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Engaging First Year Students Using a Web-supported Inquiry-based Learning

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Abstract

This paper describes a study that explored the utility and efficacy of the application of a Web-based tool to promote learner engagement among first year students in a large class in an undergraduate communications degree. The Web-based tool was developed to support an inquiry-based learning approach that was characterised by strong learning scaffolds, meaningful contexts, feedback and support and administrative efficiencies. The study explored the forms of engagement that the Web-supported inquiry-based learning approach was able to engender among first year undergraduate students and the factors that were found to influence students' levels of engagement and achievement in the approach.

Keywords: e-learning , inquiry-based learning, first year students, higher education, Web-based learning,

INTRODUCTION

With the massification and corporatisation of higher education across the globe, there is mounting pressure on universities to create and deliver curricula that reflect the diverse needs of many stakeholders (Tynjala, Valimaa & Sarja, 2003). In this climate we now see many universities seeking to utilise economies of scale in the provision of programs to their students. Information and communication technologies (ICT) are being increasingly applied to provide efficiencies and opportunities to help this cause. A growing amount of research and development is being applied to explore ways to cater successfully for the learning of the diverse student groups across faculties and departments (Scott, Buchanan & Haigh, 1997). Of particular interest to many is the plight of first year students in universities who often find themselves studying diverse subjects in large class settings.

First Year Students

First year students in university courses often experience a number of difficulties that can limit their potential to succeed and achieve (McInnis, James & Hartley, 2000). Many universities today recognise that students in their first year of study have particular learning needs as a consequence of their differing backgrounds, previous learning experiences and their often under-developed self-learning skills. First year students need to be able to assume responsibility for their own learning, to undertake independent research and inquiry and to communicate and argue their ideas in a succinct fashion (Calder & Hanley, 2004). Students entering university courses are often lacking in these skills and need to quickly develop a number of difficult capabilities to achieve success.

Designing learning environments to engage learners in their first year of university studies requires some degree of caution and care. Often first year students find their initial studies

stressful as they are exposed to new ways of learning. Many in their first year of university learning find difficulty with learning approaches that place high levels of responsibility onto them. Such strategies can work if there is sufficient scaffolding and support but in large classes, it is often difficult to provide sufficient support to address the many needs of these new students (Calder & Hanley, 2004).

Contemporary technologies have been shown in many cases to provide the forms of support that students in their first year of university study might need. Technology can provide strong systems for managing learning settings while offering students choices and opportunities to undertake learning suited to their own needs and wishes.

Technology-facilitation

Technology is increasingly becoming a mainstream element in the delivery of higher education programs. Typical infrastructure in universities today include large scale networked computing, high levels of student access to technology, high bandwidth Internet connectivity and courseware management systems supporting curriculum delivery (Collis & Moonen, 2001). Whilst considerable opportunity exists for teachers to employ technology-facilitated student-centred modes of learning, the uptake of technology in large classes has been limited by a number of practical and pragmatic issues. Such issues as student expectations, lecturer and student ICT skills and limiting pedagogies have for many years restricted the mainstream uptake of technology (Kearsley, 2005). Contemporary Web technologies now provide opportunities for the development of customised learning settings that can scaffold and support student learning and reduce some of the elements previously impeding ICT usage. These technologies are now attracting teacher uptake as they provide the means for administrative efficiencies in the delivery and management of courses.

There appear plentiful opportunities for appropriately designed technology-facilitated learning settings to be used to address learner needs and requirements in higher education, in particular, those facing first year students in large undergraduate classes. The use of technology in such settings holds particular promise for the creation of learning settings that can interest and motivate learners and support their engagement while at the same time providing the necessary forms and levels of support for independent learning (eg. Goodyear, 2005).

Learner Engagement

The extent to which a learning setting can engage learners is often seen as a strong indicator of the depth and scope of the learning that will occur (Trigwell, Prosser & Waterhouse, 1999). Typical delivery strategies within university settings involve lectures and presentations and frequently fail to engage learners (eg. Biggs, 1999). Such settings have been found to encourage learners to focus on the content and information presented itself in a superficial fashion, in what is commonly known as surface level learning. The alternative to surface level learning is deep learning. This is characterised by learners seeking to understand and comprehend content and information in ways that enable it to be applied and transferred beyond the classroom setting (Biggs, 1999).

A number of writers have explored aspects of learner engagement and have developed classification schema that can be used to describe the forms of thinking and cognition associated with learning. Bloom (1956), for example, describes six levels of cognition comprising lower and higher-order thinking processes. The lower-order thinking skills described by Bloom mainly involve accessing information and dealing wit it in ways so it can

be recalled and repeated. The higher-order thinking skills are those that are associated with organising and processing information so that it can be analysed and applied to new settings.

