Learning and Teaching Investment Fund 2011

Final Project Report

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Title of project:
Creating and evaluating interactive simulation models to engage students in industry-based courses

Strategic objective(s) addressed:
- Work-relevant and industry-partnered
- Urban in innovation and impact
- Global in reach and impact

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1. Executive summary

Students have difficulty comprehending complex concepts involved in logistics networks and supply chains. Simulation, the process of developing a model of a system that can be altered to determine the impact of key variables on the system, is promising for studying the characteristics of complex systems due its learning-by-doing, interactive and engaging nature. Using modelling and simulation tools in learning and teaching is an innovative pedagogical approach for facilitating the conceptualisation of the activities and interactions that occur within and between the firm’s functional areas and its business partners. Thus, the aim of this project was to develop a set of simulation models and tools to create a challenging, interactive and engaging learning experience for undergraduate and postgraduate students in Logistics and Supply Chain Management (L&SCM).

A set of modelling and simulation tools and accompanying teaching materials were developed in semester 1 2011 based on data provided by an industry partner. The modelling and simulation tools included several mapping models based on the publicly available Google Maps API and an agent-based simulation model of the distribution process developed using NetLogo, an open source simulation software. The teaching materials included: a case study, a user guide, a set of workshop notes and an assignment. Although not a requirement for the project, a web site was also developed to host the tools and teaching materials on the School’s web server for ease of access and use. Another extension to the scope of the project was the development of a global positioning system (GPS) tracking system to capture geo-coordinates of a delivery truck fitted with the developed device which transmits data periodically over the cellular phone network to a database hosted on the School’s server.

The teaching approach was implemented and evaluated in the postgraduate course, Logistics Systems (OMTG2087) in semester 2 2011. Two workshops were conducted to allow students to familiarise themselves with the case study and the tools and subsequently they were asked to perform an assignment.

Evaluation of the teaching method was performed using a mixed-method research approach. During the workshops, qualitative and quantitative data were collected to evaluate student experience and learning outcomes. Results show that positive learning outcomes were attained and students found the tools useful and many would use the tools at work. After the assignment was completed, students were asked to participate in a voluntary questionnaire survey to collect qualitative and quantitative data for further evaluation. Again, survey results confirmed enhanced student experience as students found the tools to be useful, motivating and engaging while examination of the assignments confirmed the high quality of students’ work. We also used Information Systems adoption theories and statistical methods based on Structural Equation Modelling to identify the factors influencing the success of the teaching method and we established guidelines for successfully implementing a teaching method using technology (simulation modelling tools in this project) in a course.

2. List of outcomes

The outcomes for this project can be classified into conceptual and concrete outcomes.

The conceptual outcome of this project is the design of a teaching method based on Information Systems theories to include technology, namely simulation modelling tools, in learning and teaching. The factors that influence the adoption of the technology-based learning tools by students in their studies were identified and a set of guidelines have been formulated to serve as framework when designing such teaching methods.

The concrete outcomes of the project are:

- A set of modelling simulation and simulation tools available online useful for teaching logistics concepts
• A set of accompanying teaching materials, namely: user guide, workshop notes, assignment
• A GPS tracking system for tracking location of delivery trucks
• Usage of the teaching approach resulted in enhanced student experience and positive learning outcomes
• Paper accepted by Informing Science + IT Education Conference (InSite) : Re-purposing Google Maps Visualisation for Teaching Logistics Systems, 22 – 27 June 2012, Montreal, Canada.

3. Project outcomes and impacts

Concrete outcomes
Originally, the project was designed to achieve the following (concrete) outcomes:
• Development of a set of simulation models and tools to enhance students learning of complex concepts in logistics networks and supply chains
• Development of a range of scenarios and strategies for students to experiment and evaluate in terms of impact on key business performance metrics
• Incorporating the tools in the curriculum of the course OMGT2087 Logistics Systems.
• Evaluation of the effectiveness of the tools as part of the Course Experience Survey and a customised survey based on a well-known Information Systems adoption theory

Not only were all these outcomes successfully achieved, but also the original intentions were exceeded with the realisation of additional outcomes. A discussion of the actual (concrete) project outcomes follows next.

Simulation models and tools
The first project outcome was the development of a set of simulation models and tools for teaching purposes. The model simulates the distribution process of a fictitious company which was largely adapted from data collected from a previous research for an industry partner. The details of the distribution process can be found in the user guide (refer to Appendix A). Using data supplied by the industry partner, and agent-based modelling techniques, we created a simulation model of the distribution process. The data supplied was analysed to determine customer-ordering patterns such as: preferred store for placing orders, frequency of orders, value of orders, etc. Probability distributions were generated for all customers in terms of order arrival rates and order amounts and these values were used to simulate the order arrival rates at the six stores operated by the company. The simulated delivery process consists mainly of aggregating the orders placed and delivering ordered items at certain times of the day using a certain amount of delivery resources (namely trucks and drivers). Since no data was available on the routes used for deliveries, we implemented a routing algorithm based on the travelling salesman problem and implemented it using the ant colony optimisation algorithm. Agent entities modelled in the system implemented include: stores, delivery vehicles, drivers, customers, orders and deliveries. These agents interact with each other using a pre-defined pattern to generate the desired system behaviours. The simulation model was tested and calibrated using the base case scenario in order to reproduce current operating conditions. Figure 1 shows an initial version of the simulation model at start up (i.e. initialised with appropriate parameters) just before launching the simulation. The coloured "house" icons represent stores while the coloured flags represent their corresponding customers.
Scenarios and strategies
Once a working simulation model was obtained, the model and its user interface were modified to allow users to experiment with a range of scenarios/strategies and evaluate them in terms of impact on key business performance metrics. Strategies that can be simulated with the model are: closing down a store, charging delivery fees (for all customers or for small customers only), outsourcing deliveries to third-party logistics (3PL) providers (for all customers or for small customers only), and various combinations of these strategies. KPIs implemented in the model are: number of orders placed, value of orders, number of orders charged for deliveries, value of orders charged for deliveries, number of delivery trips outsourced, distance travelled for outsourced trips, outsourcing costs, number of delivery trips scheduled, distance travelled for delivery trips, delivery costs, number and percentage of orders delivered, number and percentage of orders outsourced for deliveries, number and percentage of orders delivered, and number and percentage of orders delivered late. The controls for setting the strategies can be seen on the left of Figure 2 which also shows a simulation run in progress. The results of the simulation can be seen as KPIs on the right of the figure.

