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Transcending the Limits of Classrooms: Expanding Educational Horizons through Intelligent Tutoring

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Abstract

The notion of classroom-based University education is dramatically changing, education providers globally are adapting to the challenges and opportunities brought on by evolving technologies. A way of providing for this changing environment whilst maintaining a 'human-like' approach to education is the use of Intelligent Tutoring Systems (ITS). This study outlines the development and initial evaluation of an ITS designed specifically for capital investment decision-making (CID). The system tracks the student's performance, and generates a model of the student's knowledge, which is used to adapt the instructional session to the needs and abilities of each student providing individualised feedback. The ITS adds value to a traditional classroom-based tutoring approach by providing students with an enhanced problem-solving tool to be able to apply theoretical material in a 'real-life' simulated environment. The paper describes the ITS authoring environment, the creation of the tutoring system and a preliminary evaluation of academics' perspectives of using the system.

Keywords: accounting education, capital investment decision-making, intelligent tutoring systems, staff engagement, professional development

1. Introduction

The world of today has embraced technology in a way that allows for a truly global environment to exist, resulting in a world dominated by financial markets, outsourcing, competition and shifting political power, where often 'change' remains the only constant. The education environment has in recent times been criticized for not providing individuals with an educational experience that better prepares them for such an unpredictable and uncertain future (Prensky, 2012). Prensky argues that the promise of greater access, enhanced technology, social networking and widened participation is creating a seismic shift in the higher educational context. This is at a time where, in July 2012, an announcement was made of Coursera's MOOCs (Massive Open Online Courses) where some of the most illustrious U.S. universities will co-exist to offer online courses, freely available to the global learner (Lewin, 2012).

Such an expanding educational horizon requires new and innovative learning resources and techniques, readily available to educators, enabling them to engage in a development that will ultimately change the context in which we operate. It is imperative that such resource development aims to facilitate an optimal balance between the efficient delivery of education and the learning outcomes of the individual learner. The problem with traditional classroom tutoring is that it can offer individualised instruction only to a very limited extent. The curriculum and the overall benefit of a tutorial group dictate the pace. On the other hand, adequate learning support is required in order to support the aim of governments worldwide to widen participation rates in higher education. Individual human tutoring proves, in the current economic climate, too expensive to be widely used. This presents an explicit challenge for business schools globally where student numbers are increasingly growing and individual student cohorts can vary in size from 300 to 1500 students per semester.

Meeting the individual learning support needs of students requires an innovative teaching solution that enables individualised instruction. Computers have been seen as a possible provider of affordable one-to-one tutoring. However, most computer-based educational systems are rudimentary, based on a question-answer scenario, and are not significantly different from a textbook approach (Baghaei, Mitrovic & Irwin, 2006; Mitrovic, Martin, Suraweera, Zakharov, Milik, Holland, & McGuigan, 2009). In order to provide 'human-like' tutoring, a computer system must be *intelligent* enough to evaluate and model students' knowledge. Only systems that are able to adapt to learning abilities, knowledge and the needs of their students promise to genuinely enhance education.

This exploratory case study outlines the development, design and teaching staff evaluation of an Intelligent Tutoring System (ITS) designed specifically for introductory accounting. The input and professional development of teaching staff is a critical factor in expanding the educational horizon for advancing quality student learning experiences and outcomes. The study therefore presents the sentiments of teaching staff on their engagement with this bespoke tutoring system to assist with its further refinement and development. The remainder of this paper is organised as follows. A brief introduction to ASPIRE, the authoring deployment environment, is provided. This is followed by a discussion on the development of the Capital Investment Intelligent Tutoring System and the teaching staff evaluation employed. The findings of the study are then discussed, with the conclusion and planned future work presented in the final section.

2. Intelligent Tutoring Systems and the Authoring Deployment Environment

2.1 Background to Capital Investment Tutor (CIT)

ITSs are computer-based systems that track the behaviour of each student, develop and maintain a model of the student's knowledge and use this student model to adapt the instruction dynamically to the student's abilities and knowledge level. ITSs have the capability to revolutionise higher education spaces due to their high effectiveness in supporting learning (see for example, Koedinger, Anderson, Hadley, & Mark, 1997; Mitrovic & Ohlsson, 1999; VanLehn, Lynch, Schulze, Shapiro, Shelby, Taylor, Treacy, Weinstein, & Wintersgill, 2005). Despite this promise, ITSs are still not common because their development requires extensive expertise, effort and time (Murray, 1999).

The Intelligent Computer Tutoring Group (ICTG)[1] has developed many constraint-based ITSs, across varied disciplines, including Medical Sciences, Radiography, English and Linguistics, since the group was established (Baghaei et al., 2006; Mitrovic et al., 2009; Mitrovic & Ohlsson, 1999; Mitrovic, Suraweera, Martin & Weerasinghe, 2004). Their approach to building ITSs is based on Ohlsson's theory of learning from performance errors (Ohlsson, 1996) which resulted in the methodology known as Constraint-Based Modeling (CBM) (Ohlsson, 1994; Mitrovic & Ohlsson, 1999). Ohlsson proposed that knowledge should be represented in the form of constraints which specify what ought to be so, rather than generating problem-solving paths, as done in model-tracing tutors. Domain knowledge (i.e., constraints) is thus used as a way of prescribing abstract features of correct solutions. As discussed elsewhere (Ohlsson & Mitrovic, 2007), constraints are easier to develop in contrast to production rules which are used in model tracing as a recipe for performing tasks in a domain (e.g., Koedinger et al, 1997). Constraints support evaluation and judgment, not inference, and are used to represent both domain and student knowledge.