Anderson and Krathwohl (2001) provide further descriptions of Bloom's levels and argue a sequence and structure exists in the development of thinking skills that can be described in six levels; remembering, understanding, applying, analysing, evaluating and creating. This continuum provides a means to evaluate the scope and depth of learning which extends way beyond the simple acquisition of knowledge. In a similar fashion Biggs (1999) describes a series of structural levels describing learning outcomes; prestructural: unistructural: multistructural; relational: and extended abstract.

Conventional learning approaches in higher education are often unsuccessful in developing and promoting higher-order learning outcomes (eg. Laurillard, 2002). The problem often lies in the roles assumed by the learners being passive more than active participants in the learning process, receiving rather than seeking information. Jonassen (2000) argues that meaningful learning can only occur in the context of problem-solving and inquiry, activities that require students to become cognitively engaged. Kearsley & Shneiderman (1998) argue that engaged learning occurs in settings which involve active cognitive processes such as creating, problem solving, reasoning, decision making and evaluation. Boud & Prosser (2002) describe four principles that they argue are necessary for an effective learning environment: a context for learning that acknowledges the learner's contexts and needs; challenge for the learner, cognitively engaging, and opportunities to practise and use the application of the knowledge, skills and understandings being developed. Laurillard (2002) and Ramsden (1992) in their seminal texts describing teaching and learning in higher education often refer to engagement as a critical element underpinning the effectiveness of learning settings.

Inquiry-based learning

Creating learning settings that engage learners sits as a primary task of teachers across all sectors of education. A range of strategies have been developed to guide teachers in the design of learning settings that can provide the forms of learner engagement required for successful learning. Kearsley & Shneiderman (1998) for example, propose a model based on their engagement theory, that incorporates collaborative teams working on large projects that are meaningful and relevant. Collis & Moonen (2001) describe a model for teaching and learning called *the contributing student*. This model describes learning setting which provide engagement through collaborative activities that lead to the development of products in the form of actual learning materials. Collis & Moonen (2001) argue that few items could be more relevant to students than appropriate learning resources and in this model, learners work to develop a set of rich resources for a learning environment that initially contains few selected and structured learning resources. Herrington, Oliver & Reeves (2003) describe authentic learning as yet another alternative for creating meaningful contexts for learning in higher education. Their model of learning describes characteristics that they argue underpin meaningful learning based on the collaborative solution to authentic tasks that are complex and open-ended. Inherent in all these models of learning is a deliberate strategy that encourages and requires learners to engage in higher-order thinking and cognition.

There are simpler strategies that teachers can employ to engage learners rather than employing a particular learning design as described above. A number of writers have demonstrated and described the use of problems and inquiry as contexts for engaged learning (eg. Jonassen, 2000). Inquiry-based learning describes learning where some form of problem or task serves as a catalyst for student engagement and participation (Fogarty, 1997;

Kingsland, 1996). Learning comes as a consequence of the information processing that occurs as students work to explore the problem setting and to seek a solution. The novelty of working with the problem enables students to acquire new knowledge, as well as to further consolidate their existing skillset and understanding (Schiller, Ostwald & Chen, 1994). Jonassen (2000) argues that through exploration and inquiry, students necessarily assume a degree of responsibility for their own learning and are required to make decisions and judgments that might otherwise have been made by their teachers.

These factors tend to distinguish forms of inquiry-based learning from the more familiar subject-based learning (Dolmans, 1992). As well as students' roles, the role of the teacher differs also. The teacher becomes a coach and consultant rather than an instructor. There are different forms of inquiry-based learning with differences often being seen in the nature of the inquiry, for example open-ended or structured and supported. Variations also exist in the ways in which students are required to inquire. For example, in the more formal problem-based learning settings (eg. Bligh, 1995; Gijbels, Dochy, Van den Bossche & Segers, 2005), students are required to collaborate in much the same way as people tend to solve problems in real life. Inquiry-based learning does not necessarily require direct collaboration among learners, although like any form of learning, it can be enhanced by learners' direct interactions and communications with others.

Whilst inquiry-based learning is easily rationalised as an effective learning strategy for university learning, it can provide some learners, for example first year students, with difficulties and problems. Students in their first year of university studies typically come from backgrounds where they have had strong support and structure, and where their teachers have scaffolded their learning strongly. Many will never have experienced learning approaches that place the responsibility of learning onto the learners and away from the teacher. Many will not have experienced approaches that require deep learning and may have only ever been accustomed to surface learning approaches (eg. McInnis, James & Hartley, 2000). With inquiry-based learning, students must assume responsibility for their own learning and will be required to use higher-order thinking. All of these requirements can take some first year students beyond their zones of comfort and diminish their levels of learning satisfaction and possibly learning success. The implementation of an inquiry-based approach with such learners would seem to require strong scaffolding and support, attributes that technology-facilitation can often bring to learning settings.

