pages or as electronic documents, such as PDF resources. It provides an efficient and maintainable means of dissemination. The approach of providing several electronic readings rather than a single text also promotes the multiple perspectives inherent in contemporary approaches to learning, such as those espoused in cognitive flexibility theory (Spiro, Feltovich et al. 1992). However, it is erroneous to assume that students entering tertiary education are able to engage effectively in such processes. While most Australian students have little difficulty with the building blocks of reading such as phonics, studies have shown that only 40% of students can be identified as 'proficient' at the level of reading that involves engagement 'in higher level, problem solving literacy of the kind required in an information generating and information transforming economy' (Greenleaf, Schoenbach et al. 2001, p. 83).

Research has shown that metacognitive knowledge and self-regulation facilitate reading comprehension (Collins, Dickson et al. 2001) but this is an end product rather than a process.

One cannot assume that simply placing students in a mode of study that requires self-regulation will help to promote it. Rather than throw students 'in at the deep end', mechanisms must be in place which bridge the nexus between supported and self-regulated learning.

This paper reports on a study that explored the implementation of an online learning environment called Mark-UP that was created to assist students in developing metacognitive strategies to support their reading comprehension. A rationale for the design of the product is provided as well as findings based on an exploration of student use.

Promoting metacognitive regulation of reading comprehension

Several models have been developed to explain the processes that underpin self-regulated learning. Boekaerts (1997) provides a six component model that incorporates both cognitive and motivational aspects of the phenomenon. There is a large body of work that has examined ways in which the affective components of self-regulation can be targeted to increase students' motivation and persistence in their learning. Emotional factors are generally seen to be more accessible and amenable to change than the cognitive aspects. The two are not unrelated however. Corno (1986), for example, argues for metacognition as the dominant controlling process; that 'affect is the subjective perception of emotional states; thus associated attempts to control negative affect fall within the domain of metacognitive control' (p. 334).

Wilson (1999) defines metacognition as both a state and a process, with three functions:

- metacognitive awareness – individuals' awareness of their learning process, knowledge about content knowledge, and knowledge about their own strategies;
- metacognitive evaluation – individuals' judgments of their capacities and limitations; and
- metacognitive regulation – the conscious modification of thinking using cognitive resources.

In previous work, we have proposed a model to describe the development of metacognitive regulation by engaging students in activities, supports, and resources that enable students to learn and apply regulatory strategies within a domain, with metacognitive awareness being developed through students' self-monitoring (McMahon and Oliver, 2003). The regulatory strategies defined in our model include those proposed by Dole, Duffy, Roehler & Pearson (1991), specifically, summarizing, drawing inference, questioning and determining importance.

In the context of reading comprehension, the cognitive domain chosen for our instantiation of the model, the strategic activities that underpin these include such activities such as adding notes, writing summaries, posing questions, and in the case of determining importance, highlighting sections of the text. Self-monitoring is an important element in the model, defined by Dirkes (1995) as planning, monitoring and evaluating the thinking process. Those activities that involve students in such processes are inherently reflexive in nature and can include such activities as comparing notes and clarifying understandings. In our context, monitoring is framed by the use of resources relevant to reading comprehension, such as in the case of undergraduate reading, web links, readings, peer comments, and strategy information.

Mark-UP

The model was integrated into an on-line learning environment, Mark-UP, to encourage students to engage in the regulatory strategies inherent in reading through activities such as annotating, information seeking, and summarising of graphical electronic version of academic readings, as well as the underpinning metacognitive processes in reading and understanding these. These activities were framed around resources in the forms of reading content (the articles themselves in graphical form), Web links, peer comments and expository material provided by the teacher about effective reading strategies. The setting was designed to enable annotation of readings in the ways mentioned above, which were then stored in a database form which could be later accessed in the form of a summative portfolio.

The heart of Mark-UP was an innovative annotation tool that enabled students to comment on readings online in a fashion that supported collaborative and reflective activities. Mark-UP provided the mechanism to annotate a large number of readings and included tools that provided contexts for the reading and strategies for peer support and collaboration (Figure 1.).

In a typical learning sequence, students would access Mark-UP to undertake a problem. They were supported in this process by a number of tools and resources in Mark-Up.

- *Problem Tool:* This tool enables the course designer to pose questions and provide a text box for users to complete. Questions could take many forms, for example prompts about a reading, or instructions for the end user to provide concrete examples.
- *Summary Tool:* This tool was designed to allow learners to summarise a whole reading and to present their problem solutions. The tool also allows a course designer to provide a model answer, for learners to review.
- *Post URL Tool*: This tool enables learners to add a link to an external website, including a title and comment. Learners can also review and rate the URLs posted by others.
- *Annotation Tool:* This tool enables learners to add annotations to online readings which can be viewed by other students. Annotations can take the form of summaries, questions, agreement or disagreement and general comments. Learners can view each other's annotations and add to them.
- *Forum Discussion Tool:* This tool is a simple discussion board. Subjects could start general discussion threads or respond to existing discussions
- *Portfolio Tool:* The portfolio tool consists of a summary of all the learners' work organised by readings. Students are able to generate and review a portfolio for submission.
- *Review URL Tool:* A facility integrated into all tools, enabling learners to review Web links as part of the process of inquiry and problem-solving..