Figure 1: Simulation model at start up
Web site access and dissemination
On successful completion of the model and its accompanying strategies, it was decided to extend the scope of the project by converting the model for online operation as this would offer a number of benefits such as ease of access and use and hence wider dissemination than what would have been possible with a stand-alone model. At the moment, the web site for the project is hosted on one of the servers of the School of Business IT & Logistics until a more permanent replacement is found. The web site can be accessed at http://midgard.bf.rmit.edu.au/silt and is open to anyone who creates an account by providing a valid email address. Figure 3 shows the project’s home page while Figures 4 and 5 showing the online version of the simulator (with Figure 4 showing the simulator at start up and Figure 5 showing the simulator while the simulation is in progress).
Development of mapping and visualisation models

Another extension to the scope of the project was the development of several mapping and visualisation models or tools using the Google Maps API. Three applications closely related to distribution logistics (and hence to the project) that were developed are: (1) a geo-coding tool for
determining geographic coordinates in terms of latitude and longitude, (2) a geo-location tool for positioning addresses on a map, and (3) a routing tool for determining the best route to follow when visiting a set of addresses (for example a vehicle delivering parts ordered to garages). All mapping tools are available online and screen shots of their operation can be found in Figures 6 to 11. All tools were designed with ease of use in mind. They are configured with default data so that users do not have to worry about providing data in order to operate them and gain an understanding of the inputs required and the results generated. Just pressing the submit or display button will cause the tools to operate on the default data and later users can provide their actual data to generate the desired outputs.
Figure 7: Geocoding results

Figure 8: Geolocation
Figure 9: Geolocation results

Figure 10: Routing
Incorporation in the curriculum
In semester 2 2011, the various modelling tools were incorporated in the curriculum of Logistics Systems (OMTG2087), a postgraduate course offered by the School of Business IT & Logistics. In order to do so, a range of instructional materials were developed. These include: (1) a case study, (2) a user guide, (3) instructions for a workshop on the mapping tools, (4) instructions for a workshop on the simulation tools, and (5) an assignment on the simulation tools. All developed materials can be found in the appendix.

The student cohort consisted of about 70 students. Two interactive workshops were conducted by two of the researchers using a scaffolding approach to incrementally reveal the complexities of the simulation tools and hence facilitating student comprehension of the case study and the tools. Subsequently, students were given an assignment and both the workshops and the assignment were graded.

Development of GPS tracking system
In late 2011, the scope of the project was further extended to incorporate the development of a GPS tracking system for monitoring the positions of delivery vehicles in order to further enhance student experience with the tools. This part of the project was designed to achieve the following outcomes:
• Development of hardware devices for gathering GPS data and capable of storing such data on SD cards and/or transmitting them over the cellular phone network
• Development of a software system capable of receiving the GPS data collected for storing them in a database and eventually displaying the positions of the vehicles on a map

Two versions of the hardware component of the GPS tracking system were built. A basic version of the GPS unit tracks the latitude and longitude of a moving object (e.g. vehicle or person) every second and records the data on an SD card. As shown in Figure 12, three such units were built and they are very versatile as they can be powered in a variety of ways, including: a single 9V battery, a pack of 6 AA batteries or from a power adapter fitted to the cigarette lighter socket of a vehicle. These units are accurate within 5 metres which is the highest possible accuracy for non-
military purposes. They are also quite robust as they have been tested and found to operate without any problems for long period of times (up to 12 hours at a time).

![Figure 12: Basic GPS loggers fitted with SD cards](image)

A more advanced version of the GPS logger was also built which in addition of recording the data on an SD card, also transmitted the geo-coordinates in real time over the cellular phone network by means of a cellular phone (GPRS) module. Three such units were constructed and as shown in Figure 13, they must be powered by an adapter fitted to the cigarette lighter socket of a vehicle due to their high power requirements. Although three fully operational units were built, testing proved them to be unreliable since they tended to crash at random intervals. At this stage of the project, the cause of the problem is believed to be a power supply problem and the power supply circuitry is being re-designed to address the issue. In the mean time, the alternative for anyone who wishes to log GPS data is to record the data on an SD card and later transfer the data into a database using software built for that purpose.
No problems were encountered while developing the software component of the GPS tracking system since all required components were fully operational and robust as they were stress tested over long periods of time (up to 12 hours of continuous operation). A screenshot of the operation of the software component used for capturing data send over the cellular phone network and storing the data in a database is shown in Figure 14.
Figure 14: Capturing data sent by a GPS data logger in a database

Figures 15 and 16 show screenshots of the operation of the software component built for tracking the position of a vehicle in real time. The required parameters (such as vehicle to track, number of previous locations in the track of the vehicle to display, etc.) are selected from the web page shown in Figure 15.

Figure 15: Vehicle Tracking System

In Figure 16, the current position of the vehicle is shown by means of a “truck” icon while the track followed by the vehicle is shown as a red line.
In the next two sections, we describe how we evaluated the impact of the project on students.

Prior to collecting data for evaluating the use of the modelling tools and accompanying teaching materials, ethics approval was obtained from the College of Business. A copy of ethics approval can be found in Appendix E.

**Impact of visualisation/mapping tools on students**

The visualisation/mapping tools were developed to exploit visualisation as a cognitive strategy. A scaffolding approach, which progressively revealed additional complexity, was used to design both the tools and workshop.

The workshop began with defining routing and its applications in logistics and supply chain management to students. Students then experimented with the publicly available version of Google Maps to manually obtain the best route to visit a set of addresses. Afterwards, students used the three mapping tools from the SiLT website in progression. They used the most complex tool, the routing tool, last to determine the best route for the addresses they previously used with the public version of Google Maps.

At the end of the workshop, workbooks were collected and marked for assessment purposes. To ensure consistency, only one assessor marked all the submissions. Marks were allocated based on the students’ understanding of the material. The maximum marks for the entire workshop is 10, and the workshop is worth 5% of the total marks for the entire course.

**Data analysis**

From the collected data, we analysed the responses and the marks attained by the students. In particular, we focused on responses to question 5 (refer to Appendix B) as an indicator of understanding the value of the mapping software tool, and questions 6 and 7 (refer to Appendix B), as indicators for usefulness and uptake of the mapping software tool, respectively.
From the data analysis, descriptive statistics about the three questions asked were calculated, as presented in Table 1.

Table 1: Descriptive Statistics of Marks Attained, Usefulness, and Use at Work

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Marks</th>
<th>Usefulness</th>
<th>Use at Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>7.0</td>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Average</td>
<td>8.393</td>
<td>8.257</td>
<td>8.214</td>
</tr>
<tr>
<td>Median</td>
<td>8.0</td>
<td>8.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Mode</td>
<td>8.0</td>
<td>8.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Max</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.737</td>
<td>1.612</td>
<td>2.180</td>
</tr>
</tbody>
</table>

The overall results were very positive. The statistics show that, in general, most students had a good understanding of the material covered and use of the software mapping tools (marks ranged from a minimum of 70% to 100%, with an average of 84%, and a low standard deviation of 0.737). The median and mode showed that most students attained a result of 80%.

