STUDENTS' EXPERIENCES AND PERCEPTIONS OF USING A VIRTUAL ENVIRONMENT FOR PROJECT-BASED ASSESSMENT IN AN ONLINE INTRODUCTORY STATISTICS COURSE

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This paper evaluated students' experiences and perceptions of using an online simulated virtual environment, known as the Island, for project-based work within an online master's level introductory statistics course. Forty-two students responded to an Island questionnaire which rated their level of agreement to three aspects of using the Island - engagement, *ease of use* and *contributes to understanding. Students were also asked to provide qualitative comments and five students participated in semi-structured interviews. Qualitative feedback was analysed to help explain the results from the quantitative questionnaire. In conclusion, perceptions of the use of the Island for project-based assessment were very positive. Qualitative feedback provided insight into how the Island may help to develop students' statistical thinking.*

INTRODUCTION

Students learn by doing. This is a view advocated by the statistics education reform movement (GAISE, 2005) and statistics instructors alike (Griffiths & Sheppard, 2010; Holmes, 2002). Learning by doing is consistent with Kolb's experiential learning model where learning is defined as "the process by which knowledge is created through the transformation of experience" (Kolb, 1984, p. 38). Kolb's theory can be viewed from the broader "constructionist" view of learning where students learn by constructing knowledge, not through the passive transmission of information from instructor to student (Garfield, 1995). Learning by doing or "active participation" in learning is argued to better engage students and ultimately result in improved learning outcomes (GAISE, 2005; Garfield & Ben-Zvi, 2007). Actively engaging students in learning statistics has been greatly enhanced by the use of non-traditional assessment practices and innovative technology.

The statistics education reform movement changed the focus on methods of assessment away from traditional exams and hand calculations towards more diverse assessment which promotes active participation. Examples include projects, group work, portfolios, concept-maps, critiques of news reports and case studies (Garfield & Gal, 1999). Semester long projects can be effectively used to provide authentic assessment by requiring students to apply statistical knowledge to real-world research problems (Chance, 1997). These types of projects are argued to help develop students' *statistical thinking* (MacGillivray, 2010; Snee, 1993). Statistical thinking can be briefly defined as the ability to apply statistical concepts and procedures to investigate a topic within a specific context (Chance, 2002). Incorporating project-based work into statistics courses has been reported to positively impact student involvement, learning and course satisfaction (e.g. Chance, 1997; Smith, 1998). However, others warn that providing project topics that all students embrace is difficult (Griffiths & Sheppard, 2010). Large classes present even greater challenges (Bulmer & Haladyn, 2011). Providing students with projects that are individualised, practical, ethical, engaging, authentic, and based on the real-world is all too often beyond an instructor's capability. Fortunately, recent technology advances in statistics education may help address these challenges.

The use of technology can also help students get actively involved in learning about statistics. A wide range of technologies have been implemented in statistics courses to help improve learning (Chance, Ben-Zvi, Garfield, & Medina, 2007) and wide-spread accessibility of cheap computing power is making statistics educational technology more and more accessible. Examples of these technologies include statistical software packages, educational software, applets, spreadsheets, graphical calculators, multimedia material and data repositories (see Chance, 2007 for a review). A recent innovation includes the development of an online virtual environment, known as the *Island*, for simulating scientific research design and data collection (Bulmer, 2010,

2011; Bulmer & Haladyn, 2011). The *Island* was designed specifically to address the challenges of delivering individualised, authentic, real-world and engaging projects with the constraints of large introductory statistics courses (Bulmer, 2010, 2011).

The *Island* is a freely available online virtual environment developed by Bulmer (2010, 2011,) and Bulmer and Haladyn (2011). Students access and interact with the *Island* via a secure website interface (http://island.maths.uq.edu.au, request a login by emailing mailto:island@maths.uq.edu.au). Behind the website runs a complex, real-time, and realistic human population simulation. The *Island* is inhabited with virtual "Islanders" who each have their own unique name, personal history and virtual avatar. These Islanders can be sampled and recruited for the purpose of scientific research by navigating between the 39 villages. The estimated population of the *Island* at time of publishing is in excess of 9,000. Approximately 15,000 Islanders have existed (both living and dead) over the 240-year history of the simulation. The open-ended nature of the *Island* allows for the design and implementation of wide variety of research designs including surveys, observational studies, case-control studies, correlational studies and experiments. There is a diverse range of potential research topics with the inclusion of over 200 variables including tasks (e.g. taking blood pressure, ingesting aspirin, running 100 meters), survey items (e.g. "How anxious do you feel right now?"), demographic information (e.g. age, gender, residency) and medical records (e.g. smoking history, disease diagnosis). The *Island* has also been designed to give students a realistic research experience. Islanders may refuse consent, drop out during an experiment, lie about their age, get sick or fall asleep late at night.

