Learning, study and review methods 101: A fun way to learn and study complex theoretical content

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This paper examines the development and implementation of a collaborative/game-based study format in a university context and the benefits gained by the students involved. The research project compared the established delivery format of lectures and tutorials with an alternative delivery format involving collaborative learning and games-based study tools. It examined the differences that these formats had on student learning outcomes for the heavily theoretical content of the Human-Computer Interaction in Multimedia (HCI) unit, as part of the Multimedia Bachelor Degree at Monash University.

A collaborative/game-based study format was developed to provide an interactive learning environment that allowed the students to explore the unit content using a variety of tools and resources, such as textbooks, internet, and discussion groups. To verify understanding, students contributed questions, based on the content researched, to the game-based study tools designed to enhance the study and review process. The treatment compared the results of students in each group (traditional vs collaborative) to their performance scores in a pre-test and post-test of the content area (short-term retention) and the results of the semester examination (long-term retention). Data gathered by survey was used to ascertain student opinions regarding both methods.

Keywords: games-based study tools, collaborative learning, teaching and learning strategies

Collaborative learning and game-based study

Analysing existing methods and resources

When teaching a heavily theoretical subject as part of a largely practical course, there are inevitably a number of issues to overcome. The most significant is encouraging the students to learn content that they perceive as irrelevant and boring, while working within the constraints of the University's preferred delivery methods. While student engagement with the content and resources is often quite evident during tutorial sessions, it is not always so during lectures. This observation provided the motivation to investigate alternative teaching and learning strategies that would enhance the learning process and provide a more effective format for teaching predominantly theoretical subjects.

The challenge was developing a format that would satisfy the needs of both the University and students. The obvious difference in the students' behaviour during the tutorials indicated that a suitable learning environment would focus on a more collaborative approach. However, to avoid experiencing issues similar to the current method over time, a novel approach was needed for learning and/or studying the material delivered – one that was interesting and fun for the students but also providing an appropriate level of instruction and learning for university. To ensure this, several of aspects of the current learning environments were examined with the following strategies / resources being identified:

1) What are the main delivery methods of units within the Multimedia degree course?
   a) A 1–2-hour lecture, followed by a 2-hour practical tutorial session, with students working individually or in small groups on small projects.
   b) A 1-hour lecture, followed by a 3-hour studio session, with students working in small groups on a single large project or prototype.
2) What tools do the students use most frequently while participating in learning activities?
   a) The internet and e-mail are the most frequently used tools for finding/sending information.

b) The university also has an on-line facility called MUSO (Monash University Studies Online) that is accessible to all students, where materials related to the unit are posted. Discussion groups can also be created using this facility.

3) What support materials can be provided to students to help with learning the content delivered?
   a) The most common materials provided included the weekly lecture notes and tutorial activities, usually posted on MUSO.
   b) Other support materials included unit syllabus, assessment and tutorial briefs, and links to associated on-line reading materials.

Developing an alternative format

The concept of a student-centred environment is not new and the strategies for content delivery in tertiary education should reflect this ideal, to keep pace with both the needs and expectations of the current generation of students. Sander (2005) argues that with the changes in student demographics over the last decade, higher education institutions are being forced to review their current teaching strategies. This is particularly relevant, as tertiary institutions need to maintain higher numbers of students, and therefore need to implement appropriate strategies to cater for the needs of the diverse range of students now wanting higher levels of education. Sander (2005) further implies that the discrepancy between what future students perceive as a good education and current delivery strategies is causing disenchantment with the educational system, thereby decreasing prospective student numbers and the viability of many institutions. One way to improve this situation is to research, develop and implement new delivery strategies that suit both the needs of the tertiary institution and those of the student body. The author argues that these strategies must address two main issues: a) acknowledging that active student involvement is an integral part of the learning process and b) providing both interesting and flexible learning environments that engage learners with the content through a variety of resources and tools.