Exploring a technology-facilitated inquiry-based learning approach

With these considerations in mind, a project was conceived that would enable an inquiry-based learning approach to be implemented in place of a conventional content-based approach within a large undergraduate class. A Web-based tool was conceived that could support an inquiry-based learning setting. The conceptual design underpinning the development of the tool (Figure 1) revolved around the provision of the following elements:

- Meaningful contexts for student learning;
- Scaffolds to support independent learning;
- Opportunities for teacher support and feedback; and
- Strong administrative efficiencies.

A design-based research activity (Reeves, Herrington & Oliver, 2005) was designed to enable application of the tool in a teaching setting to be evaluated in terms of its ability motivate and engage first year students to participate in meaningful learning activities and to explore factors influencing the successful application of the tool.

In particular the study sought to answer the following research questions:

1. What level of engagement does a Web-supported inquiry-based learning approach provide first year undergraduate students?
2. What factors influence students' levels of engagement and achievement in a Web-supported inquiry-based learning approach?

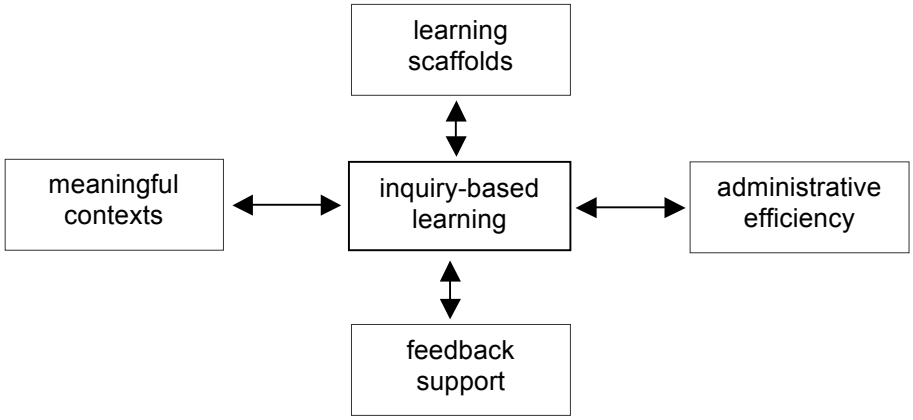

Figure 1: Conceptual design underpinning the Web-based tool

RESEARCH METHODOLOGY

a. The Web-support tool

The Web-based support tool was developed to provide a high degree of learner scaffolding for a problem-solving process and the administration of the approach. The tool was designed to provide a seamless interface for the teacher, the tutors and students to view the various problem specifications, to access relevant resources, to upload their solutions and to receive the feedback on their submissions (Figure 2).

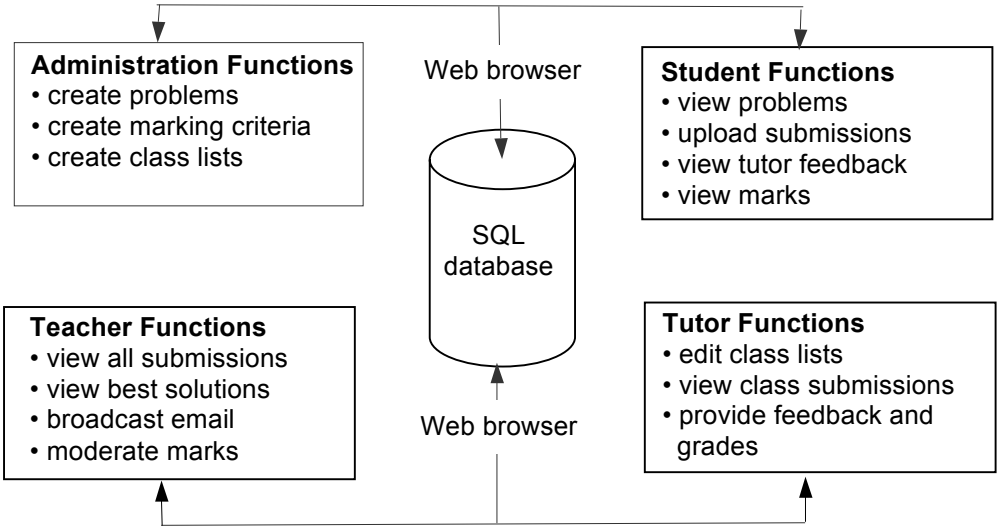

Figure 2: The functional elements of the Web-based tool

The online tool was designed with a high degree of flexibility to enable its reuse in different settings, among cohorts of varying sizes and with varying options for problem specifications, marking options and scoring of submissions. The use of a Web interface provided the flexibility to enable the tool to be accessed through conventional courseware management systems (CMS) via a single link to the supporting Web server where the tool was stored.