A histogram of the marks achieved by the students (refer to Figure 17), reveals that 55% of students received 8/10, 24% received 9/10, and 17% received 10/10.

When comparing their manually generated results against the results generated by the mapping software tool (question 5), many students stated that using the mapping software tools resulted in a better route, and was more effective and efficient. Comments such as, “Easier to get solution, less effort, less time …”, “Easier to use, provided shortest and quicker route”, and “Very useful, no trial and error” were common.

There was some confusion as to the accuracy of the address of locations. As part of its usual operation, Google Maps will approximate the location of an address if it cannot determine it exactly. In some cases, this approximation can be very far from the intended address, and there were some such cases with addresses that students had to use. Some students claimed that the publicly available Google Maps was more accurate while others claimed the opposite; that the mapping software tool was more accurate.

This was an unintended technicality that had both positive and negative aspects. Some students identified it and realised that one should not blindly accept the results generated and that one should double-check to ensure correctness. However, the inaccuracy made some students distrustful of the technology and they undervalued the usefulness of the tool and simply believed it to be inaccurate as a whole.

Another aspect that reduced the usefulness of the tool for students was that it did not consider “traffic condition, timing, weight of cargo, …”. Those students who made these comments realised that not all factors were considered, but also failed to realise that the tool was a generic routing tool and not specialised for logistics distributions and, thus, would not naturally consider factors such as cargo weight. This is a common issue with students with low IT literacy; they have high expectations of technology, which can be unrealistic (e.g., that a system will consider each and every real-life factor involved).
As hinted upon in their results to question 5, most students found the mapping software tool to be useful. This is supported by the descriptive statistics about their responses to question 6 (refer to Table 1). In general, students found the tool to be useful as the ratings ranged from a minimum of 3 to a maximum of 10, with a median and mode of 8. Compared to the marks attained, there was more variability in the usefulness ratings with a standard deviation of 1.612.

Inspection of the histogram of usefulness ratings (refer to Figure 18) shows that although there was more variability, the majority of ratings are toward the upper end (93% are in the 7-10 range).

Analysis of the justification for the ratings reveal that the low ratings were attributed to either misconception, “Same as Google Maps!”, or distrust of the tool due to lack of details, “Very simple, don’t know what’s going on behind interface”, and “Better to understand the algorithm”.

Some of the justifications provided by students re-iterated the ease-of-use, effectiveness, and efficiency of the tool, e.g., “Useful, automatic, saves time and little effort”, and “User friendly, fast, practical”. There are also comments which hint at the visual nature of the tool, “Visual and easy to justify decisions, simple UI”, and others that state the tool was easy to learn, “Easy to use, no need for much learning to use tool”. Such characteristics of the tool were not always seen as positive, as one student who provided a low rating stated, “Will make us become lazy!”

There were also re-iterations of the tool not being specific enough for logistics distribution, “Very useful and convenient, but still not perfect”, and “Fast and efficient, but does not consider traffic, road blocks, certain days”.

Some students found the technology and approach to be useful, “Yes, shows how theory can be applied and very visual with maps”, “Shows how IT is essential instead of manual calculations and
errors”, and “New logistics technology for me”. Other students revealed they were made more aware of issues related to routing and logistics, “Create awareness of choosing optimal route”, and “Transportation are costs huge! Helps to understand importance of routing”.

Students also realised the links between theory, the workshop, and practice, “Reinforces what [was] learned in [the] workshop”, and “Really useful to connect practice and knowledge learned in textbook”.

As the course was at postgraduate level and many of the students work, question 7 enquired if they would use such a tool at work as an indicator of future use (they would not use it again in the course). The responses included students who did not work, “Unlikely to use, full time student”, and others who would have no use for this type of tool in their positions (but still found it valuable), “Seldom use this kind of tool”, and “Not in current position, but can see benefits on delivery and business”.

As with the previous answers, there were accuracy concerns, “Saves time, no manual operation, but accuracy is a bit of concern”, and concerns about a lack of realism, “Useful for learning, but in real life more factors e.g. cost, traffic condition, etc. [need to be considered]”, “Useful but need to consider other factors: toll, rush hour, etc.”, “Use approximations, not useful in practice”, and “Just a fixed calculation, not flexible enough”.

There were also other practical issues raised, such as a lack of deeper integration with other systems, “No ERP integration No traffic condition! No on the fly adjustment in case of accident”, and “Does not arrange transport but will use it and prefer more advanced program, e.g. timing, traffic”.

Other justifications pointed out the ease of use, and usefulness of the tool, “Online system, doesn't need setup”, “Definitely will, easy to use and does not require much knowledge”, and “Yes, have many truckloads with multiple drops”. One student even stated that the tool was advanced, “An advanced tool, many advantages when compared with others”.

![Use tool at work](cheong_BUS_LTIF2011_finreport)

**Figure 19: Use at Work**

Although there was the most variability in this set of responses (a standard deviation of 2.180), most of the responses were higher ratings (a median and mode of 9 and 10, respectively) compared to the other questions. 87% of the answers were in the 7-10 range.

**Theoretical foundations**

The workshop and the visualisation/mapping tools were centered on three main theories from the relevant literature: visualisation, the human cognitive architecture, and information structure.
Given the visual nature of maps and routing, visualisation was an obvious theory to use as a foundation in our work. Visualisation is a cognitive strategy used for creativity, discovery and problem solving. It can be broadly considered synonymous to imagery and can be defined as “representations of information consisting of spatial, non-arbitrary, and continuous characteristics” (Rieber, 1995). The picture-like qualities of a visualisation are non-arbitrary because the visualisation resembles the actual object or event, while the continuous characteristics refer to the ability of randomly scanning the visualisation in contrast to reading a sequential description of the object.

Cognitive strategies are ways in which people manage their own learning, especially during the problem-solving phase (Weinstein & Mayer, 1986), and people have a natural tendency to use visualisation as a cognitive strategy. We used a visualisation approach to leverage this natural tendency in order to facilitate students’ learning.

We took into consideration the human cognitive architecture and the structure of the information to be learned in our approach as they can provide useful insights to successfully design appropriate instructions (Sweller, 2002). This was particularly important as visualisation, like any cognitive process, is greatly influenced by prior knowledge held in the long-term memory of the individual.

