An implementation of the generative learning object model in accounting

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In the pursuit of more effective and efficient teaching methods the concept of learning objects has been expanded and reworked. Newer more flexible learning objects called generative learning objects have empowered lecturing staff with the ability to easily adapt and mould their content to fit their circumstances. This paper reports on a project that takes the powerful concept of a generative learning object (GLO), improves its flexibility through the use of XML and Flash, and applies it to accounting instruction.

Typically generative learning objects have been developed in the area of programming where they have been well received. This research marks the first attempt at applying a generative learning object to the field of accounting, specifically in the area of depreciation. The Depreciation GLO combines animation with textual instructions and automated evaluation to increase student's interest and provide them with a variety of learning streams to improve their performance. The automated nature of the Depreciation GLO also provides lecturers with feedback on the student's performance and time spent working with the software allowing for a better understanding of their performance.

Keywords: Generative Learning Object, GLO, RLO, Learning Technology

Introduction

High quality e Learning resources have traditionally been difficult and expensive to create. In addition, there are typically a number of restrictions making it difficult to gain full benefits from the use of these resources. Many e Learning resources have been developed for specific environments that restrict them from being used in others. Differences in curriculum and qualities or attributes of students also pose a restriction to the way that e Learning can be widely reused. A well thought out explanation of a concept may be completely useless in a different environment with different rules or with different students. In order to gain a positive return on investment it is crucial that these e Learning resources are able to be repurposed, reused and to be usable on a number of different platforms. (Boyle, 2003)

The concept of a Generative Learning Object (GLO) has been developed to overcome these obstacles. Specific qualities for the effective design of Generative Learning Objects have been explicated by Tom Boyle. Drawing on Systems Design theory and previous learning technology and multimedia design theory the concept of a compound learning object has been formed. This concept specifically addresses the physical design of the objects in order to adhere to software engineering design principles. According to the field of software engineering, learning objects should be made a simple as possible. By doing so the ability of learning objects to be reused and recombined together is greatly improved. (Boyle, 2003)

The software engineering concept of modularisation is a partial solution to the issue of repurposing of learning resources. In its simplest form the concept involves breaking a piece of software down into smaller software units or 'modules' in order to make them easier to work on. Modularisation is achieved by employing the two principles of cohesion, and de-coupling. (Boyle, 2003) Each unit or module should have only one purpose within the software application (cohesion). Each Learning Object can act as a module and should be based on one learning objective only. An advantage of employing the cohesion principle is the ability for lecturers to control the order in which students view content, guiding them in a logical direction from simple concepts through intermediate to complicated concepts. De-coupling can be used to avoid dependencies between modules. In terms of Learning Objects the referencing of content from other Objects results in dependencies. This is necessary to an extent as concepts often do build on one another. However, Boyle suggests that in order to enhance the use of Learning Objects we should be focusing on minimising de-coupling. (Boyle, 2003)

At the same time as ensuring that these two principles are adhered to, Boyle also suggests that it is important to maintain the Pedagogical Richness of the Learning Objects. In order to keep the experience pedagogically rich, there is a need to maintain an overall coherency. Coherence, however, may conflict with the cohesion and de-coupling principles. We return to the concept of a compound object to overcome this conflict. Compound Learning Objects involve two or more simple Learning Objects that are linked together in order to provide the required Pedagogical Richness. A Compound Learning Object could, for example, combine a simple text-based Learning Object with a simple animation-based Learning Object to make a more sophisticated Compound Learning Object. The two objects could be related to each other in that they may be explaining the same concept however they would act independently giving lecturers the power to show the objects independently if they choose. This default Compound Learning Object could also be split up and rearranged with other simple objects being combined to suit the purposes of the lecturer. (Boyle, 2003)

In order for a GLO to be truly adaptable, the general structure of the material must be separated from the specific content. Stripping out higher level content from lower level structure is one of the key tasks for a truly re-purposable Learning Object. The difficult aspect of this separation is keeping the GLO powerful and pedagogically rich enough for it to be reusable while keeping it simple enough to be easily modified to suit. (Morales, Leeder, & Boyle, 2005)