Whilst most institutions use standard CMS to provide online support for learning, this project involved the design and development of a customised tool. Because CMSs are designed for the broadest possible use, they typically provide only very general forms of support for teachers and learners, for example discussion tools, marks books, assignment submissions. With contemporary technologies, it is not a difficult process to develop quite sophisticated online supports that can target particular needs, a feature which is lacking in most CMSs. A strength of CMSs is their capacity to support complementary tools. The Web-based support tool used in this project was accessed through a CMS and this gave the researchers the best of both worlds.

b. The Learning Environment

The study was undertaken in an Australian University in a first year foundation course of a communications degree. The course aimed to develop students' skills and abilities in visual design, particularly in regard to their use of ICT-based productivity tools. Previously the course was delivered through lectures and workshops where course content was presented and practised through classroom-based activities. In order to promote learner engagement and motivation, an inquiry-based learning approach was developed which saw the course content and information contextualised through a series of weekly problems which students were required to solve. With its visual design focus, the course lent itself to an approach where the intended knowledge and skills were acquired through application to meaningful tasks and problems. Such an approach was perceived to provide strong contexts for the use of digital tools such as word processing, presentation software and Web page development tools as the basis for developing skills and capabilities in visual design.

The course was delivered in a blended mode where weekly problems were presented in a seminar session as contexts for learning. In order to solve each problem, students were introduced to a raft of appropriate content and information, and they attended a 2 hour workshop session where they learned to use the productivity tools. The students then spent time on their own developing a 800 word response to a weekly problem which was submitted through the Web-based system for marking and feedback. The course employed 9 tutors who supported student learning in the workshops and marked the submissions. In the study, technology played a very important part in the learning process, both as the object of study and as a cognitive tool supporting learning outcomes. Across the course, students were given ten problems but were only required to submit five solutions. At the end of the unit, students received a mark for this component of the course based on the aggregate score received or the aggregate of the 5 best scores if students attempted more than 5 problems.

c. The problems

The problems were designed to provide meaningful contexts for the application of the knowledge underpinning the course. They were designed to deliver a range of open and different solutions to discourage students from copying or colluding. For example, some problems involved students researching particular areas of design to develop a précis of contemporary practice and activity. Other problems required students to demonstrate design skills through development and design tasks. The selection of problems was seen to be a very important element in the study. The problems were chosen so as to enable all students the opportunity to develop solutions. For this reason, the problems tended to be open-ended and broad with no particular response being seen as correct. Students were required to provide a rationale for their solutions creating a situation where students could be rewarded for aspects other than their solutions alone. For example, the level of inquiry undertaken and the supporting arguments provided.

d. Subjects and Data Collection

Two hundred and sixty three students completed the course that ran across a 12 week semester. Data to support an analysis of the research questions was gathered from a variety of sources. At the end of the course students were presented with an online questionnaire which consisted of multi-choice questions and short answer questions. Completion of the questionnaire was a voluntary activity and 135 responses were received representing a 51% return rate. The questionnaire required students to describe the levels of interest and engagement that the problem solving activities engendered and explored students' preferences in terms of problem type, frequency of submission and depth of treatment. Data was also gathered from the Web-support tool including numbers of problems attempted, grades given by teachers, the problem submissions themselves and feedback from the course tutors.

DISCUSSION AND RESULTS

A potential measure of the level of learner engagement supported by the problem-based approach was the number of problems students attempted. The minimum number that could be completed for full marks was five problems but if they wished, students could complete up to the maximum ten. The mark they would receive was the aggregate of their top five marks. Learner-centred approaches have been shown in previous studies to provide strong motivations for learning and if this was the case in this study, we could expect to see students attempting more than the required number of problems.

a. Numbers of Problems Attempted

Table 1 shows the number of problems attempted by the students. Approximately a quarter of the class attempted one extra problem (six) and half that number again completed two extra (seven) problems. Seventeen percent of the class attempted fewer than the required five problems.

Table 1: Numbers of problems attempted

Problems Attempted	1	2	3	4	5	6	7	8	9	10
Number of Students	3	4	13	28	116	64	34	10	4	3
Percentage	1%	1%	5%	10%	42%	23%	12%	4%	1%	1%

The number of students who attempted more than the required number of problems was not substantial. Whereas it was thought that the inquiry-based approach might create a simulating context that would encourage and motivate students to devote more time to the study of this unit, the results do not suggest that this was a feature of the course. There were 18% of the students who attempted seven or more problems and it is probable that this number would have responded equally to any other form of delivery that sought to promote engagement.

b. Perceived workload

As a further exploration of the capacity of such an environment to motivate and encourage learner participation, the relative workloads of the students studying in this unit were compared to workloads in other units they were studying. Table 2 shows the responses of students to questions about relative workloads. An interesting outcome was the fact that almost one third of the students judged the workload to be lighter than in other units. Their responses indicated that there were a number of circumstances and features leading to a reduced load. Interestingly a number commented on the small size of the problems set and the perception that these appeared less important than the larger tasks that formed the assignments in their other units. Typical responses to the question "how hard have you worked in this unit compared to others?" were:

- *I found it is easier to complete the work quicker in this unit. ie it usually only takes me 1-2 days do solve the problems and get a pretty good mark. I have to spend a lot longer on assignments in other classes like essays etc*
- *I haven't worked as hard in this unit, as the weekly tasks seem of less importance than the bigger assignments in other units*
- *I have tried to keep a balance, however if there were times that i needed to do more work on other units, then this unit would be left out. This is only due to the fact that we don't have to do all the weekly submissions-this is good!*
- *I think I worked less because the work load is spread out into small tasks u don't need to work as hard as the other units.*
- *I probably did not work as hard as I should have been. I'm not very computer illiterate and so find some of the work rather challenging. this sometimes puts me off doing the work.*

Table 2: Student perceptions of course workload compared to other courses

Workload compared to other units	lighter	equivalent	heavier	much heavier
Number of Students	51	53	35	12
Percentage	34%	35%	23%	8%

There were approximately 30% of the students in the course who responded that they spent more time studying in this unit than they spent in other units in the course. Their responses suggested that the reason for this was not so much a matter of them being motivated to spend more time because of the interest and relevance of the problems, but more so because of other factors such as their lack of IT skills, the number of assessment items and the difficulties they faced solving the problems. Some typical responses included:

- *I had to work a bit harder because of the weekly work, research etc.*
- *I worked harder due to the constant assignments and less structured feel to this course. Instead of one or two major assignments and an exam you can pick and choose the assignments you complete and this makes you feel more involved and encouraged to do things like research and investigation.*
- *I did more work in this unit than any other. It had more assessment than other units.*
- *I worked quite a bit harder. getting the weekly problems in by sunday has sometimes been a stretch.*

c. Engagement with the Tasks

In inquiry and activity-based learning settings, the nature of the problems is often suggested as a primary factor in their ability to encourage learner participation and engagement. The study sought to determine whether it was possible to see such patterns in the nature of the problems students chose to solve. Table 3 shows the number of students attempting each problem and the results obtained by the students for the various problem solutions. The number of students attempting the individual problems commenced at a high 79% for the first problem and declined across the semester with only 30% of the students completing the final problem. The average mark for the first problem was significantly lower than the average mark received for the remaining nine problems. This was probably caused by students becoming familiar with the submission requirements and marking processes. The low mark for the first problem was a factor that led many students to complete six solutions so they could hopefully recover some of the lost marks by gaining a higher mark for their extra

problem. There was a high degree of consistency in the marking of the solutions between classes and a relatively stable standard deviation between the various problems (Table 3).

In previous explorations (Oliver, 2005), students were observed to show a preference for particular types of problems. In this class, for example, students indicated more interest and enjoyment in attempting problems that involved practical design solutions over problems that involved a more theoretical and research-based outcomes. When one examines the numbers of students attempting the various types of problems as shown in Table 3, this preference is not evident in the selections students were seen to make. The research type problems (1, 2, 4 and 6) were typically attempted by more students rather than fewer students. Student preferences towards problems appears to depend primarily on where the problem is presented in the schedule, with those appearing early being attempted by more students than those that appear later.

Table 3: Problem success rates

Problem Type	% students	average mark	std dev	minimum	maximum
1 (research)	79%	5.70	1.20	2.3	10
2 (research	78%	6.61	1.03	3.3	9.7
3 (design)	67%	6.20	1.35	1.3	9.3
4 (research	43%	6.63	1.36	1.7	9.7
5 (design)	59%	6.50	1.29	1.7	9.3
6 (research	50%	6.47	1.38	1.7	9.3
7 (design)	52%	6.50	1.60	0.7	9.7
8 (design)	48%	6.10	1.50	1.3	9.0
9 (design)	38%	6.50	1.40	2.3	9.3
10 (design	30%	6.90	1.30	3.3	9.7

d. Improving problem solving skills

With problem-based learning of the form used in this project, there is a strong possibility that students will improve their problems solving abilities as they gain practice and receive feedback. This outcome was tested by determining whether there was a discernible increase in the marks obtained for solutions between those obtained at the start of the course and those gained at the end. When one examines the marks students received across the ten problems there is no apparent or obvious increase in marks that might be attributable to improving problem-solving skills. This could be explained, however, by virtue of the fact that students did not have to complete all ten problems so for many students, problem 10 was really their fifth solution. When one examines the trend for the first five problems, again there is no apparent pattern, suggesting that in a single unit of this form, while the activity might support the development of problem-solving skills, the raft of confounding variables, such as problem difficulty and the previous experience of the learners, makes this a very difficult outcome to explore in a study of this kind.