At Monash, the students within the Multimedia Degree are frequently exposed to different collaborative situations during tutorials or as the primary means of delivery, so it seemed a logical step to apply a similar format to the delivery of content usually given in lectures. However, most often lecture notes are not useful without the accompanying commentary, a fact many students berate if they miss one, and making them available on-line for later study does not guarantee that any learning will take place. While alternatives, such as recording or pod-casting lectures are supportive of student learning, they are not always available or may require a significant investment in time and effort to set up, as opposed to just posting on-line. Therefore, the collaborative/game-based study method (Figure 1) was developed to create a collaborative learning environment that provided guidance and support but also gave the students the freedom and flexibility to explore the content using tools and methods that were appropriate to them. In addition, an alternative method to support the study and review was provided, in the form of game-based study tools, to assist with the consolidation of the content learned (Howard, 2006).

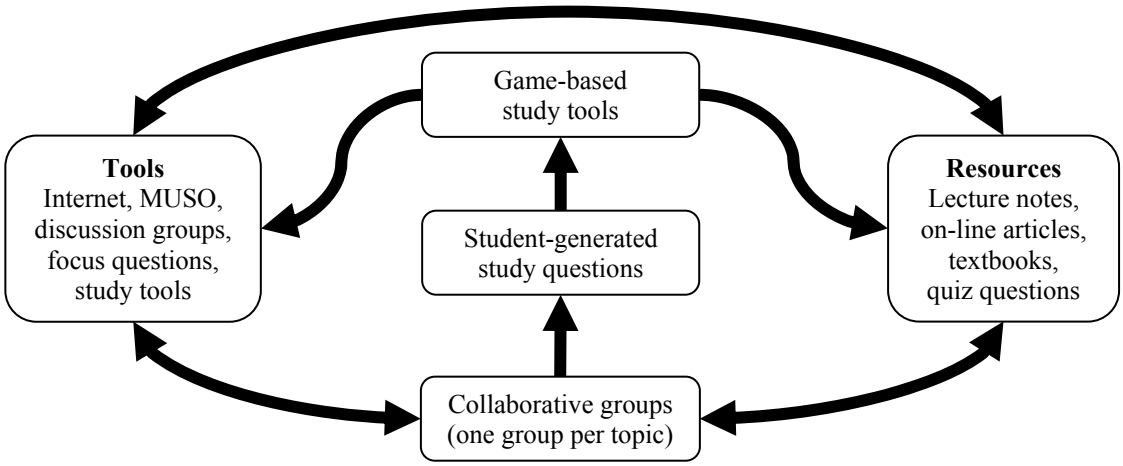

Figure 1: The collaborative/game-based study method

Race (2001:26) states that "We need to remember that learning is done by people – not to them." This implies that the current lecture format may not necessarily engage the students as actively as other strategies may, largely due to its relatively passive nature. Race (2001) also argues strongly for using strategies that students understand to support effective learning. This suggests that using tools and structures with which the students are familiar is a more appropriate strategy to adopt, as they already have some skills with which to undertake learning activities. Sander (2005) supports this argument stating that for universities to ensure their undergraduates are independent or autonomous learners, they must provide learning environments that promote both effective and independent learning. The focus must be on a student-centred approach, where students are actively engaged with the subject matter rather than passively "listening to 'an expert' about it" and are "inclusive of all students by providing teaching methods and learning environments that reach all students" (2005:117).

The proposed format substituted a collaborative learning environment with on-line research, held in a studio/lab rather than a lecture theatre, in lieu of the normal lecture. The students were divided into small discussion groups of 3–5 members, in which individuals were encouraged to participate in a variety of roles to enhance the experience, such as researcher, discussion leader, note-taker, etc. The content of the "lecture" was divided into five sub-topics with one selected by each group, allowing individuals to explore a topic based on an area of interest or familiarity of the group members. The tools available included access to a word processor, the internet and an on-line discussion group specifically created for this purpose. Students were free to use other tools as they deemed appropriate, provided session outcomes were met. However, an argument for caution when using technology becomes an integral part of the teaching process is proffered by Kiili (2005) – that the technology can often become a substitute teacher for delivering information rather than as "learning tools that support the active learning process" (Kiili, 2005:303). While computers are good for delivering content in a variety of ways, whether efficiently or not, there needs to be a balance between information delivery and achieving the required learning outcome(s) with supporting and enhancing the learning process (Facer, 2003; Grabinger & Dunlap, 2000; Quinn, 2005).