This task of separation can be accomplished by borrowing from the concepts of object-oriented software engineering. The separation involves de-coupling the learning design from its surface instantiation. This process of separation causes a refined focus on the learning design itself with the surface instantiation reflecting the structure of that design. There are a number of steps between the underlying design and the surface instantiation, giving developers many opportunities to make changes and therefore create many different instances of the same underlying design. (Morales, Leeder, & Boyle, 2005)

Morales outlines a type of Generative Learning Object Architecture and design methodology that can be used to produce quality Learning Objects with design and content separated. The process is separated into two parts with the initial construction of a Learning Object template, followed by the construction of subject specific content to go on top of that template. The advantage of the template is that from that base lecturers can build many different Learning Objects by adding different subject specific content. (Morales, Leeder, & Boyle, 2005)

The development of the Learning Object templates involved a group of people from different backgrounds working together. This group may include students, experts, a facilitator and an artist. It is the job for the facilitator at this stage is to ensure that the core Learning Object content and the subject specific content are separated out. The second stage of the development process involves automation through software tools that generate web-based forms for the Lecturers or students to add the subject specific content. Another automated process automatically combines the subject specific content with the Learning Object template in order to create a completed Learning Object. One of the benefits of this method is that if at any time in the future changes are required the content and the Learning Object template can be recombined creating a new Learning Object. (Morales, Leeder, & Boyle, 2005)

Initially software engineers make use of existing and customised multimedia tools to create the Learning Object templates. These templates are then stored in the Learning Object template library. Customisation software is then used to create the html pages by which the tutors or lecturers can add subject specific content to the Learning Object template. After a review by lecturing staff, the html pages add the subject specific content to the subject specific library. Software tools are finally used to recombine the Learning Object templates with the appropriate subject specific content. This newly combined Learning Object is then stored in the Learning Object library.

Research into the impacts of learning technology on accounting education is somewhat scarce relative to many other subject areas. To date no Generative Learning Objects have been developed in the field of Accounting. The extensive libraries of Reusable and Generative Learning Objects held by the RLO-CETL have only a few business related examples and not a single Accounting specific Learning Object. This was one of the motivations to develop an Accounting specific GLO to see if a tried and tested learning technology model can be successful in that field.

Accounting students are motivated to learn by features inherent in their learning environment. It is suggested that Accounting students are more motivated to learn through new and novel ways and it is likely that increases in student motivation can be due to the nature of technologies such as the WebCT platform. (De Lange, Suwardy, & Mavondo, 2003)

Flexible or hybrid learning has been suggested in Accounting circles as a possible way to cope with increased class sizes in business courses while improving student performance and supporting institutional economic goals. Learning Objects can be used in a number of ways, including hybrid learning components. Work by Dowling et al suggests that a significant positive difference could be seen between the final exam results of accounting students in a hybrid learning course as compared with students in a traditional course. (Dowling, Godfrey, & Gyles, 2003) While learning objects weren't featured in this research they could perhaps be used to enhance the results improvements.

Further benefits of hybrid learning or e-learning are that they enable an institution to reduce its costs of resource production. Learning Objects once created can be distributed as easily to ten students as they can be to one meaning long term reduction of costs is likely. In the same way as these cost reductions can be attractive to institutions they can also be attractive to students. Opinions of students of an introductory Financial Accounting course were split between a preference of e-books to traditional texts due to the trade off of cost savings to perceived impact on usability. (Annand, 2008)

GLO design

Based on the above recommendations drawn from the relevant literature a Compound learning design featuring modularisation in the form of cohesion and de-coupling has been developed. A learning object template was first developed capable of containing a variety of different types of learning object components. The template acts as a player for learning object content by coordinating and displaying animations with textual explanations. Learning object content was developed in a cohesive way with each animation explaining a new concept or providing a new example. The Learning object content was based around the accounting concept of depreciation, a concept that lends itself nicely to visual explanation in the form of animation. To ensure the quality of the content, an accomplished accounting lecturer designed the content for animation and created the textual explanations which were then reviewed and critiqued by other accountancy lecturing staff. Prior to student involvement with the Depreciation GLO a pilot session was held with five Accounting academics working their way through the object from start to finish. The academics were asked to comment on a variety of aspects of the GLO in terms of its content, its ease of use and its general effectiveness as a learning tool. Some minor alterations were made to the content and user interface based on this feedback leaving the Depreciation GLO ready to be used by students. The diagram below illustrates the Learning Object development process:

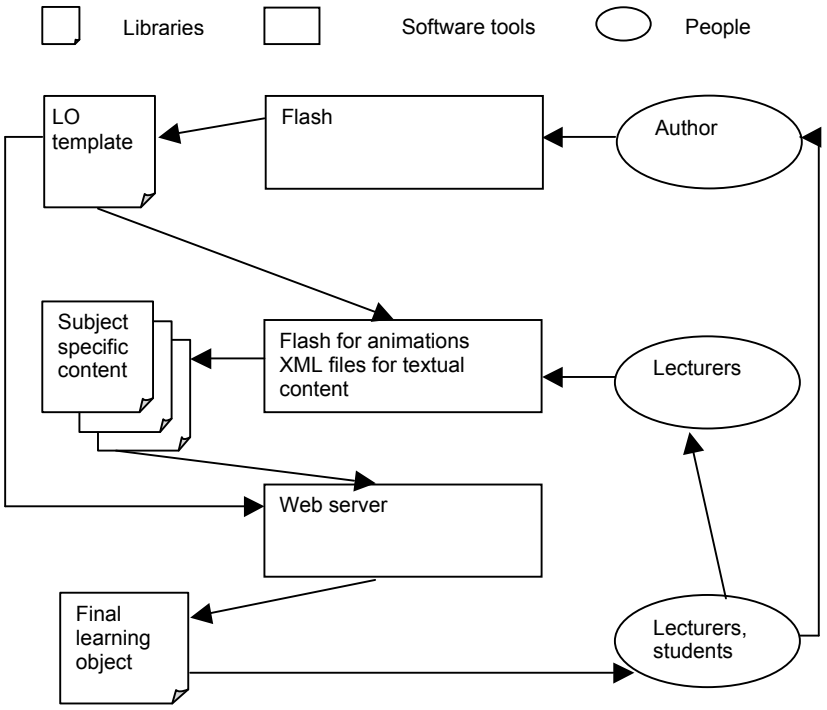

Figure 1: Diagram of the GLO development process

During the design of the GLO the most appropriate development tools were selected based upon cost, availability and flexibility. A three tiered architecture was used with Flash providing the user interface,

PHP providing the data connection and XML holding the content. Flash was chosen for the User Interface for its widespread availability, its flexibility in dealing with multimedia and its compatibility with other web technologies. PHP was used as a cost saving measure due to its open source nature. Finally XML was chosen as it is an extremely flexible database technology that yields outputs which can be used by many different applications.

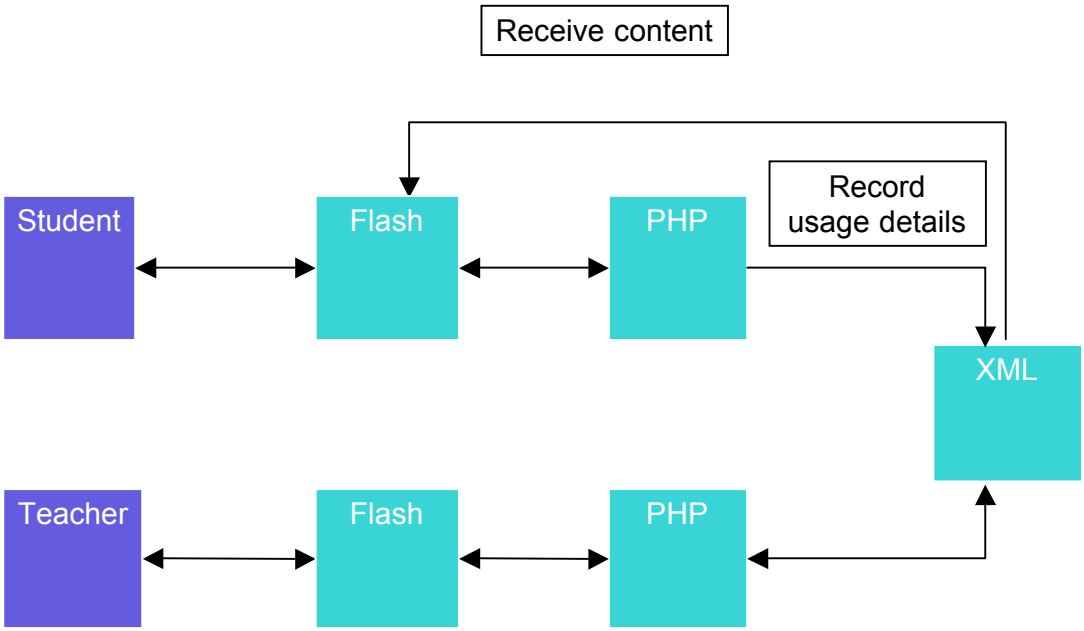

Figure 2: Diagram of the interaction of software technologies in the Depreciation GLO

