LEARNING ABOUT ECONOMIC VALUATION OF THE ENVIRONMENT USING ONLINE SIMULATIONS

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Abstract

While e-learning has been widely adopted in the tertiary education throughout the world, its use has been limited mainly to content delivery. Many of the possibilities to use e-learning to promote a 'deep learning', student-centred approach have been left unexploited. This paper reports on the use of an online simulation designed to promote these learning approaches and to attain higher level learning outcomes. The context is within an environmental economics upper-level undergraduate class at The University of Sydney, Australia. The learning task is to do with the effects of alternative willingness-to-pay (WTP) question formats on the elicited responses and the mean WTP estimates from a non-market economic method for valuation of an environmental asset. Students were asked to fill online surveys that corresponded to four different formats of the WTP question. The results from the survey were fed back to students online. To control for attainment of learning outcomes, a quiz was administered both pre- and post-survey. The results indicate that this online simulation enabled students to achieve higher level of thinking and comprehending, and has somewhat improved measurable learning outcomes.

Introduction and Background

E-learning is about improving teaching and learning through the application of instructional techniques and strategies that are enhanced by use of technology, in particular by computer and internet technologies (Waterhouse, 2005). This relatively novel development has been widely adopted in the tertiary education in Australia and throughout the world since early 2000s. The online Learning Management System at the University of Sydney has been in place in one or another form since 2001. The first e-learning site for the upper level undergraduate course in environmental economics, with which this paper is concerned, was designed and used in teaching in 2005. In the last four years the site was used mainly for delivery of content via various learning objects: lecture notes, supplementary readings, and worksheets. Some interaction with, and among students was fostered via discussions bulletins, but with limited success in drawing students into a wide ranging participation. Nevertheless, the user's statistics for the site are quite good, and the student evaluations indicate high level of student satisfaction with the e-learning site.

While the technology for e-learning was there, it was felt by the instructor — who is the author of this paper — that this technology has been of limited use especially in fostering student focused, “deep learning” approach (Biggs, 1999). Some evidence from the literature seems to suggest that this is likely the case with many course sites in various online Learning Management Systems (LMS), where the focus is on content delivery (Gibbs & Gosper, 2006). While many areas of the knowledge domain studied within the curriculum of the environmental economics course could be identified as quite challenging and conceptual in nature, and hence favouring more profound approaches to learning on the part of the students, it was found difficult to use the e-learning site to promote such approaches. There is some evidence that given student’s connectedness with online technologies in their everyday lives, this more profound deep learning approach might be better fostered through the use of e-learning, rather then through more traditional teaching and learning methods, mainly by facilitating student-centred learning (Waterhouse, 2005).

The author of this paper has been considering for some time how the e-learning site for the environmental economics course could be used better to promote student learning of some of the more challenging concepts and methods discussed in class. The idea, from which the work reported in this paper originated, first occurred in early 2008 as a result of discussion with a colleague that has peer-reviewed teaching in this course. It emerged through that discussion that some of the functionality on the University’s online Learning Management System, such as online quizzes and surveys could be used to create an online simulation in which students would participate directly. The results derived from this online simulation could be used to further illuminate the material studied in class, and to provide an opportunity for experiential learning to students. This would then hopefully enable students to achieve higher level of learning outcomes, as described by the revised Bloom’s taxonomy (Krathwohl, 2002). Such online simulation was planned and designed in the first few months of 2009, and it was conducted during Semester 1 of 2009, in early April.

This paper reports on the educational literature describing the theoretical fundamentals that helped planning and designing the online simulation. It also explains the purpose of the online simulation and describes the way the simulation was put in place. The paper reports the outcomes from the online simulation, as well as from the pre- and post-simulation quizzes that were used to gauge student learning that occurred as a result of the simulation.

Theory and Prior Literature

The literature on the theory and practice of e-learning has seen rapid expansion in recent time. While the majority of published work reports on particular applications of e-learning, several recent articles have focused on the theoretical aspects of e-learning. Nichols (2003) calls for greater role of educational, and the more general cognitive theories in shaping the future of e-learning. That article emanates the message that e-learning should be treated as another, albeit powerful tool in the educational toolbox that helps teachers help students learn (Ramsden, 2003). The advent of the new technology that can be used in teaching and learning will not, in and of itself, result with a breakthrough in student learning. The instructors will need to cleverly use this technology to promote better achievement of the planned learning objectives. Thus, e-learning is not about what student learn, but how (and presumably how much) they learn. While the new technology offers opportunity for improved learning outcomes, such outcomes will not occur simply by adopting an LMS as a part of the course, which has been a tendency by most instructors, including the author of the present paper. Achieving improved learning outcomes will require designing learning activities within the LMS that will be conducive to 'deep learning' on the part of students. For example, the concept of simulative interactivity, where student can learn from their own choices through feedback, can be used to design such learning activities. This learning process will promote experiential, student-centred learning that has been shown to result in superior learning outcomes. Even though designing these learning activities might put additional strain on already overstretched instructors in the tertiary sector, it might prove a very worthwhile 'investment' into student learning.