Although representing domain knowledge in the form of constraints makes the authoring process easier (Mitrovic, Koedinger, & Martin, 2003; Ohlsson & Mitrovic, 2007), building a constraint-based tutor still remains a major challenge. Developing such an intelligent tutor is a labour-intensive process that requires expertise in CBM and programming. In order to reduce the time and effort required for producing ITSs ICTG has developed ASPIRE, an authoring and deployment system for constraint-based ITSs. ASPIRE's authoring server eases the process of developing new ITSs by generating the domain model with the assistance of a domain expert. ASPIRE guides the author through building the domain model, automating some of the tasks involved, and seamlessly deploys the resulting domain model to produce a fully-functional, web-based ITS. The ASPIRE content authoring domain is explained next.

2.2 The Authoring Process and Deployment Environment - ASPIRE

ASPIRE consists of two distinct servers, the first provides a space in which a content expert is able to create and author a constraint-based ITS - an authoring server (ASPIRE-Author). The second comprises of a tutoring server (ASPIRE-Tutor) that delivers the resulting ITSs to students via an interactive interface (see Figure 1.). ASPIRE-Author makes it possible for the author to describe the instructional domain and the tasks the students will be performing, as well as to specify problems and their solutions. All required domain-dependent information, such as the domain model and other configuration details produced by ASPIRE-Author, are then transferred to ASPIRE-Tutor.

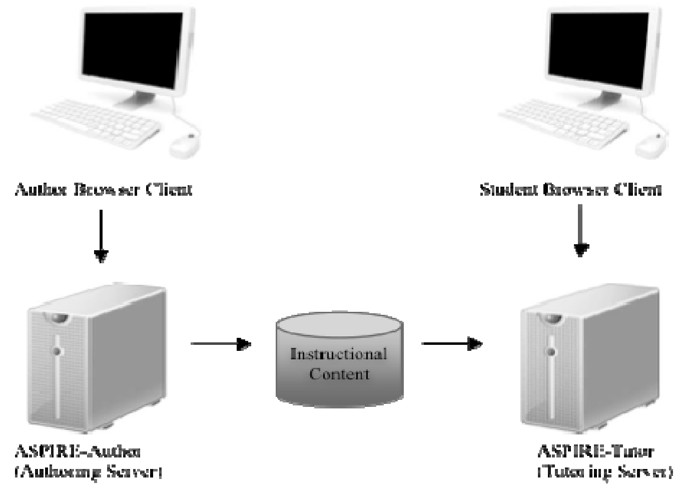

Figure 1. The components of ASPIRE

In creating an ITS within ASPIRE the content expert progresses through an eight-step process. Firstly, the expert creates a new domain and specifies its general features, such as whether the domain consists of sub-domains focusing on specific areas, and whether the domain is procedural or not. In the case a procedural domain is adopted, the expert is required to enumerate the problem-solving steps. The domain is then described in terms of an ontology, which identifies the important domain concepts, their properties and mutual relationships. The expert is then required to specify the structure of problems and solutions. This is followed by the design of the student interface and provision of a set of problems and solutions. The ASPIRE authoring system will automatically generate syntax constraints by analysing relationships between concepts and properties of concepts specified in the ontology. The syntax constraint generation algorithm extracts the restrictions specified for relationships and properties and translates them into constraints. These constraints are applicable to both procedural and non-procedural domains. An extra set of constraints is generated for procedural domains to ensure that the student adheres to the correct problem-solving procedure. ASPIRE will then generate a set of constraints for checking the semantics of the answer using a machine-learning technique: alternative (correct) solutions are compared, and, if necessary, constraints are specialised or generalised to be consistent across all the given solutions. Semantic constraints enable the ITS to model alternative correct solution approaches. Finally, the expert deploys the system.

The components of ASPIRE-Tutor are illustrated in Figure 2. The interface module is responsible for the construction of an interface once an ITS is deployed. The interface provides key operational features for the system enabling a student to, for example, login and logout, select problems to solve and submit their solutions for evaluation. The session manager is responsible for maintaining the state of each student during his or her interaction. The session manager also acts as the main entry point to the system, invoking the relevant problems when needed. For example, when a student submits a solution to be evaluated, the session manager passes on all information to the pedagogical module, which returns the feedback to be presented to the student. The pedagogical module decides how to respond to each student request. It is responsible for handing all pedagogy-related requests including selecting a new problem, evaluating a student's submission and viewing the student model. The student modeler maintains a long-term model of the student's knowledge. ASPIRE-Tutor also provides the functionality for managing ITS user accounts (for administrators, teachers, students and authors).

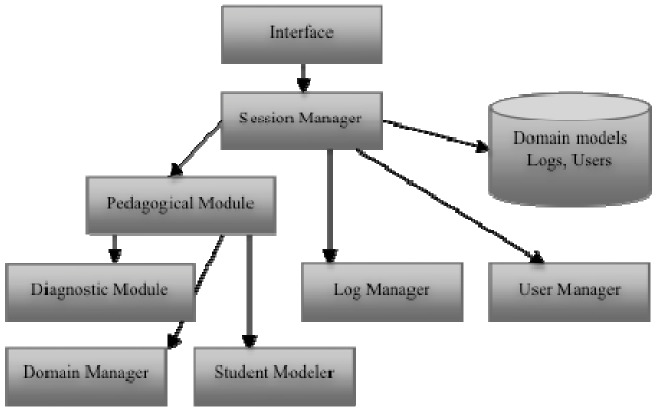

Figure 2. The components of ASPIRE-tutor

A review of literature suggests that a single other ITS was built within the discipline of accounting and finance. The U.S. based tutor was designed to assist students learn the general accounting cycle and its process (Johnson, Phillips & Chase, 2009; Phillips & Johnson, 2011). The authors cannot locate an ITS being developed in the area of capital investment decision-making.

