Title
Students' Experiences and Perceptions of Using a Virtual Environment for Project-Based Assessment in an Online Introductory Statistics Course

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1. INTRODUCTION

1.1 Theoretical Background

Students learn by doing. This is a view advocated by the statistics education reform movement (American Statistical Association, 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 (American Statistical Association, 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 has highlighted the shift away from traditional methods of assessment, such as exams and hand calculations, towards more diverse assessment methods which promote 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 a project topic 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 realistic is all too often beyond an instructor's capability. Fortunately, recent technology advances in statistics education may help to address these challenges.

The use of technology can help students become 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 et al., 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, realistic and engaging projects within the constraints of large introductory statistics courses (Bulmer, 2010, 2011).

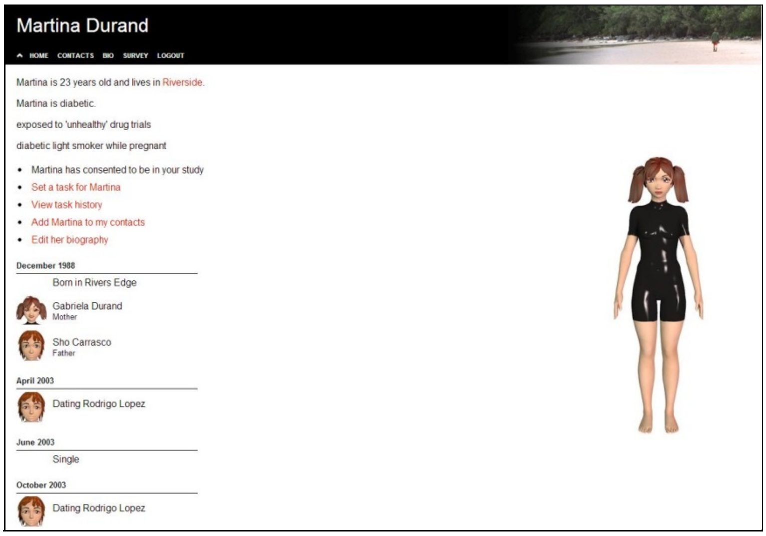
1.2 The *Island*

The *Island* (http://island.maths.uq.edu.au, see Figure 1) is a freely available online virtual environment developed by Bulmer (2005, 2010, 2011) and described in detail by Bulmer and Haladyn (2011). Students access and interact with the *Island* via a secure website interface (request access 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" each of whom has a unique name, personal history and virtual avatar (see Figure 2a.). These Islanders can be sampled and recruited for the purpose of scientific research by navigating between the 39 towns (see Figure 1, only 36 are shown on the map). Each Islander occupies a house in one of these towns (Figure 2b.).

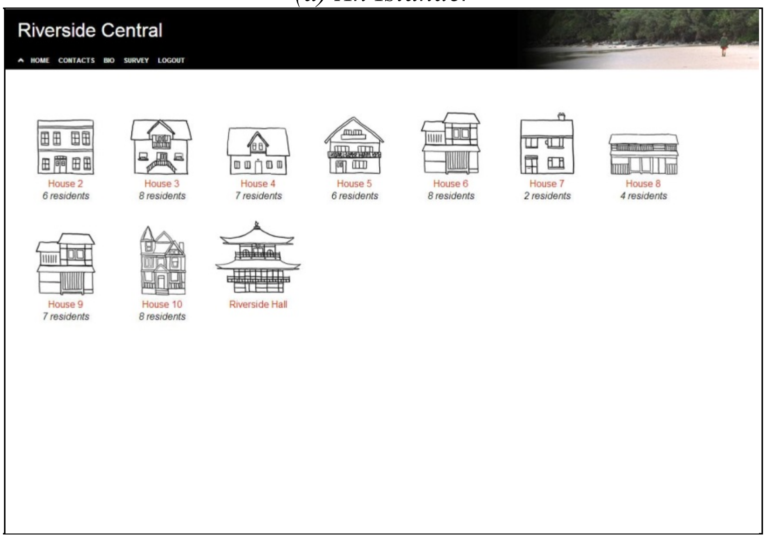
The current *Island* comprises of two different simulations. The first simulation seeded the current population from an initial shipwreck of 108 people in 1779. This simulation proceeds in monthly steps and probabilistically determines disease contraction, death, relationships (e.g. dating and marriage), pregnancy and relocation. Approximately 15,000 Islanders have existed (both living and dead) over the entire history of the simulation. At the time of publishing, the estimated population is in excess of 9,000. Town halls store information about birth, deaths and marriages. This archival information is perfect for epidemiological studies.