Another outcome that could demonstrate the capacity of the learning setting to provide an engaging, and enhancing setting for learners, would be the observation among the learners that for those who completed more of the problems, there was a discernible increase in the overall grades they achieved for this component of the unit. This outcome could be tested by determining the correlation between the number of problems attempted and the aggregated marks obtained by students. When the correlation coefficient was calculated, there was only a weak correlation observed ($r = 0.604$) suggesting that students who did more problems

could gain a higher overall mark, but clearly there were many students who completed the required number and scored among the high grades.

e. Factors influencing levels of student engagement

An important element of the study was to explore the ways in which the problem-based setting was able to provide supports for student learning and engagement. To explore this aspect of the learning, students were asked to describe the ways in which they felt the setting helped their learning. A number of patterns emerged in the responses that were given. In particular, supports for learning were perceived to stem from the ways in which the weekly problems scaffolded the learning, supported student-centred activities and promoted knowledge construction.

Scaffolds for Learning. A number of the students were able to describe the way that the problems were seen to provide a strong supporting structure for their learning processes. There were consistent suggestions among the students describing the value of the problems as a context for the inquiry. The feedback suggested:

- The problems encouraged the students to focus on the various topics in ways they might normally not have;
- The repetitive nature of the problem-solving activities from one week to the next added to the structure as did the consistent presentation requirement;
- Students commented that the problems encouraged them to explore the topics in depth and beyond the course notes;
- The problems as contexts were seen to align assessment appropriately in the learning environment; and
- The regular feedback provided by the tutors to the responses was seen to provide strong supports for learning progress.

Student-Centred Learning. Many students commented that the problem-solving process provided strong supports for independent learning and in doing so provided a range of other learning supports. For example, many commented that the process encouraged them to:

- practise sound time management in the process of exploring, synthesising and crafting their solutions and responses;
- make choices in relation to which problems they would solve and the depth and quality of the response they would make;
- meet deadlines and demonstrate some personal discipline in the way in which they approached the problems and developed their solution;
- choose the appropriate information from the vast amount of available resources;
- be able to craft the solution to be of personal relevance and interest; and
- to explore, research and inquire as a fundamental component of their learning.

Knowledge Construction. The use of problems as contexts for learning typically requires students to become more actively engaged in learning processes than alternative contexts where information and content is presented without such contexts. In their responses to questions about the ways in which this setting assisted their learning, many of the students recognised that the practicality of the problem solving process helped them to derive meaning from the information and content they worked with. Student responses indicated that the problem-solving aided their learning by:

- Providing the means to out theory into practice;
- Making the content and information from the textbooks and reference material meaningful and useable; and

- Reinforcing the theoretical elements in practical ways that aided retention and recall as well as understanding

Whilst there were many responses that showed the learning setting in a favourable light, a small number of the students commented that the inquiry-based approach provided some disincentives and discouragements to learning and listed among their concerns;

- The structure provided to support the problem solution made many of the problems easy to solve;
- There were many problems that could be solved by some without having to delve into the underpinning content and information; and
- The problem-solving process added a large time overhead and created a substantial workload for a number of the students.

f. Factors influencing extent of learning from inquiry tasks

One of the important aims of promoting engagement and interest in a learning setting is to promote the acquisition of deep rather than shallow knowledge and skills (Biggs, 1999). To gain some sense of the way in which this environment promoted depth and breadth to their learning, students were asked to indicate what factors they felt contributed to how much was learned from a weekly problem solving activity. The purpose of this was to explore, from the students' perspective, whether they could discern from the problem itself or the way it was attempted, any patterns or themes in relation to the scope of their learning. In the responses, a number of patterns and themes emerged. These patterns related to three main areas: the problem difficulty, the perceived relevance of the area being explored and access to relevant information and resources.

Problem Difficulty. The problem statements themselves were seen by most students as a factor that influenced how much they learned from the inquiry process. It was clear in the responses that some students found some problems very easy to solve. The easy problems required little research and little reflection to develop a response. The solution statement could be achieved quickly and without the need to delve deeply into the underpinning conceptual elements. Likewise when students confronted a problem that appeared beyond their understanding and capabilities, many indicated that even with large amounts of inquiry and exploration, they found themselves limited in what they were able to learn. In such instances, students often commented that they were aided by the suggested stages in the solution process that were provided for them.

Problem Relevance. Each of the problems required a submission in the order of 800 words. Students commented on the relevance of the problem statement as a factor influencing the scope of their learning. Problems with high levels of relevance encouraged students to seek strong solutions and to persevere to derive successful outcomes. Students indicated that often they would spend more time on problems that interested them and the time taken was seen as an important component in the determination of the learning achieved. A number of students reflected that they tended to avoid tackling the problems that had less relevance for them. In such instances their learning involved reading and meaning-making from the course notes as they prepared for the final examination. Many commented that the level of understanding and application derived from such processes was far less than that achieved from undertaking an inquiry that used the information in its solution.