A truly repurposable design was the result of the development process for this GLO. The textual content in the heading bar, the navigation controls and the instructional panel all draw their content from the XML file which can be updated by a relatively novice computer user with minimal computing background knowledge or experience. The main content panel on the centre left loads and displays external files such as flash animations, videos or still images and these can be altered externally and uploaded to the Learning Object web server. The figure below shows an example of the layout of the GLO as seen by the students:

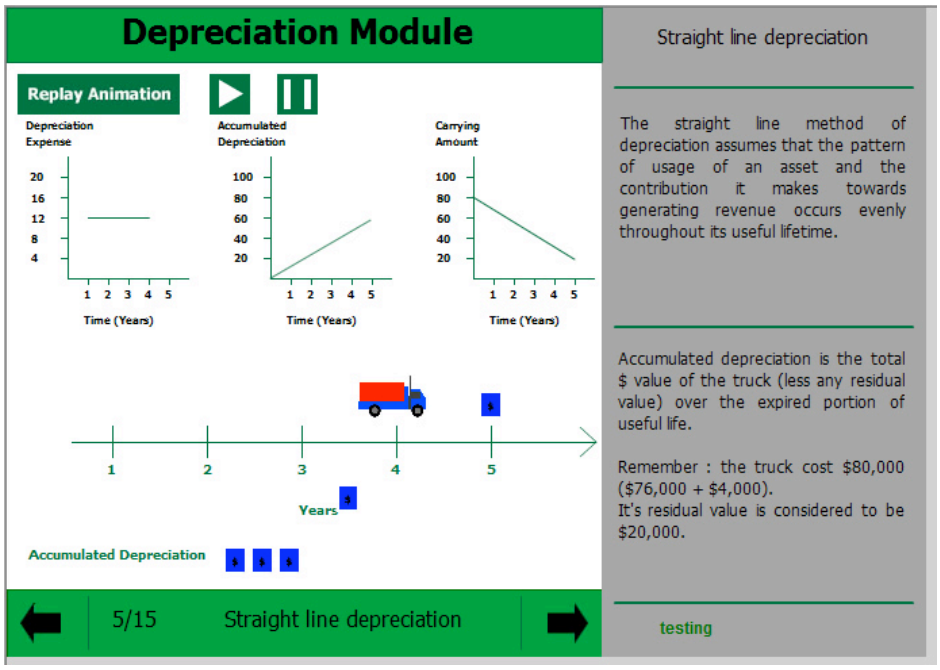

Figure 3: Screen capture of the Depreciation GLO in action

Another innovation in this learning object design is the incorporation of evaluation elements in the Depreciation GLO itself. Students were required to "login in" to the object when they first start working with it. The login details were given to students at the beginning of the learning object session and this allowed the tracking of their learning experience. In this initial version of the Depreciation GLO the evaluation data was limited to the time the students spent using the GLO and the score the student achieved in the built in multi choice quiz. These two data elements along with the student's username were automatically stored by the Depreciation GLO in an XML file on the web server.

The development of this GLO model took a significant amount of time with approximately four weeks of work spent on the development and refinement of the GLO template. However with the template built, the addition of new content is a fairly straightforward process and can be as simple or as complicated as the object author would like. The animations used as the Depreciation are an example of one of the most time consuming methods of designing content for a GLO. Each animation took approximately twenty to thirty minutes to develop depending on its complexity. For developers under tighter time constraints the used of simple images or pre developed video clips could certainly reduce this time down to only a few minutes per section. Assuming that the core concepts being taught haven't changed there is no real need to regularly modify the animations. At the same time however simple modifications can be made to the textual explanations as they are stored separately in xml files with the process of updating them being as simple as updating a word document.