The human cognitive architecture consists of a working memory of limited capacity and duration and a long-term memory of infinite capacity. Working memory is believed to consist of multiple channels or processors and the visual and auditory channels of working memory are partially separate. The partial separation of the visual and auditory channels can be exploited for learning purposes to increase the capacity of working memory by presenting learning materials in both the auditory and visual modes rather than in a single modality. Thus, in the workshop, we provided students with both visual (the visualization/mapping tool) and auditory (verbal instructions to accompany the demonstration of the tools) materials.

The structure of the information is also important as in order to learn new material, all the elements of the material must be placed in working memory. If the information structure consists of elements with little or no interactivity between them, then each element can be loaded and learned serially in working memory. However, if element interactivity is high, all the elements must be processed simultaneously in working memory, imposing a heavy cognitive workload. If the new material is sufficiently complex, it cannot be processed adequately in working memory and the learner might fail to understand such material. Thus, in designing the scaffolding approach, we ensured that students were provided with bite-size learning material each time so that it could easily fit into their working memory.

Other cognitive structures and other learning mechanism are necessary, namely long-term memory and schemas. Long-term memory holds well-learned material and is not just used to recognise or recall information but rather as an integral component of all cognitive activities. It is of critical importance to higher cognitive functioning such as problem solving and the problem solving skills depend on the schemas held in long-term memory (De Groot, 1965). Once the students understood the bite-size material provided, it is envisaged that it would be transferred from their working memory to, hopefully, their long-term memory.

Overall, the use of scaffolding in the delivery of the workshop and the design of the mapping software tool facilitated accelerated learning. Students were able to quickly understand the theory involved and put to practice recently acquired skills in using the tool. Some students were able to attain a higher level of learning by abstracting concepts and applications of the tool while others focused on the limitations of the tool (did not consider all factors; lack of realism), and others had misgivings about the tool due to a lack of details. Qualitative and quantitative results obtained showed positive learning outcomes, that students thought the tool was useful, and that they would use it at work.
Outcomes
Learning outcomes were measured by assessing students' workshop submission. All students received marks in the 7-10 (out of 10) range. Students' self-reported ratings of "usefulness" and "use at work" resulted in 93% of students rating the usefulness between 7-10 and 87% of students rating "use at work" between 7-10 (both on a 10-point scale) respectively.

Students' experience was also largely positive. Overall, they found the tool to be easy to use as it was easy to obtain a solution with little effort or time. They also believed the tool to be useful to show how theory can be applied and raised awareness about choosing the optimal route in logistics and distribution/transportation networks.

Students' concerns with the tool were mainly related to accuracy. They focused on the limitations of the tool, such as not taking into consideration traffic conditions, weight of cargo, road blocks, etc. Some students were also distrustful of the tool as they did not know how the algorithm used determined the routing.

Although the results are generally positive, this part of the research is limited to being trialled and evaluated in one workshop and should be considered as exploratory work. Further investigations should be undertaken to obtain more convincing results. In particular, future work would include trialling the tool and teaching approach to other related courses, and to use more rigorous evaluation techniques.

Impact of simulation tools on students
The other set of tools, the simulation modelling tools, were designed to provide interactive, engaging and learning-by-doing approaches, a form of pedagogical model that provides experiential learning (Kolb, 1984). The reason for developing and deploying such tools were to promote learning through reflection on direct experience rather than rote or didactic learning and hence enhance student experience as well as learning outcomes. We used a mixed method research approach to assess the impact of the tools on student experience and learning outcomes.

Workshop outcomes
Students were first exposed to the simulation tools in a workshop, the purpose of which was for them to gain familiarity with the tools so that they have enough knowledge and skills to perform an assignment later. Due to the limited time available for learning to use the tools, it was thought that some form of accelerated learning would be beneficial to students. Hence, the workshop was conducted in interactive mode by two of the researchers and scaffolding techniques were used to help students to successfully complete assigned tasks so that they can quickly progress to the next ones. The workshop was carefully planned in advance and it was divided into a number of tasks with progressive levels of difficulty. For each task, tutors interacted with students by means of demonstrations, questioning techniques, identifying hints and cues and circulating among students to question their approach to the task and providing students with constructive feedback.

Students were provided with an answer book (refer to Appendix C) to record their observations and comments and the workbook was graded. The distribution of marks is shown in Figure 20 and it can be seen that most students achieved a high level of comprehension of the materials presented in the workshop.
Figure 20: Simulation modelling workshop grades

Data collection
After the workshop, students were given an assignment and a survey pack containing a plain language statement and a questionnaire survey. Students who agreed to take part in the survey were asked to return the questionnaire to one of the researchers who was not involved in teaching the course after the assignment was completed. Apart from collecting demographics data, the survey instrument (refer to Appendix G) was designed to collect two sets of data. The first part of the survey instrument contained questions to gauge student experience with the tools in terms of usefulness, the extent to which the tools were motivating and engaging, while the purpose of the second part of the questionnaire was to collect data to identify the factors influencing the adoption of the tools by students.

Although only 22 students responded to the survey, the sample was fairly representative of the population being surveyed based on gender, age group and mode of study characteristics as shown in Table 2.

Table 2: Demographics of surveyed students

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Population</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>36</td>
<td>50.7%</td>
</tr>
<tr>
<td>Female</td>
<td>35</td>
<td>49.3%</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21 – 28</td>
<td>55</td>
<td>77.46%</td>
</tr>
<tr>
<td>29 – 48</td>
<td>14</td>
<td>19.72%</td>
</tr>
<tr>
<td>49 – 65</td>
<td>2</td>
<td>2.82%</td>
</tr>
<tr>
<td>&gt; 65</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mode of study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td>62</td>
<td>87.3%</td>
</tr>
<tr>
<td>Part time</td>
<td>9</td>
<td>12.7%</td>
</tr>
</tbody>
</table>
In the first part of the questionnaire survey, respondents were also asked to answer a range of questions in order to evaluate their perceptions about the usefulness of the modelling tools for facilitating their learning. They were also asked to evaluate the usefulness of the assignment and the business case used as the basis for the modelling tools and the assignment.

**Evaluation of simulation modelling tools**

The evaluation of the modelling tools was performed on the basis of several criteria related to their usefulness in facilitating learning in the course. For each criteria used, respondents were asked to provide a rating between 1 and 10 representing the degree of usefulness from "not useful" to "very useful" with higher ratings representing higher degrees of usefulness. As can be seen in Figure 21, respondents rated the usefulness of the tools for facilitating their learning in the course very highly on the scale, ranging from mid-scale to the top of the scale.