Access to Information. In solving the various problems students were provided with summary notes and information that provided a relatively strong set of background information to work from. It was expected and required that students would use the Web to

discover other sources of information and knowledge as part of the solution process. Student responses suggested that they often derived substantial amounts of knowledge from the course notes and found these to be extremely supportive of their learning. For some problems, students found relevant information and resources hard to source and perceived their learning to have been limited by this. This occurred in instances when there was large amount of general information discovered that was hard to digest and similarly when there appeared to be very limited amounts of information available.

g. the mediating role of technology

It would have been possible to implement this inquiry-based learning project without the technology support. One of the aims of the study was to explore the impact of the technology facilitation on the learners' experiences and to discover how it contributed to their engagement. There appeared to be three main ways in which the technology mediated student learning.

Development of technical skills. The submission process necessitated that students could complete a series of relatively complex ICT-oriented tasks. These included document merging, manipulating and storing media files and completing uploads. The technology component necessarily developed and practised students' technical skills in the application of ICTs.

Formative assessment. The technology-facilitation provided structure and rigour to the assessment and feedback process. The online marking and organization provided students with detailed and summarised information that necessarily informed their subsequent inquiries and solutions. This would not have been possible with conventional methods.

Distributed cognition. The term *distributed cognition* describes the process whereby learners are supported in the learning process by entities which assist them by sharing the knowledge and information and reducing the resulting cognitive load (Hutchins, 1995). Hutchins argues that there are a number of agents that support distributed cognition and such learning tools as technology can play a key role in this process. The technology used in this study provided many opportunities for students to distribute cognition. It was used by students to source information, to craft responses, to develop the designs and models and to send their solutions and to receive feedback. The products that students developed remained electronic throughout their lifecycle, from conception to evaluation. In conventional approaches, there are usually stages that break such a lifecycle. There was evidence gained through the students' responses and feedback that the technology acted frequently as a cognitive support for the learners and the inquiry-learning process.

SUMMARY AND CONCLUSIONS

This paper describes a study that explored the utility and efficacy of the application of a Web-based tool to promote learner engagement among first year students in a large class in an undergraduate communications degree. The Web-based tool was developed to enable an inquiry-based learning approach that was characterised by strong learning scaffolds, meaningful contexts, feedback and support and administrative efficiencies. The study explored the forms of engagement that the Web-supported inquiry-based learning approach was able to provide first year undergraduate students and the factors that were found to influence students' levels of engagement and achievement in the approach.

The findings from the study confirmed expectations that the inquiry-based approach would engage learners but revealed the levels of engagement to be less than anticipated. Forty one

per cent of the students completed more than the required five problems but only six per cent of the students completed eight or more problems. Thirty percent of students claimed to have worked harder in this unit than others as a consequence of the problems but there was no apparent improvement in problem solving skills over time. There was no discernible improvement in grades among the students as their problem-solving experience increased and no correlation between the success of students and the number of problems attempted. Across the period of the study, it was found that students developed their confidence with the inquiry tasks and the alternative pedagogical approach, an outcome that should encourage others contemplating moves to inquiry-based learning in place of conventional approaches.

The students showed a preference for research type problems over the more open-ended design problems although the popularity of problem, and the frequency of completion was influenced more by the schedule of the problems than the problem type. More students completed the problems posed earlier rather than later in the course. The study found that the more structured and directed problems were more easily solved by students and encouraged less inquiry and exploration. Those problems with more open-ended outcomes provided better contexts for supporting the inquiry process.

Students claimed that the problems supported their learning by providing a focus and context for learning, enabling them to put theory into practice and reinforcing the theoretical elements through practical activities. Student responses indicated that important elements in determining the level of engagement were the problem topics themselves, their difficulty and perceived relevance.

The research has provided evidence that the Web-supported inquiry-based learning environment was able to support learner engagement but also identified factors which could act to limit student motivation and interest. The research has demonstrated the need for problems to be well articulated so as to provide clarity of intent but not so well written so as to reduce the complexity of the solution. Similarly, problems need to be relevant and sufficiently detailed to require learners to gather information extra to that supplied to support the problem solving process, but not overly demanding on the scope and extent of the extra information required.

The research has demonstrated the ability of the Web-based setting to provide strong supports and engaging learning activities for the first year students in an efficient and organised fashion. It has provided evidence of the technology supporting students' cognitive processes by enabling their distributed cognition. From the results obtained, it is possible that the approach used might provide the forms of encouragement and support needed to support student retention in large classes. This component was not explored directly in this study but would seem a logical question in future studies. Future instantiations of the setting will seek to refine the problem specifications and requirements to address many of the issues raised in the inquiry. For example, it is intended in a future study to explore outcomes if such settings included fewer but deeper inquiry tasks. Other variations might be to explore the scope and nature of feedback, particularly that which could be given to improve students' problems solving skills. It is intended to continue to explore the use of this form of technology-facilitated learning to optimise the learning potential of the approach and use of this Web-based tool.