Key components

An integral part to the learning process is being able to understand the information presented and process it so that it becomes meaningful to the individual (Aldrich, 2005; Grabinger & Dunlap, 2000; Harper & Hedberg, 1997; Oblinger, 2004; Papert, 1993; Prensky, 2001; Quinn, 2005; Race, 2001). Harper and Hedberg (1997) also argue that educators should "view the learning environment as something the learner has a major impact upon, the process has to include the learner as an active participant." Numerous studies have examined ways in which to encourage learners to be active, such as problem, case and scenario based learning using authentic tasks/content (Cunningham et al., 1993; Grabinger & Dunlap, 2000; Schunk, 2004), and more recently the introduction of simulation and games-based learning (Aldrich, 2005; Prensky, 2001; Quinn, 2005).

Therefore, a key component to making the proposed format work was for students to link the resources provided, in an organized manner, to their research of the weekly topics. To ensure some consistency between groups, weekly focus questions were prepared that related to the topics covered in the lectures, including at least one reference or link to an appropriate resource. However, the groups were free to explore and discuss these questions, using any of the resources provided and/or others discovered during their research. Each group had to post their answers to the group discussion board for others to revise and study, and were required to ensure that the following criteria were met: a) each answer had to provide an adequate response to the question; and b) have clearly identified reference(s) used.

In order to enhance individual learning, the lecturer's role became one of a facilitator so that the students could be more actively involved with the resources and have a certain degree of autonomy over how they would use them. The links for the focus questions were only provided as a starting point – the students were free to pursue other sources if they believed that they would support the answers to their topic's questions. While these strategies promoted engagement with the content, they could not necessarily ensure the quality of the learning, if any, taking place. Thus, for this format to address the issue of effective learning, the following two additional strategies were implemented:

- The first investigated the development of some game-based study tools to support the consolidation of the learning taking place during the collaborative sessions. Due to the students' perception that the

content of the unit would be boring because it was mostly theoretical, these tools had to also provide an interesting and fun way to study or review the complex content. To ensure compatibility with the developed study tools, the Focus Questions were divided into five categories related to the current topic with a minimum of four questions each.

- The second explored the concept of the students generating the content for use within the game-based study tools. This strategy was designed to enhance the processing of the information learned by the creation of questions related to the researched topic – the premise being that in order to ask a valid question one must first understand what is being asked. It was also to challenge the students to meet specific criteria when creating the questions in order to promote higher-order thinking skills.

Format overview
The collaborative/game-based study method (Figure 1) used the following format during each session (Howard et al., 2006a):

1) Students formed random groups of 3–5 members – these can be based on areas of interest (e.g.: by topic) or familiarity (eg: with friends).
2) Each member was encouraged to take on varying roles within the group (eg: researcher, discussion leader, note-taker, etc.) to ensure that their experience encompassed a broad range of learning opportunities.
3) Each group selected one category that they thought interesting to pursue.
4) For approximately 45 minutes, the group could explore the questions and answers using the resources provided and/or other relevant sources discovered during the research process, ensuring that the following criteria were met:
a) the answers had to provide an adequate response to the question
b) providing clearly identified references
5) At the end of this time, each group would post their answers to the discussion board provided, for others to revise and study.
6) Finally, each group was provided with an instruction sheet and examples of the eight question formats to be used. Using two or more of these Q&A formats, each group would create and submit by e-mail at least four questions related to their research topic for use in the game-based study tools. The use of T/F, and multiple choice questions was limited (one of each only) to encourage the use of the other formats to improve the range of questions to challenge the students and promote different levels of thinking.