3. Research Methodology

3.1 Case Description

This study is set within the Department of Accounting and Corporate Governance (ACG) at Macquarie University, located just outside Sydney's urban centre in Australia. The accounting department incorporates both accounting and business law disciplines making it large and diverse – in terms of programs, units of study, staff and students. ACG comprises one of four departments in the Faculty of Business and Economics and the largest across the University in regards to student enrolments. In the first semester of 2011 alone, ACG offered a total of 94 undergraduate and postgraduate coursework units with a total of 15,007 enrolments. These numbers have prevailed in recent years and are expected for the foreseeable future. Approximately 120 academics are involved in teaching responsibility, including both full-time and contract sessional teaching staff.

The study of introductory accounting has proved challenging to students, where an emphasis has traditionally been placed on technical accounting principles (Lucas & Mladenovic, 2006). This is further exacerbated through introductory accounting courses usually being taught in the first year of a business degree, to large student cohorts, comprising multiple areas of interest and follow an often rigid curriculum, dominated heavily by prescribed texts (Mladenovic, 2000). This can lead students to adopt a learning approach that may result in a superficial and limited understanding of the content (Lucas & Meyer, 2005; Lucas & Mladenovic). This is particularly true for ACG, where large student cohorts with varying backgrounds and interests have proved an added challenge for teaching staff of being able to provide individualised learning feedback.

A particular topic in the introductory accounting curriculum, capital investment decision-making, plays a crucial role in the financial evaluation of non-current assets within contemporary organisational practice. Teaching experience shows that capital investment evaluation techniques, namely the accounting rate of return, net present value and the internal rate of return, are problematic for students to master. This can be evidenced through the initial offering of ACCG106: Accounting Information for Decision-making, an introductory accounting course within ACG, in Semester 2, 2010 where the overall unit failure rate was approximately 40%, 19.5% higher than the equivalent course offered in 2009. Further analysis of the final examination revealed 71.5% of students failed the capital investment decision-making question. Students find the principles of capital investment decision-making difficult to comprehend and lack the ability to translate from theory to practice.

Innovative technology such as the CIT, has the potential to enhance overall learners' engagement and participation by motivating students within their learning through personalised feedback, the creation of an inclusive learning environment and enhanced access to resources, therefore assisting in raising the desired learning outcomes within this unit.

3.2 Experiences in the Design and Development of CIT

It was envisaged that the use of an ITS would enable students to apply theoretical financial decision making to 'real-life' simulated business environments therefore enhancing the relevance of the introductory accounting programme. It was with this in mind that the lead author (referred to as ‘author’) in consultation with ICTG developed an ITS that would assist with the learning of Net Present Value, a technique commonly used in practice for Capital Investment Decision-Making. The Capital Investment Tutor (CIT) was designed and developed over a period of six months with intermittent face-to-face meetings between author and ICTG project team.

The relevance that the ITS can bring to the classroom was an impetus to the system’s design, where the author created case vignettes that were taken from a ‘real-world’ business environment. Having identified that students found the conceptual process behind such capital investment decision-making techniques problematic in their learning, the system was developed to make such *process* explicitly clear.

The author designed the activity to be procedural in nature, consisting of seven steps. The student is first required to construct a timeline of cash outflows from the information provided in the case. This step is displayed to students on its own on the first page of the student interface. Step two is displayed on a separate page, asking the student to identify the relevant problem type and the variables that need to be calculated. The student is asked in step 4 to select the formula from a number of visual options that corresponds to the chosen problem type and enters the required parameters. In steps 5 and 6 the student enters the known values into the selected formula and specifies the computed value. The final step asks the student to complete an overall evaluation of the capital investment project based on their worked calculations from step 6 above. The procedural task was varied in that some steps required values to be entered and others required a selection from an amount of choices.