The main purpose of the research was to explore the nature of metacognitive activity in the use of the Mark-Up. However, a second aim was also to explore the effectiveness of the product in terms of its design and it is this aim that forms the basis of this paper. Three research questions were used to focus the study:

1. What factors inherent in the design and implementation of the environment affect its use?
2. What factors inherent in users' backgrounds affect the use of the environment?
3. What are the external environmental factors that affect the use of the learning environment?

Figure 1: Page and task navigation view of Mark-UP

Research approach

To explore Mark-Up we used a methodology informed by *design-based research* - an approach that has been allied with action research (Hoadley 2002) but has some distinctive features. Like action research, it uses an interventionist approach with a focus on iterative activity. It is 'pragmatic as well as theoretical in orientation in that the study of function - both of the design and of the resulting ecology of learning – is at the heart of the methodology' (Cobb, Confrey et al. 2003, p. 9)

Mark-UP was implemented among a group of undergraduate students in a unit on interface and Information Design in an Australian university. In all, 126 students participated as subjects in the research. The unit was taught on campus and consisted of three contact hours per week with a one-hour lecture and two-hour laboratory session. Of these 126 subjects 12 volunteered to be interviewed formally. The unit consisted of 12 weeks of contact over a

period of four months, with Mark-UP being used in activities in each of the contact weeks. Subjects completed the majority of the Mark-UP activities in their own time outside of the regular class.

Given the contextual and interpretive nature of the research, a range of forms of data collection and analysis were required. Questionnaire approaches enabled the exploration of broad trends in terms of how the group as a whole used the product, while individual interview and analysis of the work produced in Mark-UP allowed for exploration of cause and effect as well as detailed vignettes of individuals' experiences. To conduct effective analysis in design-based research one needs to 'work systematically through the extensive, longitudinal data sets generated in the course of a design experiment so that the resulting claims are trustworthy' (Cobb, Confrey et al. 2003, p. 13). Support for this grounded approach to data analysis can be found in an Glaser and Strauss' approach to analysis known as constant comparison (cited in Lincoln and Gruba 1985, p. 339) According to Goetz and LeCompte (1981) this method 'combines inductive category coding with a simultaneous comparison of all social incidents observed' (p. 58).

Findings

Mark-UP Tools

There were a number of design features that required attention to improve Mark-UP and these issues had a minor impact on users' experiences with the product. Mark-UP provided the means for a great deal of learner activity throughout its implementation. The results revealed students used all tools, even when not prescribed. The nature and difficulty of certain readings affected the type of activity with which students engaged. In the readings which were contentious or addressed unfamiliar concepts, annotation was the most widely used tool.

Students' attitudes to the environment were remarkably consistent across the range of tools, specifically regarding those based around readings. In responding to statements regarding the value of each tool, nearly three times as many students responded positively about each tool than negatively. The tools perceived to be most useful were the Design Problem tool (weekly problems) and the Portfolio tool which were less focused on the readings themselves but provided the means of transformation of learning (design problems) or metacognitive self-evaluation (Portfolio).

This suggests students preferred tools that allowed them to apply their understandings in a practical way, rather than those that were more process-oriented, based directly upon the readings. The Portfolio tool had a strong outcome focus and seemed the most preferred of the tools. However as the primary means of collating responses, its perceived value as a learning tool was diluted, leading to a larger number of neutral responses from students concerning their perceptions of its learning value. Overall one can conclude that each tool's perceived value was related to its relevance to the course outcomes, with stronger support for tools assisting in the practical application of the unit concepts, rather than the less tangible value of tools to enhance the reading and learning process.

Mark-UP Interface

In terms of the actual interface of the product, some issues became apparent. Areas of concern that were manifest more than once in surveys and interviews related to:

- inconsistent use of arrow icons, which at times were used for navigation and at others for providing cascading menus;
- hidden tasks resulting from the use of cascading menus;
- page navigation, where users were required to move to a page before loading it;
- session time-outs, where initially the user was automatically logged out after 10 minutes of inactivity;
- insecure transactions, where in the first week some posts were lost due to an error in coding;
- graphical interface elements, which some students found unappealing or confusing;
- the lack of a help facility for formatting responses as most response forms allowed basic HTML editing;
- pop-up windows when navigating from one section of the product to another; and
- bandwidth requirements.