The questions also had to meet the following criteria:

a) a clearly phrased question with clearly identified correct answer(s)
b) the reference(s) used
c) and a short feedback description explaining why the answer was correct

The student-generated questions were entered into the question databases for the study tools using a question & answer generator specifically developed for this purpose (see: *Game-based study tools*). The study tools provided the students with an enjoyable means by which to study the material that was researched by their own and other groups. The tools were available for the use during the first half hour of their assigned tutorial time (while students in the control group or not participating were given time to answer the Focus Questions) or for individual study when reviewing or preparing for assessment later.

An advantage of using the study tools was that if a question required further investigation by the student, they could:

- review the initial resources provided for the specific focus question topic,
- review the postings on the discussion board that relate to the specific question/topic,
- use the feedback provided to help them understand the concept / topic / question,
- provide constructive comments, via the discussion board, on the information posted by other groups (e.g.: requesting clarification, adding additional resources/information, etc.).

The main thrust of the research was to determine whether the inclusion of collaborative learning using game-based study tools was a valid alternative mode of delivery that can promote student engagement with the delivered content. According to Kiili (2005) when part of the creation of the learning materials is incorporated into the instructional design then "the processes employed to produce these materials are likely to engage students and enhance learning in certain conditions." (2005:319). The rationale behind using this game format was to motivate the students to take an active role in their learning, to improve retention of the subject matter, and to encourage the motivation to learn within individuals and the results would support this. In this type of environment "students can acquire knowledge and skills that are not the consequences of rote learning or of memory or abstractions devoid of personal experience but rather acquired in a way that is interrelated and gives personal purpose to present and future" (Ziegel, 2004:106).

Developing the game-based study tools

The initial concept for the games-based study tools was inspired by Marc Prensky's games2train website where it "marries computer games and educational content into a new "Nintendo Generation" approach to learning … the underlying idea is that students learn better when they are having fun and are engaged on the learning process" (Spectre & Prensky, 2001). Prensky (2001) advocates that games can be used to present any content in a fun and interesting way to help students learn and/or study, even complex theoretical information. However, a significant limitation of the Prensky games was the limited types of questions offered – T/F, multiple choice (single answer) or multiple choice (multiple answers), catering for a fairly limited level of cognitive processing – often a best guess rather than a thought out response.

For the proposed game-based study tools to be effective, provision had to be made for students to engage in a broader range of thinking skills. To cater for the different levels of cognitive processing required, eight different question formats were devised to broaden the variety of the types of questions asked and to maintain student interest. These formats included: true or false, multiple choice with single answer only, multiple choice with multiple answers, fill in the blanks, short answer, sequencing, matching pairs, and a Likert sliding scale. All question formats allowed for the inclusion of images and/or sounds to provide alternatives to what could become predominantly text-based materials. Other features included provision for references, as web links or electronic documents, and a space to provide comprehensive feedback. To ensure that question creation would be a simple process *and* compatible with the game-based study tools a 'question and answer generator' (Figure 2) was developed.