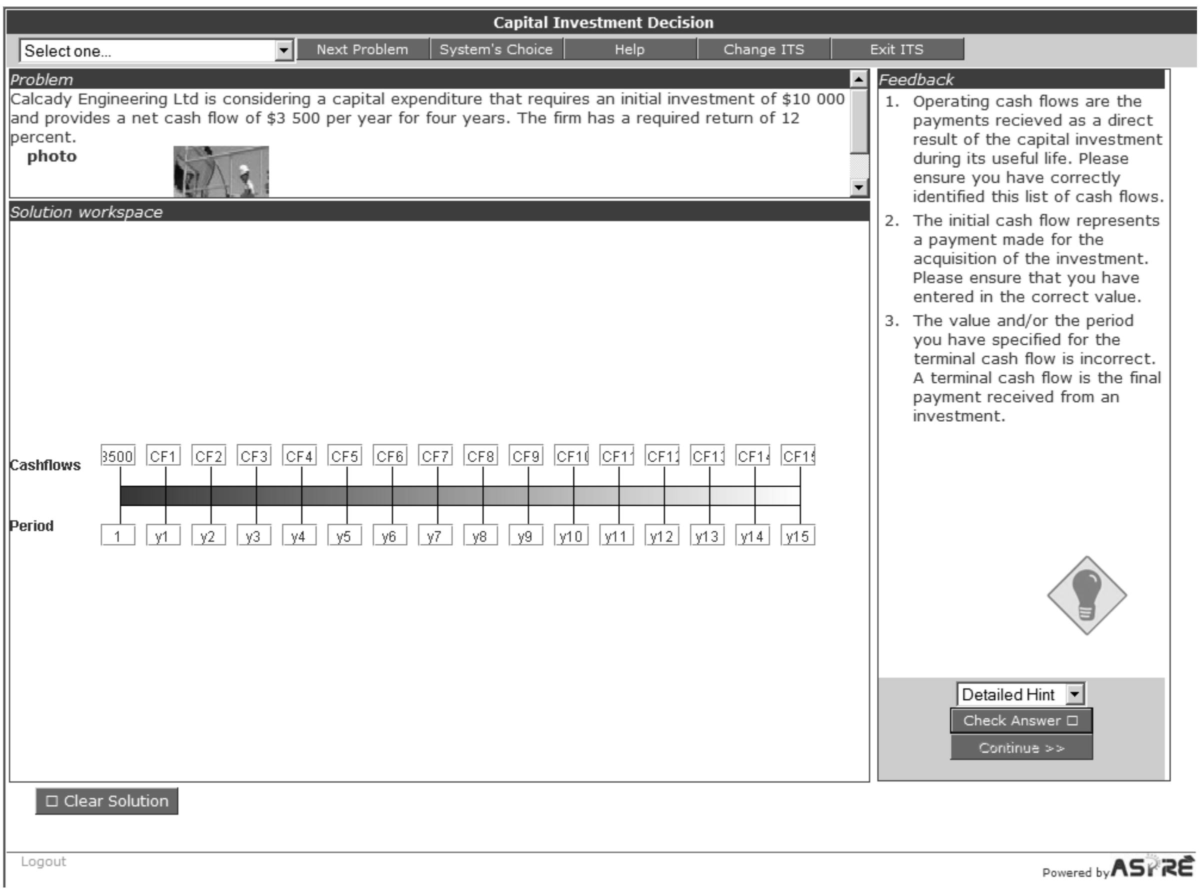

Figure 3. Student interface illustrating the first step of the procedure (timeline)

The author wanted the final student interface to use applets rather than text boxes supplied by the default student interface to make the system more visually attractive to learners. Such construction of applets falls beyond the author’s capability where expert knowledge is required. The ICTG team constructed these applets. The student interface with the applet for the first step in the CIT is depicted in figure 3. The task bar at the top of the page provides students with options for selecting problems, obtaining help and changing/leaving the ITS. The top left-hand area of the interface depicts the problem statement together with a photographic image describing the case. The problem-solving area depicted directly below consists of an applet that visualizes the time line. The student needs to label the period on this timeline and enter the amounts corresponding to the various types of cash flows. In the situation illustrated in figure 3, the student has incorrectly labeled the initial time as period 1 on the timeline, entered the incorrect value for the initial cash flow and failed to specify the rest of the timeline. Feedback on these errors are provided in the right-hand panel: the first hint discusses operating cash flows that are missing, the second discusses the initial cash flow for which the student supplied the wrong value and finally the third discusses the terminal cash flow. The student can change the solution based on the feedback provided, and submit again.

The ASPIRE authoring process is relatively straightforward for an average computer user where it is possible to clearly map the course learning material to the system's application. Academics wanting to design ITS do not need to have expert knowledge in computer science or knowledge engineering. The most difficult requirement for the author proved to be the design and construction of the CIT's ontological framework.

In constructing such an ontological framework the author was required for the first time to consciously think-through and analyze how the topic of capital investment decision-making is constructed and taught in the introductory accounting curriculum. In doing so, the author was able to gain a heightened appreciation for his content area, consciously reducing the taught material down to identified threshold learning concepts (Meyer & Land, 2003; 2005). This can present difficulties for academics where they have previously not mapped out what they are teaching in a structured and detailed manner. Creating an ontological framework in the case of CIT, proved challenging for the author where it remained unclear as to what was required of him and the purpose the ontology served. Contact with the ICTG team proved beneficial when constructing the ontology, in order to prevent frustration and slow progression.