This need for greater engagement of educational designers and instructors with the LMS at a more profound level is also recognised by Gibbs and Gosper (2006). They distinguish between e-learning driven by content delivery imperatives, and e-learning driven by imperatives for improved learning outcomes. The usual and most prevalent use of e-learning has been in the delivery of content-centric instruction which is consistent with the transmission model of learning (Prosser & Trigwell, 1999). This model is implying teacher-centred learning, where the teacher unilaterally transmits knowledge to students, and students are in turn expected to be able to reproduce this knowledge. Literature on cognitive theory and educational research suggests that this model of learning is probably not the most desirable for achieving high quality learning outcomes, as it keeps the student a passive object exposed to teaching, rather than being actively learning participant (Prosser & Trigwell, 1999). The alternative interpretivist and critical models of learning (Cohen et al., 2004) are viewing the learner (student) as an active participant and contributor in the learning process, as opposed to merely being a passive recipient and acquirer of knowledge. For e-learning to take a full advantage of its potential, it will have to make a transition from mainly delivery oriented tool, to a learning tool that helps students learn better.

The importance of experiential learning where students are able to learn by interacting with, and within, a learning environment (in class or online) that has been created by the instructor was highlighted by Laurillard (1993). In a current context, the online simulation is used to enhance a student-centred experiential learning, which fosters the capability of students to combine the learning that occurs as a result of traditional teaching/learning practices (lectures and readings) with learning that occurs through students' own activities and experiences. The links that are developed between the transmissive and the experiential components of learning allow students to learn by reflecting on their new understandings. This is a key to the practical application of another important characteristic of e-learning: its ability to transform the learning from a teacher-centered activity to a student-centred one. In a student-centred e-learning environment, such as the one that was created by designing the online simulation activity presented in this paper, students are enabled to take greater responsibility for their own learning, and they become actively engaged in the learning process (Waterhouse, 2005).

Context and Method

The learning task that was a subject of the online simulation reported in this paper is related to the methods of economic valuation of environmental and natural resource assets. Such economic valuation typically involves asking respondents how much they are willing-to-pay for preservation of environmental assets (e.g. How much are you willing-to-pay for preserving the Great Barrier Reef in Australia, or the Grand Canyon in the USA?). The purpose of asking this type of questions is to elicit the values that people place on these environmental assets. As those values can not be expressed through usual market behaviour — since markets for environmental assets typically do not exist — non-market valuation techniques have to be used. These non-market values are different from usual economic quantities, since they represent things that are not bought and sold on the market (one cannot simply purchase a given quantity of preservation for the Great Barrier Reef!), and hence intentions of behaviour under various environmental circumstances have to be stated by people (and hence the name 'stated preference methods' that is often used in environmental economics scholarly literature). The intentions of behaviour are elicited by administering surveys that are used to collect information on various characteristics of the respondents, such as income, age, gender, socio-economic status, as well as to ask a willingness-to-pay (WTP) question.

There are several different ways of how this question might be asked. Most commonly used types of WTP question are: **an open-ended question** — where respondents are simply asked to state their WTP by filling an amount in the blank provided at the end of the question (e.g. How much are you willing to pay for the protection of the Great Barrier Reef? _______ $ / year); **dichotomous choice** — where respondents are asked to accept (respond 'yes') or reject (respond 'no') a given value for the WTP (e.g. Are you willing to pay $150 / year for the protection of the Great Barrier Reef? Yes or No.); **iterative bidding (or n-bounded dichotomous choice)** — where a dichotomous choice question is initially asked, and then another dichotomous choice question with an increased amount (if the response to the first question was 'yes') or decreased amount (if the response to the first question was 'no') is asked (e.g. Are you willing to pay $150 / year for the protection of the Great Barrier Reef? Yes or No; If 'Yes', than ask: Are you willing to pay $300 / year for the protection of the Great Barrier Reef?; If 'No', than ask: Are you willing to pay $50 / year for the protection of the Great Barrier Reef?) Iterations of this type can be repeated many times; **payment list (or card)** — where respondents are presented with a list of amounts, and are asked to circle one (e.g. How much you are willing to pay for the protection of the Great Barrier Reef? Please circle one of the following: $0, $25, $50, $75, $100, $150, $200, $250, $300).