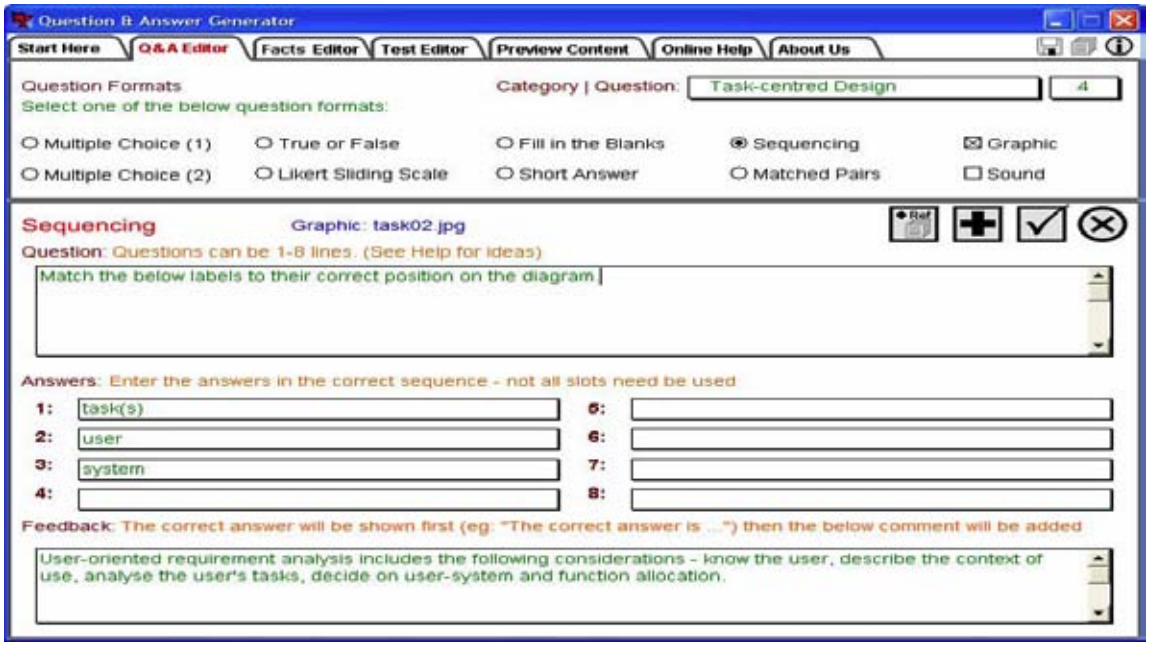

Figure 2: Q&A generator interface (Howard *et al.*, 2006a)

The structure of the "quiz" content is defined by a broad subject heading (eg: HCI), then divided into specific topic areas (eg: What is HCI?, Task Analysis, etc.), and still further divided into five categories, breaking the content into manageable learning chunks. These categories relate directly to the topics researched by the students with the aid of the Focus Questions. In addition, for the application to be suitable across disciplines and useful for those who wish to customise their own subject data, complete documentation was developed to provide simple instructions on how to use the Q&A generator and suggestions for maximising effectiveness of the question formats. These suggestions demonstrate that by varying the complexity of the questions asked, higher order cognitive thinking and processing can be encouraged, and therefore would increase the value of the questions and challenge students to think carefully before answering (Howard et al., 2006a).

For the games to be effective, a number of issues had to be addressed. Firstly, the games themselves were only intended to be the vehicle by which content created by the students (and/or teacher) was accessed. They were *not* designed to be an encapsulated learning environment but rather an adjunct to the format developed, as the majority of the learning would take place during the collaborative research and question creation. The advantages the study tools provided include engaging the students more effectively with the content being taught, the potential to promote higher order cognitive thinking and processing, to make the questions more meaningful. Extending the experience by adding the student-generated content to MUSO facility for use when studying and allowing students the opportunity to debate, challenge and discuss their content.

Secondly, to reduce the effect of cognitive load (Chandler & Sweller, 1991) when learning how to use the study tools, the development of the games was guided by the principles of simplicity and familiarity whereby the rules of the games were easy to learn and master and the game play would be familiar to a large number of users. This design was to allow students to focus separately on the two aspects of the games – playing the game and learning the content. Therefore, the following types were chosen to develop:

- two arcade games for individuals – a variation on a Pac-man style game and a version of a space invaders style game;
- one turn-based game for those who prefer a controlled pace or playing against another player – a Pick-a-Box style game (Figure3).