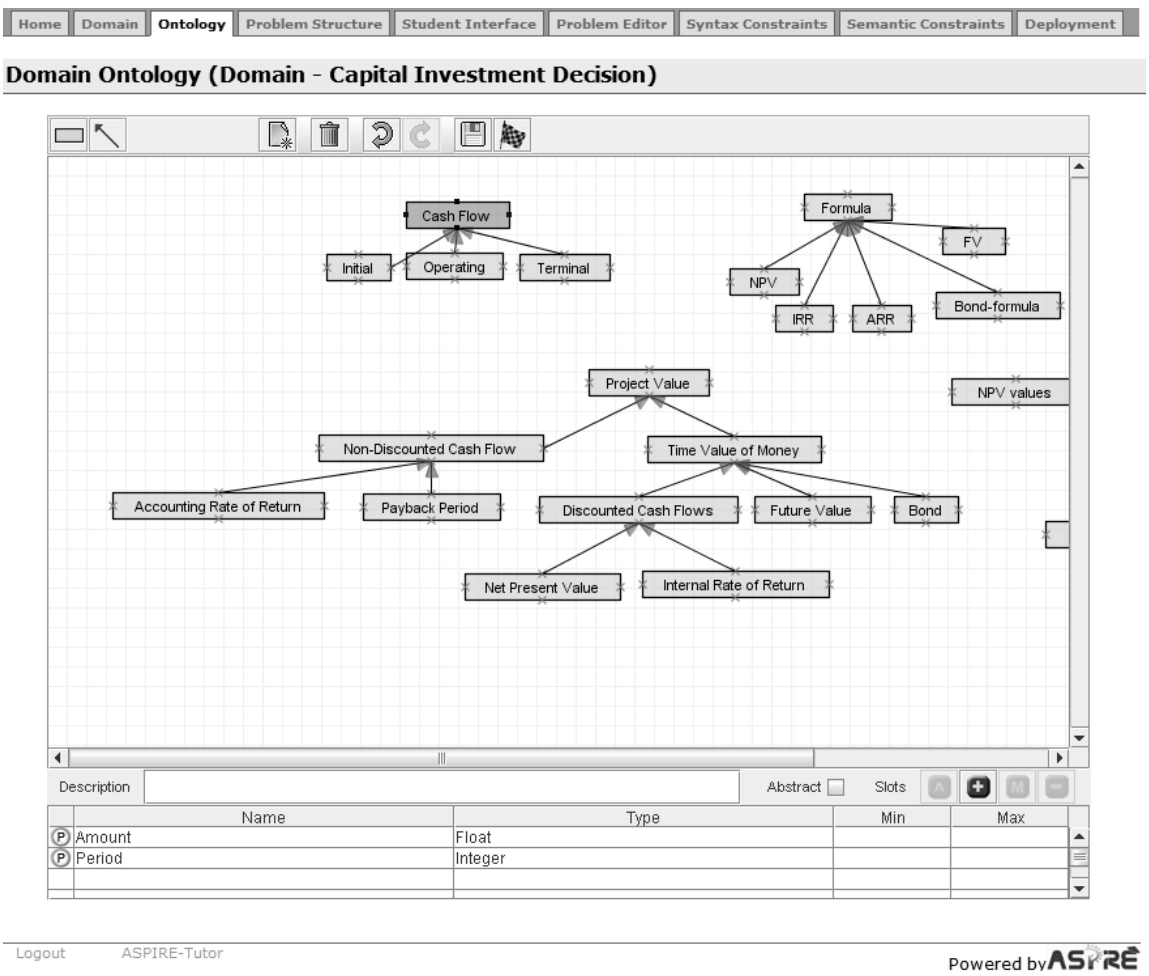

Figure 4. The ontological framework for the capital investment decision-making domain

The ontology for capital investment decision-making is illustrated in figure 4, clearly illustrating the important domain concepts and their corresponding relationships. The ontology contained a total of 30 concepts, each containing a number of properties. Due to the nature of the task, the ontology was displayed in a tree format where each tree represented the concepts relevant for one or more problem solving steps. This can be illustrated through the *Cash Flow* concept which is then further defined into *initial*, *operating* and *terminal* cash flows. These *Cash Flow* concepts prove relevant for the first problem-solving step only - constructing a timeline.

3.3 Teaching Staff Training and Development

ACCG106 is an introductory core accounting service unit for programs offered in a number of university departments such as computer science, engineering, actuarial studies, applied finance, business administration, marketing, creative arts and biology, across multiple faculties. There were approximately 1,000 students enrolled in 2011 and the number has risen to 1,300 in 2012. Approximately 30% of these students are from the Bachelor of Business Administration and Bachelor of Marketing programs.

The focus of ACCG106 is primarily from a user's perspective of decision-making and problem solving in business contexts rather than that of the preparer of financial information and reports. There is emphasis on the understanding of the basic concepts underpinning the preparation and analysis of financial reports and to apply these concepts to the interpretation of accounting information. The student cohort in ACCG106 is diverse consisting of both domestic and international students, and accounting and non-accounting majors.

The course is taught through a two-hour lecture and one-hour tutorial per week. The teaching staff comprise of a full-time academic staff member acting as course convener, one part-time lecturing staff and 17 part-time sessional teaching staff teaching across 50 tutorial classes. The sessional staff in ACG consist predominantly of postgraduate students and industry experienced individuals who are either working in paid full-time employment during the day and teach tutorials in the evening or are teaching part-time due to family commitments. Typically, sessional teaching staff would not have undergone any formal education or training qualifications.