While virtual simulation software aimed at enhancing student learning has been used in a wide variety of disciplines (Spinello & Fischbach, 2004; Stafford, Goodenough, & Davies, 2010), the *Island* is a relatively new instalment for statistics education and distinguishes itself with its ambitious aim to simulate an entire human population for the purpose of delivering project-based assessment in large classes. While Bulmer (2010) reported positive student feedback using the *Island* in a large introductory statistics courses and Linden and Baglin (2011) reported similar results from a course in the design and management of clinical trials, a continued effort must be made to further validate these findings in other education contexts.

The aim of this study was to evaluate student perceptions and experiences of using the *Island* for semester long projects designed to develop and assess statistical thinking in an online introductory statistics course for masters' students. While this is an indirect method for evaluating the effectiveness of the *Island* for project-based work, it does serve as an important initial step that future research can build upon.

THE COURSE

The course in this study is an online introductory biostatistics course. It is largely taken by Masters of Laboratory Medicine students, a majority of which are international temporary on-shore students. Other students that typically enrol in the course include students from Master of Statistics and Operations Research, Medical Science and Biotechnology. The course has been growing in popularity over the years. Masters students, who often have family and work commitments, are attracted by the flexibility of the online delivery. The course covers the usual introductory topics including descriptive statistics, probability, estimation, one-sample inference, two-sample inference, categorical data, non-parametrics, correlation and regression, basic epidemiology and one-way ANOVA. The course assessment is broken up into three parts: weekly on-going assessment, online tests and a major course project. The on-going assessment (10%) consists of weekly exercise submissions to ensure students are working through weekly content. The tests, which make up 60% of the course grade, involve a mid-semester test (15%), late semester test (15%) and final test during the exam period (30%).

In the years prior to 2011, the projects (30%) required students to find available data sets, either from their workplace or the internet, in order to complete a project demonstrating the application of a statistical procedure covered in the course. The inclusion of these projects aimed to enhance student's statistical thinking by getting them to "do" statistics. The project was split between a research proposal due mid semester (5%) and development of a project presentation summary slideshow due at the end of the semester (25%). Students had the option to audio or video record commentary to the presentation. Only a few students did so. Project presentations were

marked utilising a rubric which rated students on levels of achievement (unacceptable, needs improvement, good and superior) across the following five criteria: 1) Topic Background, Rationale and Research Question, 2) Method, 3) Statistical Analysis and Presentation of Results, 4) Discussion and Conclusion, 5) Professionalism.

Project-based work prior to 2011 had been problematic. Approximately half of the students each semester were unable to find suitable data sets. To avoid disadvantaging these students, a number of pre-existing large biomedical data sets were provided. This created issues with authenticity, the possibility of collusion, and poor student engagement. By using pre-existing data, the students were also missing out on the planning and gathering stage of data collection - an important step that statistical thinkers must grasp. A better approach would involve conducting scientific research from the ground-up, from planning right through to data collection, analysis and reporting. However, doing so within the constraints of the online course was inconceivable prior to the *Island.*

Island-based projects replaced the pre-existing projects in both semesters of 2011. While students were still allowed to analyse data from their workplaces, this was only allowed with permission from the course lecturer. Remarkably, only one-student in 2011 took up this offer. The *Island*-based projects required students to investigate a research topic of their choosing in order to demonstrate the application of a statistical technique covered in the course. The *Island* gave students access to an environment allowing them to choose from a large variety of topics whilst ensuring that each student's data was individualised and available online. The *Island*-based projects would also give students the experience of conducting an entire cycle of a simulated scientific study. Examples of the topics chosen by students are listed in Table 1. The topic diversity reflects a large degree of variability in what students perceived answerable in light of the data available. A wide variety of research designs were employed, including correlational, observational and experimental designs.