![Usefulness of simulator](image)

**Figure 21: Usefulness of simulation tools for facilitating learning**

In order to validate responses regarding the perceived useful of the simulation tools, we also incorporated a number of questions to assess students’ perception on various criteria that would be closely related to the usefulness of the tools and check whether consistent responses were provided. The criteria used were: (1) reduction of complexity of the system studied in order to evaluate process improvement strategies, (2) facilitation of visualisation of the system studied in order to evaluate process improvement strategies, (3) facilitation of understanding of the system studied in order to evaluate process improvement strategies, (4) facilitation of experimentation by trying out various strategies in order to evaluate process improvement strategies, (5) provision of a practical or hands-on approach in order to evaluate process improvement strategies, (6) engaging enough to complete the assigned tasks, and (7) motivating enough to complete the assigned tasks.

As can be seen from Figures 22 to 28, all the responses to these aspects of the simulation tools were largely positive and hence confirming the overall usefulness perceptions of students.
Figure 22: Extent simulation tools reduced the complexity of the system

Figure 23: Extent simulation tools facilitated visualisation of the system
Figure 24: Extent simulation tools facilitated understanding of the system.

Figure 25: Extent simulation tools facilitated experimentation.
Figure 26: Extent simulation tools provided a practical approach

Figure 27: Extent simulation tools engaging
Figure 28: Extent simulation tools motivating

Further validation of perceptions of usefulness of the tools was sought by a question asking respondents whether they would recommend the tools to others since it makes sense to recommend something that is useful for others to benefit. Again, Figure 29 confirms the usefulness of the simulation tools, since the majority of respondents affirmed that they would recommend the use of the tools to others. The presence of a negative answer is puzzling and is most probably an outlier since the respondent did not provide any particular reasons to justify his/her response and he/she was very positive about most usefulness aspects of the simulation tools.

Figure 29: Recommending the simulation tools to others

Evaluation of business case
We also evaluated the business case since the simulation modelling tools, the workshop and the assignments were based on that particular business case. As shown in Figure 30, the business case was well received by most respondents (apart from one below average rating provided without any accompanying justification).
Evaluation of assignment
Finally, we evaluated the assignment since it was the main vehicle for promoting deep learning among students and also the means to evaluate learning outcomes. Although the assignment was perceived at an appreciable level of difficulty (as shown in Figure 31), it was rated at a high level of usefulness (as shown in Figure 32).
Learning outcomes
In terms of learning outcomes, the results were very encouraging since nearly 80% of the class scored 70 marks and above (as shown in Figure 33).

Analysis of comments from students
Apart from quantitative perception ratings, we also invited qualitative comments from respondents and although sparse some of them are quite interesting. Positive comments were made regarding the simulation modelling tools as shown in Table 3.
### Table 3: Comments on simulation modelling tools

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Usefulness</strong></td>
<td>“Would need this type model in job role”&lt;br&gt;“It provides an intuitive logistic process i.e. make me understand the context easily”</td>
</tr>
<tr>
<td><strong>Reduce complexity</strong></td>
<td>“The software provides many options which can guide me to establish improvement strategies. The options can be provided directly which facilitates my evaluating and analysing of each strategy”</td>
</tr>
<tr>
<td><strong>Visualisation</strong></td>
<td>“Helpful to see the orders fulfilled and colours associated with stores”&lt;br&gt;“Saw what was happening, able to come up with improvement strategies on observations”&lt;br&gt;“The ‘world’ display provides visual information to facilitate the understanding of distribution and fulfilment processes”</td>
</tr>
<tr>
<td><strong>Facilitate understanding</strong></td>
<td>“We could find how different scenarios worked in the real time world and that was interesting”&lt;br&gt;“The input and output provided from the simulator is clear and simple to understand”</td>
</tr>
<tr>
<td><strong>Facilitate experimentation</strong></td>
<td>“As the simulation was easy to set up I did try many different strategies and it was quite simple and fun”&lt;br&gt;“There are many options can be chosen in the simulator to test different aspects of each strategy”</td>
</tr>
<tr>
<td><strong>Hands-on</strong></td>
<td>“In terms of providing guidance for decisions, it was hard to fault”&lt;br&gt;“It gave us an accurate gauge of what was happens in the real world and it was very informative”&lt;br&gt;“A creative teaching method”</td>
</tr>
<tr>
<td><strong>Engaging</strong></td>
<td>“I found it addictive – only issue was the time taken to run”</td>
</tr>
<tr>
<td><strong>Motivating</strong></td>
<td>“Quite good fun running the simulation”&lt;br&gt;“The simulator is simple to understand. I’d like to use it to explore further issues. It motivated me to complete my workshop and assignment”&lt;br&gt;“I know it’s useful, but because it’s not my area, I’m not really really motivated”</td>
</tr>
<tr>
<td><strong>Recommend to others</strong></td>
<td>“Provides good results”&lt;br&gt;“Good to use scientific tool to justify decision making”&lt;br&gt;“It’s useful – It provides visual understanding of distribution processes”&lt;br&gt;“It can help the strategies provided for improving supply chain to be evaluated. Quantitative analysis is very important. The simulator can compare the anticipated result and the simulate result”</td>
</tr>
</tbody>
</table>

Comments regarding the business case used included: “Helped to visualise and think”, and “The case is real”. Comments regarding the usefulness of the assignment included: “This assignment enable me to have a better understanding of the distribution process in the real world”, and “I have learned how to analyse & solve problems” while comments regarding its level of difficulty included: “Challenging enough – had to choose strategies carefully”, and “It requires lots of research and the simulation is challenging”.

**Issues raised by students**
One issue raised by a few students was that the simulator was terribly slow when performing the assignment. In some cases, a single run could take up to 3 hours, instead of the expected 30 minutes. Unfortunately, this issue was reported mainly in the survey questionnaire, well after the
assignment was submitted and most of these cases could not be investigated except for one. In that particular case, the cause of slow execution was due to traffic being routed to a server located in an overseas head office as the student was running the simulation on a computer at work. At this stage, the reason for such slow execution times for some computers is still largely unknown and will have to be investigated when such cases arise.

Another issue mentioned was that the simulation tools did not consider inventory levels as real life distribution processes are tightly coupled with inventory levels. Although the simulation modelling tools can be extended to incorporate other aspects of distribution processes, a more pragmatic approach would be to design and implement a new simulation model based on a business case that incorporates distribution, inventory and may be forecasting as well. While building the new modelling tools, currently identified issues can be addressed as well. The new modelling tool would be an addition to the set of modelling tools as the current tool is valuable as a distribution-only model.

One student commented that the tools have “no memory of strategies”, meaning that the results of previous simulations are not automatically saved by the software in order to facilitate comparisons between strategies. This facility is sometimes available in commercial software. This is a useful request which can be implemented in future versions of the tools.

Other comments made by students include: “how can we trust the system”, “limited inputs – some of my strategies cannot be tested in the simulator”. These comments demonstrate that students can sometimes have unrealistic expectations and their expectations on these aspects should be managed. Trust can be achieved by experimenting with the tools and interpreting the outcomes for any inconsistencies whereas not able to test their own strategies should be interpreted as a case of decision making under constrained situations.