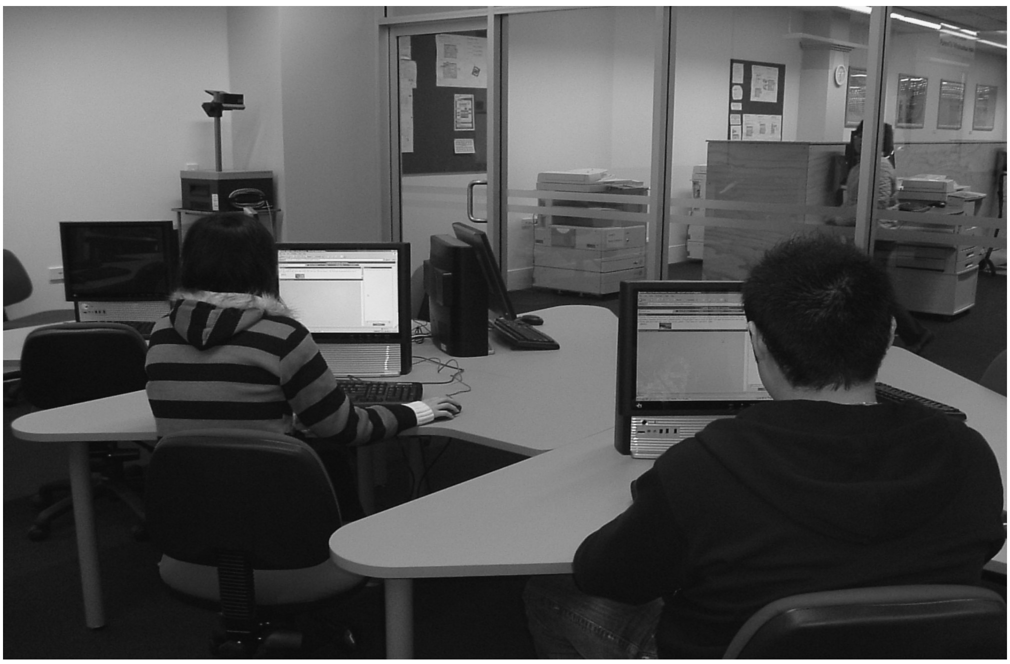

Figure 5. Part-time teaching staff interacting with the CIT during training workshop

The authors decided that it would be advantageous to design and run a training workshop for part-time teaching staff on the use of CIT. This would enable sessional staff an opportunity to engage in learning and teaching professional development directly tailored toward the accounting and finance content area. Two 90-minute workshops were run during the mid-semester break in Semester 2, 2011 to provide all of the sessional teaching staff an opportunity to interact with the tutoring system. Initial operating instructions were provided to staff including an individual username and password for the system. Teaching staff were freely able to interact with the system and its problems during the workshop, whilst the author of the system and one other full-time academic provided one-on-one question support. Figure 5 depicts part-time teaching staff interacting with the CIT during the workshop training.

3.4 Research Objective, Instrument Design and Data Collection

The primary objective of the study was to investigate teaching staff's perceived usefulness of the ITS for teaching capital investment decision-making and engagement of students within the introductory accounting programme. This study presents the sentiments of teaching staff on their engagement and development with the CIT to assist with its further refinement and development.

To achieve this, a user questionnaire was designed and administered to solicit staff impressions of the CIT at the end of the training workshop for all sessional staff. Nineteen usable questionnaires were completed, representing a 100% response rate. The questionnaire consisted of fourteen open-ended questions about staff interaction, engagement and enjoyment with the system, aspects of the system requiring further improvement and potential topics that could be developed using such technology in the future.

4. Results and Discussion

Teaching staff spent on average between five and ten minutes learning the functions of the CIT system and how to navigate through its interface, with one respondent commenting that it took approximately 30 minutes. There were no experienced software problems or system crashes during the training workshops. Four questions in the questionnaire asked for respondents to select a response on a scale ranging from 1 (*not at all*) to 5 (*very much*). These are presented below in table 1.

Table 1. Respondent perceptions on their interaction with the CIT

Qu. #	Question	Mean	Std. dev
2	Amount learnt from using the system	3.792	0.924
3	Enjoyment learning with this system	4.034	0.700
5	Ease of user interface	2.938	0.996
6	Usefulness of feedback generated by system	4.117	0.750

Teaching staff enjoyed interacting with the system (mean 4.0, sd 0.7), and believed that their understanding of the domain was improved as a consequence of using CIT (mean 3.8, sd 0.9). Staff varied on the time it took to learn how to interact effectively with the system and this either hindered or excelled their ability to learn from the system. One respondent commented, "After I have figured the system I began to learn a lot about capital investment decision-making. Learning the system is a barrier" (Respondent, 16), whilst another commented on the ease of the system design stating "as with using any form of technology or computer package, there is a learning curve, at least to be familiar with the 'menu' (where to next click). That was overcome quite quickly as the system is very user friendly and I know the topic well (which I was sure helped)" (Respondent, 12).

For others the system proved a tool to refresh content where one respondent commented, "the last time I looked at this material was 6 years ago" (Respondent 5). The enjoyment of staff using the system was high where respondents' commented again on the initial barrier of learning the system but, once this was overcome, it was "easy to engage", "another way to learn the concept" and "very interesting".

Teaching staff rated CIT's interface as relatively easy to use (mean 2.9, sd 1.0). Although above the mid-point (2.5) it is interesting to note that this was the lowest rated of the questions asked and relates to previous comments being made in relation to time taken to learn the system. A respondent comments "I recall at the time of using it, I had difficulty trying to figure what to click (especially to move onto the next level), I kept having to repeat the exercises that were available at a particular level. Maybe it's just me" (Respondent 13). Another respondent reflected on his/her interaction with the CIT and indicated concerns in regards to its use with students, "I had a better understanding of the system when using it myself. I tried to relate it to pedagogical principles. I also tried to relate the workings of the system to the academic abilities and motivations of my students. While I caught on with using the system after a little while, I did have some concerns for students, especially the weaker ones, who knew very little about the topic from the lecture" (Respondent 1). This indicated for the authors an area for further development, where more instructional material on using the CIT can be incorporated into the student interface upfront.