Table 1. Eight Examples of Student Project Topics

Project Title
Short Term Effects of Caffeine from Cola on Mental Acuity
Murder and Relationship Instability
The Effects of Eating Habits on Blood Pressure in Adults
The Relationship Between Sleep and Wellbeing
Association between Blood Type and Disease Mortality
Comparison of Natural and Synthetic Insulin
The Effect of Cocoa on Sensory Memory
Effect of Exercise on Anxiety and Endorphin Levels

METHOD

A sample of 42 students from the Semester 1 and 2, 2011 iterations of the introductory biostatistics course participated in the evaluation of the *Island* project-based assessment. The participation rate across the semesters was 18/35 (51%) for first semester and 24/43 (56%) for second semester. Sample characteristics are shown in Table 2. The sample was mostly on-shore international, mature-aged-students studying full-time.

An explanatory sequential mixed methods approach was used for evaluating student perceptions (Creswell & Plano Clark, 2011). This type of design involves gathering quantitative data first and then following up with qualitative methods to explain the quantitative results. In the quantitative phase of the research, students responded to an 18-item online questionnaire designed to evaluate student perceptions of using the *Island*. Three specific aspects of using the *Island* were assessed using this questionnaire - *engagement*, *ease of use* and *contributes to understanding*. Each item was responded to on a seven point Likert scale ranging from (1) strongly disagree to (7) strongly agree. Agreement to an item was defined as a participant scoring an item as a 5, 6, or 7. Reliability of each subscale was measured using Cronbach's α which found that $\alpha = .79$, .62 and .90 for engagement, ease of use and contributes to understanding respectively.

Table 2. Introductory Biostatistics Course Sample Characteristics

		M ± SD	N
Age		29 ± 4	42
		Count	%
Gender	Male	15	35.7%
	Female	27	64.3%
Semester	Semester 1	18	42.9%
	Semester 2	24	57.1%
Residency	International	28	66.7%
	Domestic	14	33.3%
Study Load	Full-time	33	78.6%
	Part-time	9	21.4%

Following the quantitative questionnaire, two open-ended questions were included for qualitative feedback. These questions were (1) "Share at least one positive experience of using the *Island*" and (2) "Was there anything that you did not like about using the *Island* or you think needs improvement?" The second, qualitative phase used qualitative comments given in the questionnaire and five semi-structured in-depth interviews to assist in explaining the results of the quantitative questionnaire. The interviews were conducted over telephone with five volunteer students. Qualitative comments and interview data were analysed using thematic analysis (Braun & Clarke, 2006). This method involved six steps: data familiarisation, initial coding, theme searching, theme revision, theme definition and naming, and reporting.

RESULTS AND DISCUSSION

The descriptive statistics of the quantitative responses to the *Island* questionnaire are shown in Table 3. These quantitative results will be discussed alongside themes identified in the qualitative thematic analysis that help explain and expand upon the forced-choice responses. The themes will be discussed around the three domains of the *Island* questionnaire.

The results from the *Island* Questionnaire showed a remarkable overall positive perception of using the *Island* for course projects (Table 1). For example, 38/42 (90.5%) of students agreed that using the *Island* for projects was an overall positive experience. Qualitatively, when eliciting from students the reasons behind the positive experience, the major theme that emerged was the *Island's* ability to immerse students. Two major themes emerged to explain this engagement – *realism* and *contextualisation*. By far the most powerful feature of the *Island* that appeared to immerse students was the *Island*'s realism, "*It feels like a real Island*". The realism was aided by the *Island*'s open-endedness. Students appreciated the wide range of tasks available that allowed them to individualise their project topics, although some students requested further additions. Students also liked how Islanders realistically reacted to various treatments which were the topic of their scientific studies, "*It was fun to see how individual 'islanders' reacted to the various tasks, and the selection of tasks available was extensive.*"

The *Island's* ability to contextualise the theory being covered in the course was also a very powerful way to captivate students. One student summarised this perfectly as follows:

> "*I didn't enjoy [Introductory Biostatistics] (I found it a chore) until we got to the Island: Suddenly I had a problem, and to solve it I had to learn about study design, sampling and sample sizes, statistical power, statistical methods etc. It was no longer a chore, but a mission.*"

This student may otherwise never have been engaged in the course had it not been for the use of *Island*-based projects. This finding suggests that engagement with the *Island* may have flow-on benefits to other aspects of the course.