Subsequent to conducting the surveys, where the willingness-to-pay is elicited from the respondents, the collected information is arranged in data sets. The data sets are then subject to statistical procedures designed to derive mean willingness-to-pay, as an indication of the demand that respondents have for the valued environmental asset. The mean WTP is subsequently aggregated across the relevant population to obtain a monetary value for the environmental asset of interest. Sometimes very different monetary values are obtained dependent on the type of question format used in the survey. This is due to various biases introduced by the design features of the survey, and by other psychological phenomena (e.g. protest responses, anchoring, yay-saying) that are introduced by each particular way of asking the WTP question (Bateman et al., 2002). It is very important that practitioners who conduct these kind of environmental valuation studies have clear understanding of the influence that question format might have on elicited final monetary values. Consequently, it is crucial that students of environmental economics, who are likely to become practitioners in environmental valuation, develop that understanding during their undergraduate studies.

However, teaching and learning about the causes of the discrepancy in the estimated values for environmental assets that might be caused by different question formats, and about how exactly people's stated preferences change in response to changing question format, is challenging for both the instructor and the students. For the instructor, it might be tempting to adopt the transmission model of teaching, where the causes and the outcomes from asking alternative question formats are being 'told' to students, which might be supplemented by assigning relevant readings. Similarly, students may tend to adopt a 'surface' learning approach that will constitute of just memorising the alternative type of question formats, and simply knowing that they can influence the outcome, without understanding the key causes and the full mechanisms of this occurring. This might result in learning outcomes that correspond only with the less sophisticated levels of cognitive behaviour according to the Bloom's taxonomy (Waterhouse, 2005). Ultimately this may lead to professionals in environmental valuation not being able to design surveys that will adequately represent the respondents' valuation of environmental assets.

To promote students' deep learning approach towards this learning task in the environmental economics course, it was decided to make use of the functionality offered by the course e-learning site, by designing an online simulation where students themselves would be asked to respond to the WTP questions of varying type. In 2009, the size of the environmental economics class was 53 students. Students were split into four groups, corresponding to the four types of WTP question formats. Questions similar to the examples given above, and using the Great Barrier Reef as an environmental asset to be valued were designed as a survey on the course e-learning site. This site is a part of The University of Sydney's LMS CE6 that is based on WebCT. Each survey containing a specific type of WTP question was assigned to one group of students, who were then given a window of three days to respond to the survey online.

The data collected through this activity were used to calculate the mean WTP for the environmental asset (the Great Barrier Reef in this case). The mean WTP was calculated using non-parametric statistical techniques, based on estimating a survivor function (Bateman et al., 2002). The calculated value was then fed back to students online. The students were then asked to reflect on the effect that their own choices in completing the online survey had on the estimates of the resulting value for the mean WTP. This in effect provided simulative interactivity, and helped students' learning process by allowing them to explore directly the results from their own survey responses.

To control for the attainment of learning outcomes, an online quiz containing four multiple choice questions about the role of alternative WTP question formats on the results from a non-market valuation study was administered before and after the survey. The students were initially asked to complete the quiz immediately after the lecture that dealt with this topic in class. No marks were given to students, but their responses were recorded online. The following day, the students were asked to fill in the survey, with the actual willingness-to-pay question. After the survey was completed and the data were used to produce estimates of the mean

WTP for the environmental asset, the results from the survey were posted online and students were asked to look at those results. This happened within one day of surveys being completed. After they had two days to look and reflect at the results that came from the surveys, the students were asked to complete the same online quiz that they completed prior to completing the survey. It was expected that the proportion of correct answers will be higher on the post-survey quiz compared to the pre-survey quiz. In some sense the quiz served as a 'control' for the learning outcome, and the completion of the survey was a 'treatment'. This was an attempt to measure the effects of this online simulation on student learning.

Results and Findings

The results are presented in terms of student responses to pre-survey quiz, in terms of the mean WTP estimates and the descriptive statistics of student responses obtained from the online surveys, and in terms of student responses to post-survey quiz.

Pre-survey Quiz

Out of fifty three students taking this course, thirty seven completed the pre-survey quiz. The maximum possible score on the quiz was 40, and the minimum was zero. The descriptive statistics of the student scores are given in Table 1.