Overall, the evidence collected supports the positive influence of the teaching method incorporating the simulation modelling tools on student experience and learning outcomes.

Identifying factors influencing use of simulation modelling tools
After having established the positive impact of the teaching method on student experience and learning outcomes, we analysed survey data collected in the second part of the survey questionnaire to identify the factors that contributed to the project outcomes.
Theoretical foundations

The second part of the survey instrument was developed based on the popular Information Systems adoption theory, known as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) which is used to measure people’s intention to accept and use technology. Since all students used the tools as part of the course, we are interested in determining factors that will influence “behavioural intention” (i.e. intention to use) and not actual “use behaviour” (i.e. actual use) as all students need to use the software for their studies. If we can identify the factors and influence them to a certain extent, then we can influence students’ intentions to use the simulation modelling tools in order to enhance their learning experience and outcome.

According to UTAUT, four key constructs that directly determine usage intention are: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). In our study, performance expectancy is the degree to which a student believes that using the simulation software tool will help him or her to benefit in learning performance. In the UTAUT model, performance expectancy is hypothesised to have a positive direct influence on behavioural intention.

Effort expectancy is the degree of ease associated with use of the simulation modelling tools. Since it is hypothesised to have a positive direct effect on behavioural intention, the easier the tools are to use, the better the chances for students to accept and use them. Social influence is the degree to which a student perceives that people of importance believe that he or she should use the simulation modelling tools. It is hypothesised to have a positive direct impact on behavioural intention. Facilitating conditions is the degree to which a student believes that existing school’s facilities and technical infrastructure support the use of the simulation modelling tools. Facilitating conditions are expected to have a positive direct impact on behavioural intention.

Following our previous experience with using UTAUT for measuring acceptance of technology (Le, 2011), we adapted the theory to include computer self-efficacy (SE) and computer anxiety (AX) since most of the students in the logistics course do not have an IT background and hence they may not be comfortable with the use of the simulation modelling tools. Self-efficacy is defined as people’s beliefs in their ability to influence events that affect their lives and is to be considered the foundation of human motivation, performance accomplishments, and emotional well-being (Bandura, 2010). Computer self-efficacy is hypothesised to have a positive impact on behavioural intention.

Computer anxiety is commonly defined as emotional fear, apprehension and phobia felt by individuals towards interactions with computers or towards the thought of using computers (Herdman, 1983; Howard & Smith, 1986). Computer anxiety is hypothesised to have a direct negative effect on the intention to use the simulation modelling tools.

We also collected demographic variables such as age, gender and level of computer experience from respondents and hypothesised the following:

1. Age has a positive effect on attitude (AT). Coding used for age groups were: 1 = 21-28 years, and 2 = 29-48 years
2. Gender has a positive effect on attitude (AT) since males are more inclined in applying technology. Coding used for gender were: 0 = female, 1 = male
3. Computer experience (CE) has a negative impact on anxiety (AX) and a positive impact on attitude (AT). Coding used for computer experience were; 1 = less than 1 year experience, 2 = 1 to 3 years, 3 = 4 to 6 years, 4 = 7 to 10 years, and 5 = greater than 10 years.

Figure 34 shows the modified UTAUT model with endogenous latent/ unobserved variables (or constructs) represented as ellipses and indicator/exogenous variables (i.e. survey questionnaire items used to measure the corresponding constructs) as rectangular boxes (the actual questions are shown in the questionnaire which can be found in Appendix G). Our hypothesis is that...
students’ attitude (AT) towards using the simulation modelling tools will be largely influenced by performance expectancy (PE), effort expectancy (EE), social influence (SI), computer self-efficacy (SE), computer anxiety (AX), age (A), gender (G), and computer experience (CE) while their intention (IN) to use the tools will be influenced by their attitude (AT) towards the tools and the facilitating conditions (FC) that are in place.

![Conceptual Acceptance Model](image)

**Figure 34: Conceptual Acceptance Model**

In addition to the direct impacts from the included latent variable, we also hypothesised that self-efficacy and computer experience will have negative impact on anxiety. By reducing the anxiety of the use of the simulation tools, self-efficacy and computer experience are assumed to have positive indirect impact on attitude and subsequently the intention to use the simulation tools.

**Statistical analysis using Structural Equation Modelling (SEM)**

In order to validate the formulated hypotheses and the conceptual acceptance model using a quantitative approach, we used structural equation modelling (SEM) to analyse the data collected by means of the survey questionnaire. SEM is a modelling procedure that assesses the inter-relationships among latent variables (unobserved variables). It has been used extensively in the IT acceptance literature, in particular, and in IS literature, in general, both under theoretical and empirical perspectives. We also used Partial Least Squares (PLS) analysis which is one of the statistical methods for structural equation modelling. SEM analysis was performed using the SmartPLS software (Ringle, Wende, & Will, 2005). A detailed explanation of the statistical analysis can be found in Appendix H.

When using SEM as a research method, the sample size is an important issue in estimating and interpreting the results (Hair, Black, Babin, Anderson, & Tatham, 2006). Boomsma (1983) suggested at least 100 responses, according to the rule-of-10, we need 310 responses (31 indicators x 10 responses per indicator (Flynn & Pearcy, 2001), and according to Hair et al. (2006) we need a minimum of at least 5 respondents (10 being most appropriate) for each estimated parameter. We require at least 50 responses to reliably use the chi-square test as a reasonable measure of fit (Boomsma, 1983). Only 22 students responded to the survey, and although the
small sample size does not permit the generation of accurate estimates for reliably interpreting the results, we can still gain valuable insights on the factors that influence the attitude and intention of students towards the modelling tools.

Results and discussion
After having checked the reliability and validity of the measuring instrument and deleted survey items that were not a reliable measure of the constructs they were supposed to measure, we obtained the model shown in Figure 35.

The resulting model from the SEM statistical analysis shows that most of the main constructs of the UTAUT model explained well the variance of the attitude about using the simulation tools (AT). However, the impact of attitude (AT) on intention to use (IN), was surprisingly not statistically significant. This could be the result of inconsistent responses from students regarding attitude and intention to use. Possible reasons for this inconsistency could be that the questions regarding to the intention to use were not relevant for the context studied and/or the small sample size of the survey.

The low degree of freedom of the t-test for the path coefficients reduced the chance to reject the null hypotheses. Hence, the path coefficients became statistically insignificant. However, this does not imply that attitude is not an important factor influencing the intention to use; this may simply be due to problems with the data collected. A larger sample is certainly needed to obtain more robust and reliable statistical results.