Table 3. *Island* Questionnaire Descriptive Statistics (Both Semesters Combined)

Items	*M*	*SD*	Agree	%	*N*
Engagement (Cronbach's α = .79)					
Enjoyed using for project	5.93	1.02	40	95.2%	42
Enjoyed being in control of virtual study	5.71	1.11	37	88.1%	42
Did not enjoy using for projects (R)	2.43	1.40	5	11.9%	42
Felt immersed in virtual study	4.86	1.32	25	59.5%	42
Recommend to other students	5.71	1.38	36	85.7%	42
Positive experience overall	5.88	1.38	38	90.5%	42
Ease of Use (Cronbach's α = .62)					
Easy to use	5.62	1.21	39	92.9%	42
Difficult to use (R)	3.48	1.80	11	26.2%	42
Learning to use was difficult (R)	2.21	1.26	4	9.5%	42
More instructions needed (R)	4.45	1.80	24	57.1%	42
Easy to conduct virtual scientific studies	5.48	1.29	34	81.0%	42
Contributes to Understanding (Cronbach's α = .90)					
Better understanding of scientific research design	5.43	1.33	33	78.6%	42
Appreciation for practical consideration of scientific research	5.55	1.31	35	83.3%	42
Improved understanding of how data is collected	5.43	1.40	33	78.6%	42
Better understanding of statistical analysis in scientific research design	5.50	1.44	35	83.3%	42
Improved confidence with design, implementation and analysis of scientific studies	5.31	1.39	33	78.6%	42
Experience with statistical issues that arise during research	5.76	1.30	36	85.7%	42
Improved understanding of how scientific studies are analysed	5.74	1.25	36	85.7%	42

Note. R = reversed item

In terms of ease of use, there were some mixed perceptions. While students felt the *Island* was relatively easy to use (39/42, 92.9%), conflictingly, about a quarter (11/42, 26.2%) of students also reported that the *Island* was difficult to use. The fact that most students agreed that more instructions were needed (24/42, 57.1%) provides some explanation for this inconsistency. However, qualitative themes offered further explanation. Students agreed that using the *Island* made conducting scientific studies possible within the course, "*Using the Island I had the opportunity to conduct a full research without having the classical real problems which normally interfere with it (like costs and time)*". This theme related to ease of use was called labelled *facilitates virtual studies*. On the other hand, a second theme, *time inconvenience*, revealed students felt that aspects of using the *Island* were too time consuming, "*Having to wait in 'real time' for data gathering is a bit frustrating - a bit too realistic!.*" Others suggested ways to overcome this by using task automation, "*It would have been great if we could schedule tasks in advance and the islanders then carry them out as per the schedule. It took me a lot of time having to manually instruct islanders to carry out a regular task.*" A few students also criticized the Islander's sleeping patterns, "*It took a very long time to administer the tasks I wanted, especially when islanders go to sleep at around 10.30pm!*". In summary, students felt that the *Island* made research a virtual reality; however, certain aspects of using the *Island* were perceived as being an unnecessary time nuisance.

Bulmer and Haladyn (2011) explains that the *Island*'s ease of use is limited in many ways, but only by deliberate design. Bulmer and Haladyn wanted the *Island* to not only simulate a human population, but also simulate what it is like to conduct scientific research. They wanted students to experience recruitment, sampling, experimentation, data collection, data entry and statistical analysis. While they are quick to point out that *Island* research is still far easier than real world research, they do contend that the *Island* acts as an intermediate method of connecting research with statistical analysis. In the authors' opinion it would be a disservice to students to build the expectation that data collection is convenient and instantaneous. It would degrade the real world experience aspect of the *Island*. Regardless, instructors, whom are probably all too aware, should anticipate that some students will not relish the hard work of gathering realistically simulated data.