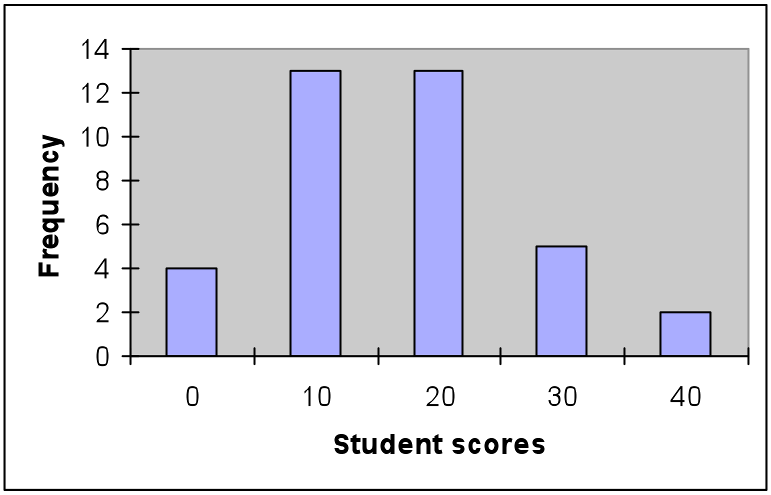
Table 1: Descriptive Statistics of Student Scores on the Pre-survey Quiz

Count	37
Mean	16.76
Standard Error	1.69
Median	20
Mode	10
Standard Deviation	10.29
Range	40
Minimum	0
Maximum	40

These statistics show that the mean correct response was less than 50%, which indicates that students did not do so well on this quiz, and might indicate only limited achievement of the learning outcomes for the studied concept.

The histogram of the frequency distribution of student scores is provided in Figure 1.

Figure 1: Frequency Distribution of Student Scores on the Pre-survey Quiz



Inspection of the histogram also reveals that the largest number of students was only able to provide half or less correct responses to the quiz questions, which again indicates very limited attainment of learning outcomes. It is interesting to note that while only two students have achieved 100% correct responses, four have achieved 0%.

Survey Results

The results from the analysis of the survey responses are presented in Table 2. The same table was used to communicate the results to students online.

Table 2: Results from an Analysis of Survey Responses to Four Types of WTP Questions

	WTP question format				
	Open Ended	Open Ended w/o outlying $1000 bid	Dichotomous Choice	Iterative bidding	Payment List
No of responses	11	10	16	9	8
Response rate	0.92	0.83	0.67*	0.75	0.67
Min bid accepted /stated	$20	$20	$50	$0	$0
Max bid accepted /stated	$1,000	$400	$300	$300	$150
Mean WTP	$196.40	$118	$175	$116.70	$62.60

* The response rate for dichotomous choice reflects the larger size of the sample for this question format due to the need to elicit responses to multiple bid levels (three in this case)

The results show high participation rate of student in the online survey, which is relatively consistent across the groups that were responding to the different WTP question formats. The results also show the wide discrepancy in the minimum and maximum bids — WTP values that were either stated (open-ended question format) or accepted (other formats) by the respondents — across the four different question formats. This discrepancy is also reflected in the estimates of the mean WTP. As expected and as widely reported in environmental economics literature, open ended question format resulted with an apparent 'outlier' bid (a bid that is unusually high) of a $1000. This single 'outlier' bid was responsible for a large portion of the estimated mean WTP for this question format, which came markedly down when this 'outlier' was removed from the data.

An unexpected observation is that 'open ended' format had the highest response rate, and that there were no zero bids stated (so called protest bids). The dichotomous choice was the question format that expectedly produced the highest estimate for the mean WTP, after correcting for the outlier in the 'open ended' question format. For the iterative bidding question format, the final estimate of the mean WTP reflects the starting point bias (the starting point was $150). The payment list format was the most surprising, with a relatively low response rate, a couple of zero bids, and the lowest maximum bid. The former two characteristics are usually typical for open ended questions.

These results were provided to students online immediately after the surveys were completed. Students were given one day to look at these results and reflect on them. On the second day, they were asked to complete the post-survey quiz. This quiz contained the same questions as the pre-survey quiz, and in addition contained a space where students could put their comments and observations in relation to the survey results.