Facilitating conditions (FC) showed a strong and significant impact on intention to use (IN). Although we did not use the “Actual Use” UTAUT variable in our model (because we could not reliably measure it), we can thus predict that facilitating conditions will have a significant impact on the “Actual Use” variable if included. This implies that facilitating conditions will play an important role in adopting the new technology in practice. Besides the physical facilitating conditions such as computers, software, IT infrastructure accessibility, and the simulation tools; soft facilitating conditions such as introduction, demonstration, and training regarding the use and the usefulness of the tools are also very important for improving the usage of the tools by students in order to enhance their learning.
Overall, statistical analysis of the results showed that theoretical expectations were met in terms of expected relationships between the four key factors that determine students’ attitude towards the tools (AT) and then the intentions to use the models (IN) and enhance their learning outcomes. However, due to the small number of students participating in the survey, there is a need to obtain a larger sample size for re-estimating the model in order to generate statistical results that are more robust and reliable for making interpretations and deriving implications.

**Development of disciplinary and interdisciplinary linkages**

Another outcome of the project is the successful integration of knowledge and skills from a range of disciplines to build a software artifact to enhance learning and teaching. The disciplines from which knowledge were drawn are: Computer Science (simulation modelling, agent based modelling, software development, web site development), Computer Systems Engineering (hardware for GPS tracking systems), Information Systems (use of UTAUT for evaluation), Business Process Modelling (modelling and simulation of a distribution process), Design Science Research (designing, implementing, and evaluating the simulation modelling tools in a learning and teaching environment), Logistics (distribution), and education (learning theories).

The approach used in this study can be applied to the learning and teaching of other disciplines as similar techniques can be used to design, implement and evaluate simulation modelling tools in Management (e.g. strategic decision making), Economics and Finance (e.g. simulation of stock markets), Social Sciences (simulation of behaviour), Environmental Science (simulation of environment) etc. just to name a few. In fact, simulation modelling tools are especially useful for teaching complex systems where many variables are at play and simple cause and effect relationships cannot be used to explain the behaviour of the system. Employing modern technologies to build these tools, can provide an additive and immersive environment that enhances student experience and their learning outcomes using a learning-by-doing approach.

**Publication outcomes**


**4. Dissemination strategies and outputs**

The planned workshop has not yet been delivered since the analysis of the results were completed late last year and with most staff on annual leave at the beginning of this year, it was thought that it would better to present the findings at the start of semester 1 2012 to the school’s Learning and Teaching Committee meetings.

We are also planning to disseminate the simulation modelling tools to whoever wishes to use them. In particular, we intend to demonstrate them to Program Directors of the Bachelor of Business (L SCM) and Bachelor of Business (L SCM) (OUA) and discuss possible adoption of the tools within their programs at RMIT and RMIT Vietnam.

Since we have decided to make all the materials developed for this project (simulation modelling tools and teaching materials) publicly available on one of the School’s web servers, we shall promote the availability of such tools in various forums (e.g. School’s web site, etc.), colleagues from other universities and research papers.
However, due to the limited web resources of our School, we can only support a limited number of users at a time and for a limited time period. For larger scale and long term operation, we would like to hand over the system to others who are better equipped than us to do so.

5. Evaluation of project outcomes

The main aim of this project was to enhance student experience and learning outcomes in the course OMGT2087 Logistics Systems by developing a set of simulation modelling tools and accompanying teaching materials and incorporating them in the curriculum in semester 2 2011. The rationale for using simulation modelling tools in learning and teaching is that they provide a learning-by-doing environment and when appropriately implemented they also provide a challenging, interactive and engaging learning experience for students. From the data collected and analysed (discussed in the previous section), there is sufficient evidence to support the fact this objective was largely achieved by the project. Student experience was enhanced as students found the teaching method to be creative, they were motivated to complete the tasks assigned to them, they had “fun” using the tools and they even found the tools to be “addictive”. Learning outcomes were high given the grades achieved and the quality of submitted work.

Although the findings of this project are very encouraging, the project was only a first step in investigating the potential of simulation modelling tools in learning and teaching. More studies should be undertaken with a range of simulation modelling tools for teaching a variety of courses and evaluated with a variety of student cohorts in order to firmly establish its usefulness for enhancing student experience and improving learning outcomes.

Conceptual outcome: Design guidelines

Although the simulation modelling tools have the potential to motivate students to do better, just introducing them in a course will not necessarily produce the intended impact because the right conditions have to be put in place for this to happen. The tools must be incorporated within a well-designed teaching method with attention paid to the factors that will influence their use. In what follows next, we discuss how to address these factors in practice and we hope that the discussion will serve as guidelines for designing teaching methods that incorporate simulation modelling tools.

Performance expectations

It should be evident to students that using the tools will improve their learning outcomes (i.e. "performance expectations" must be met). This can be achieved by simulating a system or process of interest in the real world and described as a suitable business case for the course. The process should be of sufficient complexity such that a simulator is required to understand its operation. The tools are especially useful for teaching complex systems where many variables interact and simple cause and effect relationships cannot be used to explain the overall behaviour of the system. Simulation models are invaluable tools for simulating and evaluating scenarios and strategies since these can be easily implemented by manipulating model variables and simulation runs executed to collect and analyse metrics of interest. Experimenting with the simulation tools should enable students to grasp concepts quicker to obtain a fuller understanding of the concepts being taught and eventually increase their chances of getting a better grade in the course.

It is also important to manage students’ expectations given that they sometimes can have unrealistic expectations about the appearance and performance of the simulation modelling tools. It should be made clear to them that the purpose of a simulation model is not to replicate the real life system in every possible detail. Instead, a simulation model is a simplified abstraction of a real life system and the focus is only on a limited aspect mainly for learning purposes.

Effort expectancy

Another factor that should facilitate the uptake of the tools among students is the ease of use and convenience of access of the tools (i.e. “effort expectancy”). The tools should be intuitive to use and the “look-and-feel” should be similar to that of software generally used by students in the
course. Using web-based and mobile technologies should greatly facilitate the use and access of the tools.

Social influence
Since the “social influence” construct was also found to positively impact the attitude of students to use the tools, students should see the tools as an important part of the course. This can be achieved if course lecturers and tutors use the tools frequently and lead by example.

Facilitating conditions
“Facilitating conditions”, another construct that influences the use of the tools can be achieved in a variety of ways, namely: easy access using RMIT computers, online access, access from a mobile device, availability of a comprehensive user guide, interactive demonstrations by tutors, scaffolded teaching techniques for accelerating the acquisition of skills for operating the tools, assistance to students who have fallen behind, discussion forum for raising issues encountered and potential solutions, frequently asked questions (FAQ) and wiki pages, social media, etc. It is important to provide a good range of facilitating conditions such that the needs of a variety of students with diverse skills and capabilities are covered. Providing a range of facilitating conditions would also reduce any computer anxiety students may have.