Student Interaction

The opportunity to work with the Depreciation GLO was made available to all students of first year accounting courses at Unitec New Zealand. The Depreciation GLO was offered as a revision tool a week after the students had been taught the concept of Depreciation in class. All content available in the Depreciation GLO was based upon the same concepts and examples that had been covered in class time and therefore provided students with merely a new format to their existing instructional content. Session times were made available at night and during the day. Across the day and night classes thirty two students out of a possible seventy five decided to make use of the Depreciation GLO and take part in the research. Students who made use of the GLO were all given an instructional handout that explained the basics of how the Depreciation GLO worked. It explained the way they could navigate through the software, how it could be used as a learning tool, how they were able to submit their results for grading, and how to submit comments to support the study. While the Depreciation GLO is fairly straightforward in terms of its navigation and use, it was important that all the participants were fully aware of how to operate it before allowing them to use it.

Students were able to use the Depreciation GLO for as long as they liked within the one hour experimental session. They were able to step forward and back through the 15 content steps including the final Multiple Choice quiz within the GLO. After they were finished using the Depreciation GLO the students were encouraged to fill out a questionnaire based on their experience. The questionnaire was based on one designed and validated by the Centre for Excellence in Teaching and Learning (CETL) in Reusable Learning Objects (RLOs). For the purpose of this research the students were only able to access the GLO during their allotted class time period. This meant that they needed to be in the class computer lab at the specified time in order to use the object. Under normal conditions the students are able to use the GLO from wherever, whenever and as often as they like as it is web based.

Evaluation

Positive perception results were seen from participants on the ease of use of the Depreciation GLO. Only one student of the thirty two participants disagreed that the Depreciation GLO was easy to navigate. Agarwal and Venkatesh suggest that ease of use is the second most important factor of usability in a system (Agarwal & Venkatesh, 2002). In terms of navigation the Depreciation GLO allows the participants to navigate forward or backward through simple left and right arrow buttons. Allowing users to reverse there actions is seen to be an important navigational feature, and coupled with a simple design can ensure a high quality navigation system. (Benbunan-Fich, 2001)

One of the key questions posed was whether they would recommend the Depreciation GLO use to others. Sixteen of the thirty two participants "strongly agreed" with the statement. This suggests students would happily recommend the use of the Depreciation GLO to others in the future. The remaining sixteen participants "agreed" with the statement. Hence every one of the participants appeared to have found value in the use of the software.

Another question asked students if they would like to see more of the learning object in other courses. Again sixteen of the thirty two participants "strongly agreed" that they would like to see more of the learning object. Fifteen students "agreed" with the question and one student "disagreed". Again a very large majority of students responded favourable towards the Depreciation GLO hoping to see more of it in future modules.

An encouraging sign was that all students except two were happy to be able to learn on their own, with twelve students "strongly agreeing", eighteen students "agreeing" and two students "disagreeing". With most students being happy to work on their own the software should allow students to take on more responsibility for their own learning.

Of interest to the project over time are the comments from students relating to preferred future improvements of the Depreciation GLO. The addition of a definitions guide could be made in several different ways, the easiest of which would be to add in a step at the beginning of the object listing definitions. However a more effective way could be to include an interactive and intuitive definitions system that could tie in with each of the concepts allowing students to drill down to more information about the concepts they are currently reviewing. Such a method would help to support students as they work through reality imitating activities supporting their learning in a Constructivist way. (Martens, Bastiaens, & Kirschner, 2007)

The addition of audio to the Depreciation GLO is a natural progression from the use of animation and text-based knowledge streams. This suggestion was made both by a lecturer in the peer review and by a student and will be investigated during the next iteration of the Depreciation GLO. Adding audio and possibly video will increase internet bandwidth requirements however additional multimedia streams of knowledge should help cater to the various student's different learning styles and preferences. An example of this would be a student with dyslexia who may struggle with written text while finding spoken information much easier to deal with.

Positive perceptions of the users involved with the Depreciation GLO give an indication of its worth.

One easily trackable aspect of the students usage of the Depreciation GLO was the time they spent using it. The table below shows some basic statistics on time spent with the object:

Table 1: Depreciation GLO time spent descriptives

	Time
Minimum	13 minutes and 41 seconds (822 seconds)
Maximum	43 minutes and 44 seconds (2624 seconds)
Mean	27 minutes and 58 seconds (1678 seconds)

A fairly large spread exists between the minimum and maximum times spent by students using the Depreciation GLO. Time constraints were imposed on the students due to the nature of the experiment as it took place inside a one hour class period.