REFERENCES

Anderson, L.W. & Krathwohl, D.R. (Eds.). (2001). *A Taxonomy of Learning, Teaching, and Assessment: A Revision of Bloom's Taxonomy of Educational Objectives.* New York: Longman.

Biggs, J. (1999). *Teaching for Quality Learning at University*. Buckingham: Open University Press.

Bligh, J. (1995). Problem-based learning in medicine: an introduction. *Post-Graduate Medial Journal, 71*(8), 323-326.

Bloom, B. (Ed.). (1956). *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain.* New York: Longmans, Green.

Boud. D., & Prosser, M. (2002). Key Principles for High Quality Student Learning in Higher Education: A framework for evaluation. *Educational Media International*, 39(3), 237-245.

Calder, A. & Hanley, P. (2004). Transition – helping students bridge the gap. *Issues of Teaching and Learning @ JCU*, 2(2). Retrieved January 2005, from http://www.jcu.edu.au/office/tld/teachingsupport/documents/TLD_vol2_issue2.pdf

Collis, B., & Moonen, J. (2001). *Flexible Learning in a Digital World*. London: Kogan Page.

Dolmans, D. (1992). The relationship between student-generated learning issues and self-study in problem-based learning. *Instructional Science, 22*(4), 251-267.

Fogarty, R. (1997). *Problem-Based Learning and Other Curriculum Models for the Multiple Intelligences Classroom*. ERIC Document No. ED405143.

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research, 75*(1), 27-61.

Goodyear, P. (2005). The emergence of a networked learning community: Lessons learned from research and practice. In G. Kearsley (Ed.), *Online Learning: Personal Reflections on the Transformation of Education* (pp. 113-127). Englewood Cliffs, NJ: Educational Technology Publications.

Hutchins, E. (1995). *Cognition in the Wild*. Boston, MIT Press

Jonassen, D. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development, 48*(4), 63-85.

Kearsley, G., & Shneiderman, B. (1999). *Engagement Theory: A framework for technology-based teaching and learning.* Retrieved July, 2003, from http://home.sprynet.com/~gkearsley/engage.htm

Kearsley, G. (Ed.). (2005). *Online Learning: Personal Reflections of the Transformation of Education*. Englewood Cliffs, NJ: Educational Technology Publications.

Kingsland, A. J. (1996). "Time expenditure, workload, and student satisfaction in problem-based learning." In L. Wilkerson & W. H. Gijselaers (Eds.), *Bringing problem-based learning to higher education: Theory and practice* (pp. 73-81). San Francisco: Jossey-Bass.

Herrington, J., Oliver, R. & Reeves, T. (2003). Patterns of engagement in authentic learning environments. *Australian Journal of Educational Technology, 19*(1), 59-71.

Laurillard, D. (2002). *Rethinking University Teaching: A Conversational Framework for the Effective Use of Learning Technologies* (2nd ed.). London: Routledge Falmer Press.

McInnis, C., James, R., & Hartley, R. (2000). *Trends in the First Year Experience in Australian Universities*. DETYA: Canberra.

Oliver, R. (2001). Exploring the development of critical thinking skills through a Web-supported problem-based learning environment. In J. Stephenson (Ed.), *Teaching and Learning Online: Pedagogies for New Technologies* (pp. 98-111). London: Kogan Page.

Oliver, R. (2005). Using blended learning approaches to support problem-based learning with first year students in large undergraduate classes. In C.K. Looi, D. Jonassen, M. Ikeda

(Eds). *Towards Sustainable and Scalable Educational Innovations Informed by the Learning Sciences.* (pp 848-851). Amsterdam: IOS Press.
Ramsden, P. (1992). *Learning to Teach in Higher Education*. London: Routledge.
Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education, 16*(2), 96-115.
Reigeluth, C. (1992). Elaborating the elaboration theory. Educational Technology Research & Development, 40(3), 80-86.
Schiller, J., Ostwald, M., & Chen, S. (1994). Implementing a problem-based, distance education undergraduate course in construction management. *Distance Education, 15(*2), 300-317.
Scott, J., Buchanan, J., & Haigh, N. (1997). Reflections of student-centred learning in a large class setting. *British Journal of educational Technology, 28*(1), 19-30.
Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education, 37*, 57-70.
Tynjala, P., Valimaa, J., & Sarja, A. (2003). Pedagogical perspectives on the relationship between higher education and working life. *Higher Education, 46*(2), 147-166.