Advantages of in-house implementation
Implementing a simulation model is a very demanding task requiring specialised knowledge and can be a very time consuming and expensive undertaking. Instead of using in-house built simulation modelling tools, it is possible to use commercial ones such as those available from Strategy Dynamics\(^1\) which are used for teaching strategic decision making. At present, not many such simulation modelling tools are available on the market as the main focus of vendors is to sell software that provides the necessary framework to create simulation models, i.e. they do not implement any model as this is left to the user to do so.

Simulation modelling tools built in-house have the advantage of being capable of high levels of customization to meet the precise requirements of the course being taught. Furthermore, highly sophisticated capabilities can be incorporated into the tools. Some examples are: tracking usage patterns by students, monitoring student progress and difficulties encountered, devising individual tutoring plans for students, integration with a learning analytics system, etc. just to name a few possibilities.

Although we are not the first for using simulation modelling in learning and teaching, we hope that our research has further established simulation modelling as a valuable tool for educational purposes. Our research has not only revealed the positive impact of the tools on student experience and learning outcomes, but factors influencing the adoption of the tools by students were also identified. We discussed how we took advantage of these factors in our project and we also established the guidelines for successfully implementing such tools in a course. Widespread usage of teaching methods based on these tools would not only benefit RMIT University but the whole educational sector as well.

\(^1\) http://www.strategydynamics.com/
6. Budget report

The expenditure incurred for this project is shown in Table 4 while Table 5 shows the expenditure against the approved budgeted categories.

Table 4: Financial statement

<table>
<thead>
<tr>
<th>YTD Actuals</th>
<th>Income</th>
<th>Total Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operating Expenses</td>
<td></td>
</tr>
<tr>
<td>511300</td>
<td>SALARIES- CASUAL ACADEMIC</td>
<td>5,905</td>
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<tr>
<td>511400</td>
<td>SALARIES- CASUAL GENERAL</td>
<td>8,612</td>
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<tr>
<td>Salaries</td>
<td>14,517</td>
<td></td>
</tr>
<tr>
<td>Salaries</td>
<td>14,517</td>
<td></td>
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<tr>
<td>521000</td>
<td>SUPERANNUATION- OTHERS ACADEMIC</td>
<td>625</td>
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<td>521350</td>
<td>SUPERANNUATION - OTHERS GENERAL</td>
<td>681</td>
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<tr>
<td>Superannuation &amp; Pension Schemes</td>
<td>1,306</td>
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<tr>
<td>523100</td>
<td>PAYROLL TAX- ACADEMIC</td>
<td>371</td>
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<td>523200</td>
<td>PAYROLL TAX- GENERAL</td>
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<td>Payroll Tax</td>
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<td>524100</td>
<td>WORKCOVER PREMIUM- ACADEMIC</td>
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<td>524200</td>
<td>WORKCOVER PREMIUM- GENERAL</td>
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<td>Workers Compensation</td>
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<td>Oncosts</td>
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<td>Total Salaries &amp; Oncosts</td>
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<td>555200</td>
<td>STUDENT MATERIALS</td>
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<td>Consumer Materials</td>
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<td>584501</td>
<td>EQUIPMENT&lt;$2000</td>
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<td>584502</td>
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<td>584550</td>
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<td>584700</td>
<td>SOFTWARE&lt;100,000</td>
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<tr>
<td>Minor Equipment, Repairs &amp; Hire</td>
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<td>551301</td>
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<td>INTERNAL EXPENSES-CONTRA</td>
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<td>Finance, Legal &amp; Other</td>
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<td>581750</td>
<td>STAFF DEV- NOT FBT</td>
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<td>Staff &amp; Student Related Expenses</td>
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<td>Total Other Operating Expenses</td>
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<td>Total Expenditure</td>
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<td>Operating Result</td>
<td>35,612</td>
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<tr>
<td>Total LTIF Budget</td>
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<tr>
<td>Balance</td>
<td>7,388-</td>
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</table>
Table 5: Statement of income and expenditure against budgeted categories

<table>
<thead>
<tr>
<th>LTIF Expenditure</th>
<th>Budgeted</th>
<th>Actual</th>
<th>Difference</th>
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<tbody>
<tr>
<td>Teaching/staff relief</td>
<td>$32,204.00</td>
<td>$17,241.66</td>
<td>-$14,962.34</td>
</tr>
<tr>
<td>Workshops</td>
<td>$500.00</td>
<td>$0.00</td>
<td>-$500.00</td>
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<tr>
<td>Simulation software</td>
<td>$4,874.00</td>
<td>$2,970.42</td>
<td>-$1,903.58</td>
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<tr>
<td>Computer programmer</td>
<td>$5,422.00</td>
<td>$9,977.90</td>
<td>$4,555.90</td>
</tr>
<tr>
<td>GPS tracking system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td>$4,000.00</td>
<td>$0.00</td>
<td>-$4,000.00</td>
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<td>Electronic components</td>
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<td>$5,421.72</td>
<td>$421.72</td>
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<tr>
<td>TOTAL</td>
<td>$43,000.00</td>
<td>$35,611.70</td>
<td>-$7,388.30</td>
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</tbody>
</table>

The budget for teaching relief was underspent because of the School’s policy for academic staff to teach at least 3 hours per week per semester and hence could not be fully utilised by one of the researchers involved. The workshop has not been held yet, and the software budget was underspent because of the approved decision to use open-source software and purchase technical books rather than using commercial software. The budget for the computer programmer was overspent because: (1) the left-over funds from the teaching relief item was re-allocated to hire a computer programmer to complete part of the work originally assigned to the researcher who could not claim the budgeted teaching relief, and (2) the increase in scope of the project and the intensive testing of the tools that had to be performed before release to students. Approval was obtained to re-allocate part of the unspent staff relief budget to build a GPS tracking system. The budget for the electronic components for building the GPS tracking system was slightly overspent while the labour budget was not utilised at all due to the inability of finding capable research assistants in November/December 2011.
7. References


Sweller, J. (2002). *Visualisation and instructional design*.


8. Appendices

- Appendix A: SiLT User guide
- Appendix B: Workbook 1 for Visualisation/Mapping workshop
- Appendix C: Workbook 2 for Simulation Modelling Workshop
- Appendix D: Assignment 1
- Appendix E: Ethics Approval
- Appendix F: Participant Information and Consent Form
- Appendix G: Survey Questionnaire
- Appendix H: Statistical Analysis Using Structural Equation Modelling