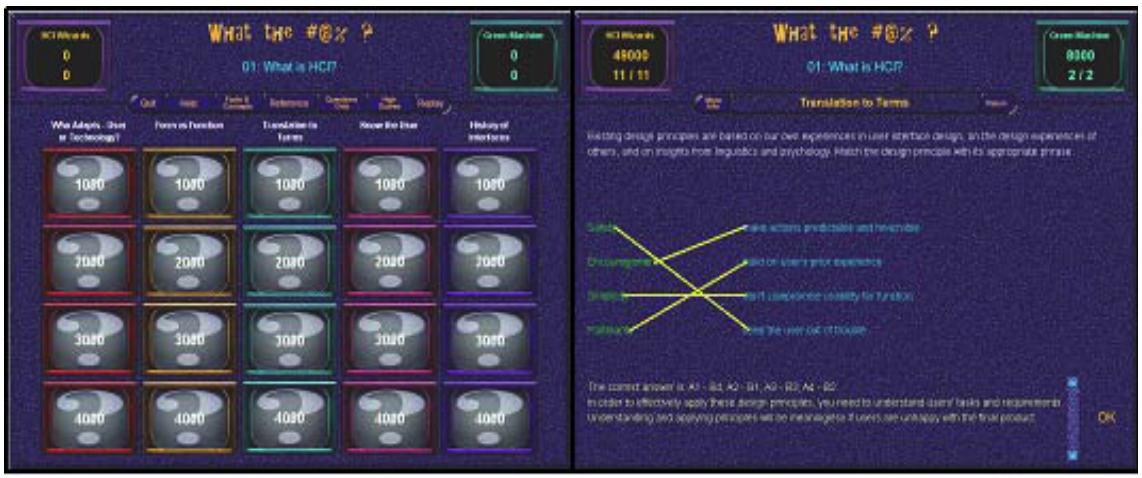

Figure 3: Game-based study tool interface

In the arcade style games, the students play until they complete a game level (e.g.: eat all monsters). To continue, they must then answer four questions correctly from a non-repeating randomly selected category. This approach was used to maximise the players' focus on the question content rather than interspersing it throughout the game level and interrupting game play. In the turn-based games, the students select an action, governed by the game rules, and answer a question taken from either the selected category or a non-repeating randomly selected category. The turn-based game also has a 2-player mode to cater for those who like to compete against another player or as teams of players. Play continues until twenty questions have been answered in both game formats.

Other features built into the study tools include the provision for immediate feedback once the student checks their answer by clicking the OK [☑] button, access to links of associated references, a question only mode, reviewing facts and concepts only mode, and pop-up game help.

Experimental treatment

The mode of delivery for the majority of courses in the Multimedia Bachelor Degree is a lecture followed by a tutorial. Working within the budgetary constraints of delivering a course to a large body of students (98) with a small staff (3) and timetabling constraints due to limited availability of rooms a strategy had to be devised (Table 1) that would also ensure that students were not deemed to be disadvantaged by the process (Howard, 2006).

Initially, all students attended the lectures and tutorials, as they would normally be given using the current Lecture/Tutorial format. The purpose was to introduce the changes to the instruction used during each session, preparing the control group participants, as follows:

1) Students attend the weekly lecture that introduced the content to be covered (1–2 hours)
2) Students attend their scheduled tutorial (2 hours)
3) The first ½ an hour was allocated for the answering of the Focus Questions to consolidate the content delivered during the lecture:
   a) The Focus Questions sheets were available on MUSO
   b) The students were encouraged to answer as many questions as possible, using a variety of resources (their own notes, the posted lecture notes, the textbook and readings)
   c) They were permitted to work together, if they wished
   d) The final 1½ hours for the pursuit of the normal tutorial activities, usually practical activities related to the assessment tasks.

Table 1: Proposed research timeline

Week	2	3	4	5	6	7	8	9-13	14
Con	Lecture / Tutorial			Lecture / Tutorial			Lecture / Tutorial		Exam Period
Exp	Lecture / Tutorial			Collaborative / Game			Lecture / Tutorial		
Data			Survey 1 Pre-Test				Survey 2 Post-Test		Final Exam

At the end of the first three weeks, students completed a practice quiz (pre-test) on their understanding of the topics covered. A second practice quiz (post-test) was also conducted at the end of the second three weeks (Table 1). At the start and end of the second three-week period, all participants completed a survey about their learning experiences and the different delivery methods. The results of these quizzes did not constitute part of the normal assessment for the unit (Howard, 2006).