Overall, there was vast agreement in students' perception that project-based work on the *Island* had a positive impact on students' understanding of scientific research design, data collection, and statistical analysis, i.e. their statistical thinking. Encouragingly, 36/42 (85.7%) of students agreed that using the *Island* for project-based work had improved their understanding of how scientific studies are analysed. Qualitative responses provided clues as to how the *Island*-based projects may have assisted. Many respondents expressed the view that the *Island*-based projects improved their understanding by putting statistical analysis within a context or by helping them to "*apply what has been learnt*". This sub-theme of contributes to understanding was labelled *learning by doing*. The projects also helped students in thinking about the bigger picture of statistics in scientific research, "*It gave a whole rounded picture of the collection of your data set*". The *Island* gave them an appreciation for practical issues, e.g. time, and the difficulties that can arise. The *Island* helped put statistical analysis in perspective and in doing so, students seemed to gain a deeper understanding, "*I got a chance to understand my statistics and I used what I've learned on the Island. I think it is a great experience having time on that wonderful place. I really recommend the Island for new students to conducting further research with different topics*." This theme was called *putting it all together*. One particular student also believed that the *Island* had improved their confidence in their ability to conduct scientific research. Before using the *Island*, this student explained that they were dreading the commencement of their Master research project. However, after one project on the *Island*, the student admitted that they were now looking forward to getting started.

Not all students seemed to benefit and some may have missed the point. One highly experienced student working in the marketing industry found the *Island*-projects of no direct benefit. They explained that the concepts and activities completed in the *Island* projects encompass what they do on a day-to-day basis. This drawback may be re-interpreted as validation of the real-world applicability of *Island*-based projects. A few students appeared to have missed the point. For example, one student was surprised when they unknowingly experienced natural biological variability, *"sometimes the participants change their answers at the same day. For example; when you ask about cholesterol; the result will be for the first time 155 and the second time will be 160 or something*". Another student expressed disappointment that not all Islanders wanted to fill out their survey, "*Some people in the villages don't do the survey*".

From the instructor's perspective, the use of *Island*-based projects had a number of benefits. Individualisation of topics created great diversity, where in the past, diversity was lacking. This made marking the projects far more enjoyable, but somewhat more difficult to compare between students. Clear marking rubrics were helpful in this respect. The *Island*-based projects felt more authentic due to the individualisation and diversity of topics. Student activity logs available to instructors from the *Island* made it possible to confirm students had collected the data presented in their projects. The students' data sets were also a good source for examples and assessment items to be used in the future. From an assessment perspective, the projects provided unique insight into the student's ability to think statistically by getting students to carry out scientific research design and analysis from the ground-up. The authors cannot think of a more practical method of engaging students to think statistically within the constraints of an online introductory statistics course.

CONCLUSION

The results reported in this study on students' experience and perceptions of using the *Island* for project-based assessment in an online introductory statistics course suggest that students perceived using the *Island* as being engaging, relatively easy to use and beneficial to the development of their statistical thinking. A limitation to this conclusion was the response rate. A positive response bias cannot be ruled out. However, these results were consistent with findings from a similar study by Linden and Baglin (2011) which used the same questionnaire and had a 91% response rate.

The results of this study suggest that the *Island,* in and of itself, does not develop a students' ability to think statistically. The *Island* acts as a virtual playground for students to explore, experience, experiment, practice, problem-solve and err conducting virtual scientific studies. It is through this experience of learning by doing that students become motivated to question, learn and understand the statistical concepts related to what they're doing. This is how

Island-based projects are hypothesised to help develop students' statistical thinking. This study suggests that multiple design factors of the *Island* work together to achieve the level of engagement required to facilitate this development.

Despite these positive findings, there is more research required for understanding how *Island*-based projects can improve assessment methods and student learning outcomes. Studies which map specific learning outcomes to use of *Island*-based projects would help explain the education benefits of its use. Studies which compare the learning outcomes of using the *Island* for projects to existing project methods would help evaluate the ability of the *Island* to better engage students. Other research should also look beyond statistics and project-based assessment. Other courses (e.g. Research Methods) and methods of learning (e.g. Tutorials) may also benefit from the inclusion of *Island*-based content.

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