The feedback generated by the system was perceived by teaching staff as being highly beneficial (mean 4.1, sd 0.8) commenting, " [CIT] providing interesting feedback step by step process is very useful", "hints very useful", "it is useful and necessary for teaching this kind of topic". The feedback provided by the system is one of the most useful elements of CIT as it could be tailored to the student group based on the learning outcomes of the course and the task at hand. The manual modification of generated feedback messages was conducted towards the end of the system's development and was jointly achieved by the ASPIRE team and author. Users are able to request differing levels of feedback based on their general level of understanding. An option is presented where users can request 'quick' or 'detailed' hint with varying degrees of feedback being provided. One respondent requested that they would like to have seen more feedback provided whilst another found the feedback provided useful "but have to scroll up and look for it. I was initially sitting there waiting to be shown something but it's up there and I have to scroll up. I was tuned into looking for feedback" (Respondent 16). Seventeen out of the nineteen teaching staff indicated they would recommend CIT to students.

Question 10 asked respondents to discuss the aspects of the system that they particularly liked. Overwhelmingly, teaching staff discussed the step-by-step learning process of the CIT tutoring system as being of high value. Comments included:

> "I know that students have problems with understanding the capital investment topic and I felt confident in engaging my students because I believed that the ITS system will help them learn and understand this advanced topic at a deeper conceptual level (this topic is usually taught in a finance unit in the second year). It starts from the most fundamental level (cash flows, timing etc) and there are enough examples at each level for students to really master knowledge at that level before moving on to the next. This would have been too time consuming if it is pen and paper exercise." (Respondent 12).
>
> "The step by step process building a personal profile." (Respondent 10).
>
> "Each higher level introduces new knowledge systematically. Such 'level' increments in knowledge and learning (through personalised interactive learning) would not be possible in a classroom environment." (Respondent 7).
>
> "The stories are interesting, I can see it coming step by step to assist learning." (Respondent 12).
>
> "The step by step method. Positive enforcement." (Respondent 14).
>
> "Step by step to practice how to do this kind of question. It may help students to understand NPV." (Respondent 13).

Other benefits included the ability to practice and receive instant feedback (Respondent 7), the visual motivation experienced as the intelligent tutor "corrects you as you proceed" (Respondent 8), its simplicity and straightforwardness with problem, working space and feedback all being located relatively centrally on the same page, ease of navigation and ability to work to solve a problem in phases (Respondent 11, 4). Respondent 19 commented, "I think, in general, students like to use computers and do things online. They are more familiar with the online environment and I think they prefer online than paper" suggesting an openness of staff towards the expansion of teaching spaces.

Teaching staff overall felt engaged with the system, again referring to its step-by-step taught process as allowing the user to engage with the process of calculating capital investment decision-making techniques. Question 11 asked staff for comments on their engagement, these included:

> "Visual, logical, takes you step by step." (Respondent 8).
>
> "It is an interactive learning process, it is more efficient then just passively learning." (Respondent 18).
>
> "Solving a problem step by step if a mistake is made. Can get useful hints and won't be able to progress to next phase until answering everything correctly." (Respondent 12).
>
> "Step-by-step and making do things in a 'prompted' way. I'm imagining myself as a student who is new to for the topic. I felt more engaged with the system then with the topic. (maybe the system is new to me & the topic is not)." (Respondent 16).
>
> "Yes. I think it's helpful for student to understand NPV." (Respondent 13).

Respondent 15 was cautious of the system commenting on its engaging features for students, however was unsure as to the extent that learning can be improved stating "The system did engage me, however, I am unsure if the students will actually be able to relate the problems to the topic (particularly if they had not done any reading or prep). I.e. they will be engaged by the system - fun, but unsure if their knowledge will improve." An evaluation of the system from the students' perspective is beyond the scope of this paper. However, the ITS enables the authors to collect objective data, such as student usage statistics, from the system which can be analysed and compared to student performance based on students' pre and post tests and examination questions to determine. Respondent 14 felt a lack of engagement with the system commenting, "I would think if there is more feedback [it] will enhance this [sic] learning".

Overall, respondents felt the most frustrating aspect of the ITS was the time taken to learn how to interact with the system. This is surprising given the average time recorded was between five and ten minutes. Respondent 11 commented on a "… student's need to have some basic training before know [how] to run it". This highlights a need for extra support on how to use key aspects of the system. This could take the form of dialogue boxes that could be opened once clicked on or appear when the mouse is hovering over key areas of the interface. A secondary area of support could be to make the display of instructions more prominent within the interface design.

Question 13 asked respondents to comment on improvements that could be made to the CIT in the future. A number of respondents stated that cosmetic changes could be made to the visual student interface; these included dialogue boxes for entering text being too small (respondent 1, 10, 12, 13), more guidance provided through instructions of where students should physically enter text (respondent 3, 10, 15) and increasing the size of the workspace provided (respondent 2, 7, 14, 19).

Others appreciated the step-by-step procedural approach to learning, however commented that this created an amount of repetition which caused them to be "conscious of time spent in the repetitions" (Respondent 16). Due to the procedural nature of the constraint-based system, the system is unable to skip over a particular step in the process to let the user continue with new aspects of knowledge. Respondent 3 found the accurateness of the system problematic: "If errors are made the system won't allow you to continue until the errors have been fixed". Such constraints have been built into the system parameters in order to facilitate a student's learning. In this case, if errors are made students can receive individualised feedback about the type of error that has occurred in order for them to progress with the problem.

Respondent 4 suggested that the worked problems created and loaded into the CIT should have a difficulty-level indicated so that students are aware of the type of problem in which they need to solve. Related to this is the availability of the 'show solution' function with suggestions for this function to only be made available in the final phase of the worked problem to prevent students from prematurely clicking without sufficient consideration and attempt of the question.