Table 2: Pearson Correlation of Time and Exam score

		Time	ExamQScore
Time	Pearson Correlation	1	-.439(**)
	Sig. (1-tailed)		.006
	N	32	32
ExamQScore	Pearson Correlation	-.439(**	1
	Sig. (1-tailed)	.006	
	N	32	32

The correlation between Time and the Exam Q score is negative ($r = -0.439$) suggesting that the more time spent by a student on the Depreciation GLO the lower their exam score would be. The correlation is significant at the 0.01 level with a significance of 0.006, ($r = -0.439$, $p < 0.01$). While the is the opposite result from that expected, it is likely that the weaker students spent more time using the Depreciation GLO and would likely have scored lower regardless. This highlights the importance of pre and post testing for such an experiment which will certainly be a feature of any future research.

There is also weak evidence that the Depreciation GLO had an effect on students' exam results. The difference in results between students who used the Depreciation GLO and those who didn't was evaluated using t-tests.

In one class a two-tailed t-test produced a t-test statistic of -1.602 with a significance of 0.117 which is below traditional significance levels. However, the students who used the software have scored more highly than the students who didn't use it. Results for the second Class were also not significant, so the next task was to test for a generalisable difference across the two classes.

A Factorial ANOVA test was used to find a generalisable difference across the two classes between those students who used the Depreciation GLO and those who didn't. The table below shows the results of this test:

Table 3: Factorial ANOVA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	85.862(a)	3	28.621	1.13	.341
Intercept	9357.819	1	9357.819	371.43	.000
C1	3.691	1	3.691	.14	.703
WS	72.212	1	72.212	2.86	.095
C1 * WS	2.056	1	2.056	.08	.776
Error	1763.584	70	25.194		
Total	11682.000	74			
Corrected Total	1849.446	73			

Dependent Variable: Q4Score

The F value for the effect of using the Depreciation GLO (WS) is significant at the 0.10 level. A graph is presented in Figure 4 to reinforce the findings of the Factorial ANOVA.