Results from student feedback

As part of the experimental treatment implementing this method, the participants were asked to provide feedback about the delivery of content in two surveys and by undertaking a pre- and post-test. Due to the relatively small sample size, the test results produced statistically non significant results and were inconclusive. However, the feedback from the surveys did provide some interesting information.

The following summary is of the data collected from the second survey (Figure 4) specifically relating to the participants (*n*=24) attitudes towards the use of the collaborative learning environment (1–2 hours), in lieu of lectures, and followed by a 2-hour tutorial.

Some 75% of the participants in the experimental group found participating in the discussion groups both useful in general and for learning new information, with 66.7% indicating that they preferred this method for learning new information, suggesting that this method more suitable to their needs. A large portion of participants (70.8%) found posting their notes on-line during the discussion group helped them to study later, and 54.2% found the notes posted by others also helpful to their study. Some 62.5% found the using the Focus Questions useful for exploring and understanding the content. This would suggest that the change of delivery method, including access to a greater range of note taking tools such as computers, word processors, e-mail and discussion groups, may have encouraged a more effective use of the Focus Questions as a resource – from 38.1% prior to the treatment to 70.8% after the treatment.

Perhaps one of the most significant findings of the study was the experimental treatment appeared to be well received by almost all the participants. In particular, 87.5% of the participants found discussing and creating the questions for the study tools helped with remembering the information learned and 79.2% found the games a useful study tool. This would suggest that nearly all the participants found the combination of collaboration and the game-based study tools quite effective and useful to them. It may also indicate that the method is more suited to a greater range of learners by providing a practical hands-on learning environment even though the content is largely theoretical.

The combination of discussion groups and Focus Questions was deemed an effective way to learn by 66.7% of participants with 62,5% also finding this an effective way to study the content. Motivation to find out more information about the topics presented from other sources (e.g.: readings, set texts, internet, library, etc.) increased from 14.3% (pre-treatment) to 37.5% (post-treatment). This was the second major finding to emerge from this study potentially indicating that a greater proportion of the student population where motivated to seek out further information and therefore become independent learners. The change in attitude towards using the Focus Questions and an increased motivation to explore other sources of information may be directly related to the increased level of engagement the participants have with the content and being able to interact with a variety of resources in a more meaningful context.
There was a strong indication that the experimental treatment of the collaborative/game-based study method provided greater support for a greater range of learners. The participants also demonstrated a strong change in attitude towards the value of the resources available to them for learning the content. The provision of an active learning environment, allowed the participants to use the Focus Questions more effectively to help them learn, summarise and understand the content presented from a variety of resources. Having immediate access to tools, such as a word processor, discussion boards and e-mail, may also have improved some of the participants' attitude toward the importance of note taking. The value of the game-based study tool may also have increased by the participants being actively involved in the creation of the content used within them, helping nearly all of them (87.5%) to remember the information studied more clearly.

The experimental participants were also asked to express opinions on their experiences with the new method. This included identifying both the aspects they liked and problems or issues they experienced while learning. The types of responses mostly focused on the content delivery, the focus questions and using the games. Following are some student responses on these aspects of the method:

- Quite a number of participants found the discussions most useful for analysing, understanding and remembering the content – "I like getting other people's views and understandings of the information we're learning. In a subject area where there are no black and white answers, it is really difficult to develop an understanding on your own."
- Some participants found the learning environment was also more enjoyable for them being "very user friendly, relaxing study environment, and most importantly the teacher was very useful."
- Other participants commented on sharing the workload as a positive element – "The idea of having groups to answer different section of the questions was a good idea. Having it posted to MUSO helps me to study later."; "We interact (with) each other and try to find the answer together. It is fun!" and "The learning was more fun because you had to actively seek it out. Working in groups means the information was easier to find since everyone was helping."