A final area suggested for improvement is within the problems' design and composition in the CIT. Respondent 12 suggested that the problem case could include more visual images and external links to outside (web-based) information. External links to information found on company websites has the advantage of bringing greater relevance to the problem-solving environment. An exposure to such external information, including that of a non-financial nature, would also more closely mirror a 'real-world' business environment enhancing the complexity of the capital investment decisions that are required.

Finally, teaching staff were asked to comment on further areas within the introductory accounting curriculum that may make use of this technology. Comments varied amongst respondents with a primary focus on procedural tasks within the accounting discipline, namely learning transaction analysis (respondent 19, 11), double-entry bookkeeping (respondent 19, 11), financial statement (income statement, balance sheet and cash flow statement) construction (respondent 6, 13), Cost-Volume-Profit analysis (respondent 12, 14, 15, 16) and financial ratio analysis (respondent 12, 14). Respondent 9 felt that this technology would enhance students learning stating: "Definitely if we can use this in tutorial, student[s] can understand more and the tute [sic] might be more interactive".

5. Conclusion and Planned Future Work

Educational horizons are rapidly expanding to take advantage of current technological advances, creating greater access and widening participation within higher education. A problem exists in this mass education environment of how best to achieve individualised learning. This is particular true for business faculties and in particular accounting departments with in excess of 1000 students per semester. This study has provided a possible solution for achieving one-to-one 'human-like tutoring', through the use of a computer-based intelligent tutoring system. The study has described the construction of and investigated teaching staff sentiments and engagement with an ITS designed to assist with the learning of capital investment decision-making.

The construction of such an ITS proves to be a labour-intensive and time-consuming task for the content expert requiring a large, up-front time commitment. The most problematic aspect in the design of the CIT revolves around the construction of a suitable ontological framework. This proves problematic as it requires the content expert to explicate the learning process associated with the chosen topic in a logical and systematic manner. Such a reduction of the content area into core threshold concepts and their associated interlinking relationships can prove difficult for educators as often this has not previously occurred, at least not on a conscious level. This problem can be further illustrated by an educator's inability to place themselves back in the context of their students, without their level of expert knowledge and/or understanding, to try to imagine what it is like to solve a problem. However, once completed, the process of creating such an ontological framework is rewarding as the content expert is left with a deeper and more enriching appreciation of such content.

Teaching staff sentiments illustrate openness towards the expansion of teaching spaces to incorporate a blended instructional approach in introductory accounting that includes such a computer-based system. Staff felt that the system would provide a supplementary learning resource that would enhance student learning. As the system is web-based it can be accessed from any location where internet connection occurs, providing greater flexibility for students. The biggest benefit of the system, as perceived by teaching staff, is the step-by-step process that the procedural designed system offers. In this way, students are introduced to the process of capital investment decision-making gradually by the system unpacking the decision-making process and asking students to repackage through problem-solving capability into a final decision. There was a degree of criticism to this approach where it has the potential to become repetitive. The feedback provided by the system is seen as a secondary benefit to students' learning capability through instant and individualised feedback. Alternative levels of assistance can be sought from the system ranging from 'quick' to 'detailed' hints. Because the feedback is tailored towards the course and its student composition, where specific errors are made, the system will identify these and question students on their understanding allowing them to resubmit. Sessional teaching staff overall enjoyed interacting with the system, with 17 of 19 recommending the capital investment tutor for student use.

A barrier to learning in the system is the time taken to initially know how to interact and use the user interface. Although a degree of familiarity is expected to take some time the system may benefit from further refinements to its displayed instructions including the development of dialogue boxes that appear either by clicking on or hovering over these areas with the computer mouse, bolding of key instructional texts and a deeper level of strategic thinking on the placement of instructions and associated resources. Feedback received has indicated a need for cosmetic changes to the applets that appear on the student interface to include larger boxes for text input and a larger workspace to be displayed on the screen in order to prevent the necessity for the user to scroll down the page to locate information.

Finally, an option worthy of investigation is the expansion of the case material problems to incorporate external links to relevant company or business environment information. This has the potential to introduce further dimensions, such as non-financial information, to the decision-making environment creating a more enriching and complex problem-solving context. It is currently planned to incorporate some of the suggested improvements in the CIT and expand the system to include other capital investment decision-making techniques such as the accounting rate of return, internal rate of return and payback period. The system has undergone student pilot tests in New Zealand and is currently being trialled in Australia.

Further planned work includes the design and construction of an ITS that assists in the learning of cash flow statement construction and analysis, a secondary accounting topic traditionally proving difficult for students. Students are presented in introductory accounting with the principle of accrual accounting where income and expenses are recognised in the period they are incurred independent from any actual payments made. This traditional view has led to the fact that accounting systems are designed to capture accrual-based information. Constructed on actual receipts and payments during the relevant financial period, the statement of cash flows reverses the accrual concept.. Essentially, students need to apply 'cash accounting' principles using an 'accrual based' accounting system. Students are so conditioned to accrual accounting and the traditional concept that they show major difficulties in the application of cash accounting. Such an ITS demands a complex understanding of financial statement relationships and requires the development of professional judgement. It is envisaged that the ITS will assist in the integration of students' conceptual understanding across years of academic study.

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Note

Note 1. The Intelligent Tutoring Computer Group (ICTG) is an internationally recognized research group based within the College of Engineering at University of Canterbury, Christchurch, New Zealand.