Post-survey Quiz

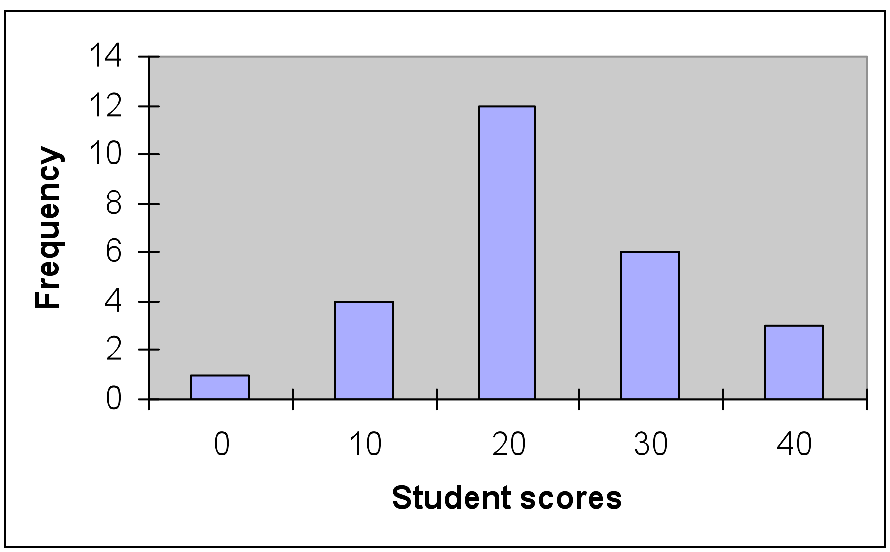
The post-survey quiz was completed by twenty six students out of the fifty three enrolled. Most respondents to the post-survey quiz were the same as the respondents of the pre-survey quiz. As in the pre-survey quiz, the maximum possible score on the quiz was 40, and the minimum was zero. Individual student scores were weighted by the score obtained on the fifth question in the post-survey quiz, which did not exist in the pre-survey quiz. This question asked students to reflect on their learning through the on-line survey. It was framed as follows: "In the space provided below please state any reflections and inference that you had while looking at the survey results. Have you noticed something that surprised you? Have you noticed something that reaffirmed your understanding?" The quality of responses to this question was graded based on the descriptive criteria for grading for the whole course, with which students were familiar. This grade was then used to weigh the answers to the other four questions. The descriptive statistics of the weighted student scores from the post-survey quiz are given in Table 3.

Table 3: Descriptive Statistics of Student Scores on the Post-survey Quiz

Count	26
Mean	19.35
Standard error	1.96
Median	20
Mode	20
Standard Deviation	10.01
Range	40
Minimum	0
Maximum	40

Compared to the results from the pre-survey quiz the mean correct response was much closer to the 50% mark, but does not indicate an overwhelming change in student learning outcome. The paired t-test for the difference in means between the responses to the two quizzes does not indicate statistical significance at the conventional levels (p-value = 0.32). Part of this can be explained by the lower participation rate in the post-survey quiz, and another part can be explained by several unusual results from the online survey, as discussed above. Nevertheless, the histogram of the responses from the post-survey quiz indicates some improvement in attainment of learning outcomes. It is presented in Figure 2.

Figure 2: Frequency Distribution of Student Scores on the Post-survey Quiz



The histogram indicates improvement at the two extremes of the distribution — only a single 0% correct response, compared to four 0% responses in the pre-survey quiz, and three 100% correct responses compared to two in the pre-survey quiz. In addition, significantly larger proportion of the students achieved 50% or more correct responses in the post-survey quiz than in the pre-survey quiz. This indicates that the completing of the online survey has increased student understanding of the learning task, and has increased somewhat the attainment of learning outcomes.

Conclusion

E-learning has been present in the higher education for some time, but its use has been largely reserved for online content delivery. To promote the use of e-learning for attaining better quality student learning outcomes, the educational designers and instructors will have to come up with specific online learning activities that will foster a student-centred, deep learning approach on the part of students. One such activity, an online simulation where students were asked to respond to a willingness-to-pay survey for an environmental asset was reported in this paper. This activity in the context of an upper level undergraduate environmental economics course at The University of Sydney was conceived out of dissatisfaction of the author of this paper with the way the e-learning site for this course was used over several years. The results presented in this paper suggest that students improved their learning through the use of this ‘experiential learning’ tool, albeit not at any spectacular rate. While various explanations can be offered for the modest improvement of learning outcomes, it seems that the process of learning is too complex to be accurately controlled by pre- and post- learning activity assessments, as attempted in this paper. As the learning in the course that was the subject of this paper is ongoing (the course concludes in June, 2009), continuous monitoring of learning outcomes will be applied to identify any further expected positive impacts from this online simulation. Assessing and quantifying the improvement in learning outcomes as a result of improved use of the e-learning site will be necessary in order to be able to justify the considerable extra commitment in planning, preparing and conducting online learning activities on the part of instructor.

The findings of this paper are in line with the previous published work indicating that the use of e-learning in tertiary education can be beneficial. There is no doubt that e-learning has a great potential to be effectively used in teaching that helps student learning. However, how to most effectively use it and whether its use is worthwhile — taking all costs and benefits into account— remain important questions that warrant further scholarly inquiry.

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