- For one student, "It was an unusual experience to approach learning this way, particularly since the timeframe was so short. I enjoyed it a lot, but it would have been better if it had gone longer."
- A number of participants sometimes found the discussions difficult because they had difficultly communicating with others, found the process confusing or "It only takes one completely uninterested discussion group member to make meaningful discussion impossible."
- Some participants also found the researching the focus questions for only one topic was perhaps not an effective means of studying "because we only researched a portion of the content ourselves, we ended up having a disparity in levels of knowledge between different content sections."
- Some also thought the posted answers "… did not help much because they did not contain useful information" or "some of the information posted was not enough detail or completely correct."
- For some types of learners, this method may not have been particularly suitable – "I like to have my own written notes from lectures, something that I can interpret into my own words. Due to time constraints I found most groups had highly summarised research content which is in their own words so I'll still have to go through old lecture slides and find out the full info for myself."
- A number of participants as found "The game based (study tool) certainly a more fun way of learning the content."
- Some also found that the repetition of the questions through the games was helpful for remembering the content, chunking the information better for learning or an indicator for what was not known by "Playing the game before being presented with the content allowed me to focus better on the content itself."
- On the other hand, some participants found that "some questions made by students were hard to understand or made no sense at all" while others found some issues with the games being too slow or buggy.

Conclusions

Engaging students in creating content for the game-based study tools encouraged a deeper level of learning. Even though a small sample, observations and survey responses indicate that the collaborative / game-based study format had a positive effect. However, its application to larger groups may be logistically difficult to implement due to the need for increased resources – one lecturer and theatre vs a number of computer labs with tutors. On the other hand, the long-term benefits gained by the students may well negate this issue, particularly with the observed increase in student interest with the content being taught. The data suggests that by increasing the student interactivity during the delivery of theoretical content, it may increase student levels of motivation to learn because they can process the content in ways that make sense to them and this may be significant in overcoming their perceived shortcomings of the current format.

Perhaps the most significant finding of the study was that 87.5% of the participants in the experimental treatment found discussing and creating questions for the game study tool helped them to remember the information they had learned and 79.2% found playing the games a useful study tool. This demonstrates strong support for using a combination of collaboration and the game-based study tools as the participants found this to be quite effective and useful to them. The other major finding was the increase in motivation to find out more information about the topics presented from other sources (e.g.: readings, set texts, internet, library, etc.) of the experimental group from 14.3% (pre-treatment) to 37.5% (post-treatment). This would suggest that providing opportunities for students to actively engage with a variety of sources of information relevant to their learning using familiar tools (e.g.: computers, word processors, e-mail and discussion groups) prompted a greater proportion of the student population to become more motivated to seek out further information and therefore become independent learners. An additional benefit may also be the improvement in note taking skills.

The implementation of the Focus Questions to guide study and aid revision was deemed successful with 57.1% (control) and 70.8% (experimental) of students finding them helpful. The inclusion of the Focus Questions to help guide the students through their study and understanding of the content could be implemented for large groups quite easily. The questions combined with a collaborative research and/or discussion session may improve both the interest and motivation of the students to learn complex theoretical content. Many students, from both the control and experimental groups, commented that they felt these questions helped them focus their study of the content (Howard et al., 2006a).

The level of student satisfaction, engagement with the material and motivation to learn was markedly different between the groups, particularly during the experimental period. This had a flow-on effect for a few weeks after the conclusion of the experiment in that a number of students from the experimental group continued to work in groups on the Focus Questions at the beginning of the tutorials. This would suggest that these students found the collaborative format useful to their learning and understanding of the content and wanted to continue using it even though there was no further requirement to do so (Howard *et al.*, 2006b).

Despite some initial issues with implementing software on a network, most of the participants found the game-based study tools provided them with a novel way in which to engage with the complex theoretical content required for the unit. Observations indicated that the combination of the games and the generation of the questions for use within them became a key element in increasing the students' level of interaction with the resource materials and their motivation to learn the content. The potential of this format to provide an adaptable alternative method for delivering complex theoretical content is quite high.

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