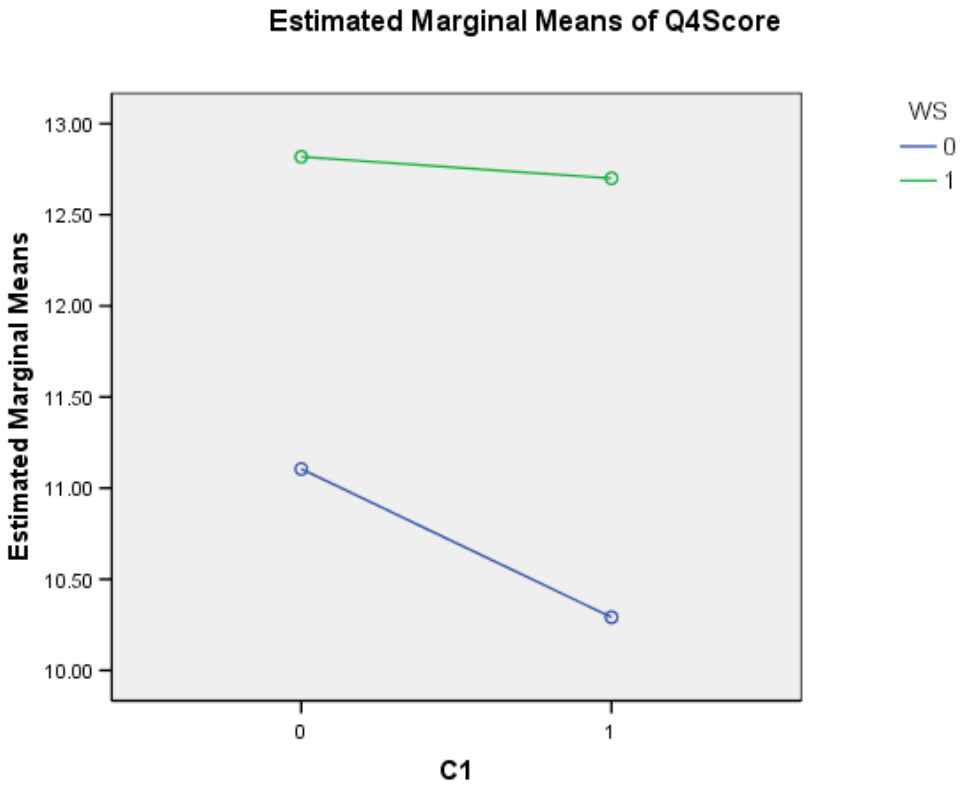

Figure 4: Exam score estimated marginal means

The above graph shows that there is a noticeable difference between the scores achieved by students who have used the Depreciation GLO (in green) and the students who have not used it (in blue). This effect is more apparent in the second class (101) than it is in the first class (5206). The difference in scores can be assumed to be between 1.5 and 2 marks on the final exam. Given that the Depreciation GLO only covered a topic worth 20% of the exam marks introducing GLOs for all topics could possibly improve student results by 10%.

Future direction

The addition of new modules is an area of focus for the author with demand from both students and staff for more generative learning object based content. When analysing the costs of the initial software development it can be seen that the majority of development costs are attributable to the software engine which controls the content modules. Adding new content to the software can be as easy as adding videos or as complicated as developing animations. Creating content can be much quicker and requires less in terms of software engineering skills. Lecturing staff can make use of screen video capture tools to demonstrate software or include basic diagrams developed through applications such as Word without needing any programming skills. By expanding the team involved with the Depreciation GLO a library of objects could be created around the various concepts of involved.

A natural progression in terms of the content displayed to students is to add audio explanations to the text-based explanations currently provided. Some people may respond better to audio based instruction than to text-based instruction and this could be especially effective when dealing with students whose first language is not English. The addition of audio would not require significant additional programming and the instructions could easily be recorded or adjusted by any member of staff.

Increased levels of interactivity and student control are seen as being another way in which we can engage digitally minded students with the generative learning objects (Andone, Dron, Pemberton, & Boyne, 2007). Increased control and interactivity can incorporate some of the lecturer and student suggested improvements, such as the addition of progressive assessment and interactive instructions. Additional features such as a readily accessible glossary of terms, graduated and varied assessment points, and interactive animations are all possibilities for areas of development.

During the development of this work, Second Generation Learning objects have been developed by Boyle which improves upon the user's ability to create their own Learning Objects. This advancement has come through the development of a GLO authoring tool which provides a simple user interface that requires limited computing skills on the part of the user. This authoring tool creates an XML file which can then be viewed through a player program, separating out the content from the player in a way similar to this current GLO project. (Boyle, 2006) Further work would provide interesting insights into the lecturing staff's perceptions and performance gains from the availability of such a tool.

Conclusion

Following along from the good work by the members of London Technology Research Institute and the Centre for Excellence in Teaching and Learning in Reusable Learning Objects a new generative learning object has been created. This generative learning object is based on the accounting concept of depreciation and teaches students through a series of animations with textual explanations in support. The learning experience is rounded out by a multi-choice quiz which is automated giving students feedback on their learning progress. The Depreciation GLO was developed using modern flexible web development tools and technologies including Flash, Php and XML.

A preliminary peer review session involving five accounting lecturing staff was held in order to screen out any problems and gain the lecturers opinions was held. Lecturing staff went through the software as if they were students and then completed a short peer review questionnaire. Students from two different courses (101 and 5206) made use of the Depreciation GLO under experimental conditions in a computer lab session. Information from the student's experience was automatically tracked, such as the time spent using the software and the score achieved in the multi-choice quiz. Each student filled out a questionnaire providing their perceptions of the Depreciation GLO as well as some demographic and other background information. A total of thirty-two students took part with eleven coming from the 101 diploma level class and twenty-one coming from the 5206 degree level class. The questionnaires used in the experiment and peer review form part of toolkit used and validated by the London Technology Research Institute in their own award winning learning object work.

Analysis of the results showed very strong support and positive perception of the Depreciation GLO by both students and staff. Many of the questions were based on Likert scales with the majority of responses being positive while some open questions gathered detailed qualitative responses. Further analysis of the data was carried out through a points system in order to aggregate the responses and indicate either a positive or negative overall opinion, with a strongly positive opinion being the result.

Statistical analysis was used to compare the exam results of students who used the software with the students in the class who didn't. This found differences between the two groups of students of varying levels of significance. Further testing showed a difference when combining the two classes of students worth approximately two marks at a 90% level of confidence.

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