On the whole such issues had a minor impact on users' experiences with the product. Some, such as the use of graphical icons and approaches to the navigation system within Mark-UP, are easy to modify. Others, such as the bandwidth requirements of the system, are intractable, but will improve with advances in technology and the wider adoption of broadband Internet. None of these issues prevented students from using Mark-UP to read or transform texts, and it is important to acknowledge a number of Mark-UP's strengths with regard to overall ease of use. On the whole, students found the environment manageable, particularly once they had overcome any initial difficulties caused by the design features identified above.

Problems and context

Subjects in the study had little negative to say about the learning design within Mark-UP, evidenced by the paucity of comments relating to course design both when they had to respond to Mark-UP in their Week 4 activity and in the final survey conducted at the end of semester. There were some initial difficulties with the reading process, however, that were related to the fact that the product made use of readings from multiple sources rather than a single text. Firstly this led to some repetition between readings, one student commenting, 'Yes, I also think that the readings in some cases are a bit much to read on screen. However, I think that if the readings were cut down and sifted through a bit more it would not be as much of a problem as there is often repetitive information within the readings that is unnecessary' (Subject 96).

Unsurprisingly, the readings that caused the most difficulty within the first few weeks were the ones that were from academic journals rather than websites or text books:

> The content of the reading itself requires concentration in reading and understanding it, especially week 1 and 4. In my opinion, students who already have multimedia background will find the reading challenging, however for students who start from zero, it will require much more effort to understand the reading (Subject 28).

The product's focus on reading comprehension did require some level of challenge. It would seem important however to balance the level of challenge with the readings and to ensure they and the activities are relevant to learners' needs. A common theme through the survey and the Week 4 Mark-UP response was that learners enjoyed the reciprocal interaction inherent in reviewing each other's work and engaging in discussion on topics. Nevertheless, there was one issue that did come through strongly, specifically the amount of work involved in using Mark-UP each week, with an overwhelming majority of the students indicating that this was

excessive. Several students suggested reducing the workload in their review of their portfolios, either by making activities fortnightly rather than weekly or giving students the option to only do activities on a percentage of the readings.

Student and external environmental factors that impacted on the use of Mark-UP

To provide a context for interpreting student feedback on the product it was important to understand the nature of the student population and the environmental factors that impacted on its use. One salient finding was that students in the course generally lacked both intrinsic motivation and a range of strategies to ensure maintenance of effort, with strong levels of agreement to survey statements indicating a difficulty to study subjects they don't enjoy and a tendency to give up easily. Such findings were tempered by a strong bias in favour of using technology, hardly surprising in a unit that teaches multimedia design. Nevertheless, this positive bias was limited by students' external environment. While students were 3.74 times more likely to agree than disagree to survey statements reflecting access to high quality technology, there was a general consensus from students that they had difficulty managing the multiple demands on their time including both work and social lives.

Conclusion

The study produced findings about Mark-UP and how it was used that could further improve the software as well as in implementing on-line approaches generally in a blended learning environment. Mark-UP was found to have generally worked successfully throughout the semester with regard to its technical stability and design features. Initial problems such as a coding error and session time-outs created some negativity towards the product though subjects were able to overcome this insecurity as they started using it. The majority of subjects were also able to accommodate some design features that impacted negatively on ease of use relating both to the interface and graphical design of the product as well as issues with its implementation into the existing courseware management system. Problems relating to icons, pop-up windows and a lack of help for formatting text are issues that can be improved in future iterations of the product.

There were few issues with the course design except for one major problem relating to the level of activity within Mark-UP. It placed students in a mode of study that had much greater expectations of effort than they were previously accustomed to. There are two sides to this issue. On one hand, it led to some negative perceptions of the product in terms of it being a 'chore'. On the other it is clear that the consistent level of work across all of the tools and activities within Mark-UP meant that students were actively engaged in their learning; possibly more than if readings were set without any specified activity around them.

It must be noted that the subjects in the study tended to lack motivation for study, particularly in units that they did not find intrinsically enjoyable, and this overall lack of reported volitional self-regulation was likely to have impacted on the quality of the work that was created with Mark-UP. Nevertheless, their backgrounds demonstrated an overall positive orientation to the use of technology that would have helped them to overcome some of the problems with Mark-UP's interface. Overall Mark-UP created some barriers for students in reading academic texts; however it also afforded subjects the opportunity to participate in complex types of activities around the readings.

The findings from the research supported our contentions that Mark-Up would be a successful instantiation for our model for self-regulated learning. Mark-UP was found to provide a stable

and steady online platform to support teachers seeking to develop students' reading comprehension. Clearly, the success of the tool depended on a number of external factors relating to the context in which it was used, choice of tasks and problems and attributes of the target audience. The capacity of the tool to support the development of students' self-regulation in reading comprehension was the subject of an extensive inquiry (McMahon 2005) and will be reported in publications still to come.

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