The second set of simulations control the various types of data that can be collected from the *Island*. These data are obtained by setting tasks for consenting Islanders. There are now over 200 different tasks available (See Figure 3a. and b.). Task categories and examples include survey items (e.g. "How anxious do you feel right now?"), blood tests (e.g. cholesterol, glucose, and type), physiological measures (e.g. blood pressure, pulse rate, and spirometer), alcoholic drinks (e.g. red wine, beer and vodka), non-alcoholic drinks (e.g. green tea, water and coffee), food (e.g. chocolate, carrots and banana), injections (e.g. adrenaline, methamphetamine and morphine), tablets (e.g. aspirin, codeine and vitamin D), other drugs (e.g. cigarette, reefer and betel nut), mental tasks (e.g. IQ test, memory test and mental arithmetic), coordination (e.g. balance test, ruler test and light flash test), exercise (e.g. swimming, running and strength test), music (e.g. classical music, heavy metal music and play flute) and environment (e.g. nap, read book and sit). Biographical information for each Islander includes demographic information (e.g. age, gender, and residency), medical records (e.g. smoking history, disease diagnosis), family tree and relationship history. The task simulations run in real time and most are based on mathematical models built from scientific literature. For example, Bulmer and Haladyn (2011) report there are statistical models governing the effect of caffeine on exercise, alcohol on blood pressure, ageing on body temperature, oxygen on cognitive performance, obesity on cholesterol, sleep on mental tasks, and smoking on blood pressure.

Figure 1. The Island (Bulmer & Haladyn, 2011)



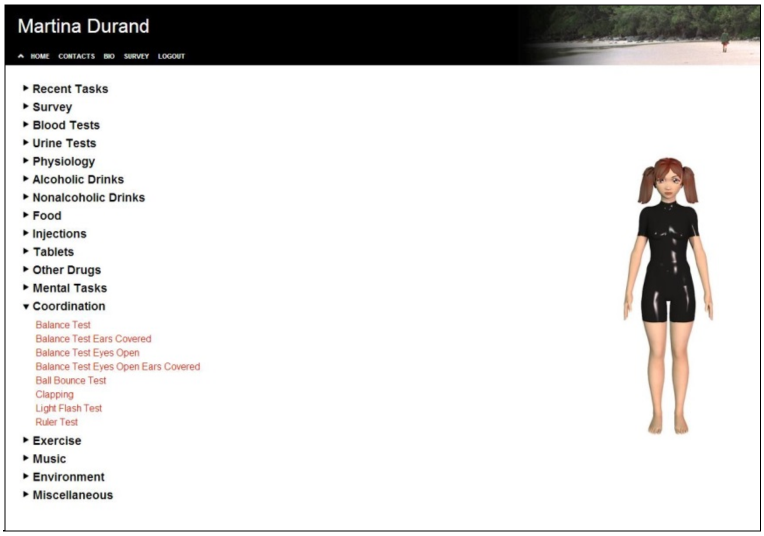
(a) An Islander



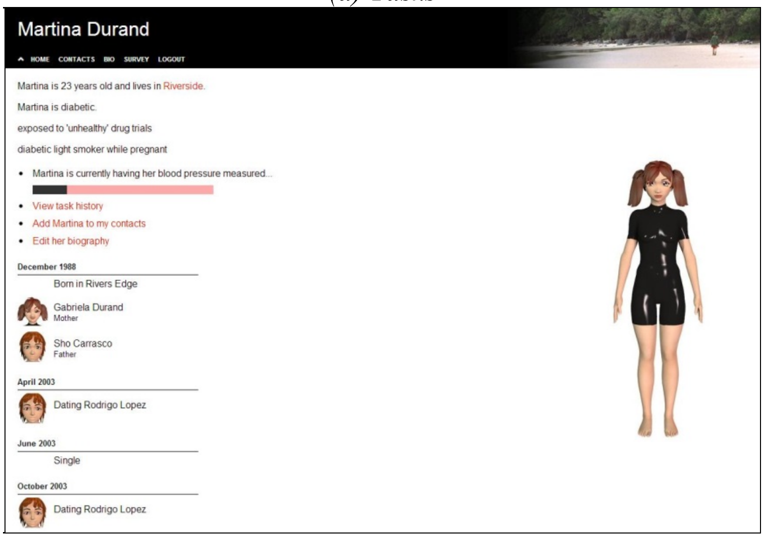
(b) The town and houses of Riverside

Figure 2. Islanders and Towns

There are a number of key features to the *Island* that make it ideal for project-based assessment in statistics education. The wide range of tasks and demographic information available on the *Island* allows students to select topics of interest to them. It also allows students to design and implement a wide variety of research designs including surveys, observational studies, case-control studies, correlational studies and experiments. The *Island* has been designed to give students an authentic research experience. Islanders may refuse consent, drop out during an experiment, lie about their age, get sick or fall asleep late at night. The *Island* does not provide a way to automatically sample Islanders. Thus, students must deal with the issues of sample size and sample selection. Interactions with Islanders cannot be automated. Students quickly realise the “cost” (i.e. students’ time) of research. The *Island* does not provide students with data files or summarised data. Nor does it provide tools for data analysis. The aim here is to provide students with the experience of gathering raw data and preparing data files for analysis as they would in real-world research.



(a) Tasks



(b) Measuring blood pressure

Figure 3. The Island Interface

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 realistically 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, Baglin and Bedford (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 and student populations.

1.3 Aim

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.

2. THE COURSE

2.1 Course Particulars

The course in this study was an online postgraduate introductory biostatistics course. It was largely taken by Masters of Laboratory Medicine students, a majority of whom are international students. Other students typically enrolled in the course included students from Master of Statistics and Operations Research, Medical Science and Biotechnology. The main course objective was to provide students with fundamental skills required to collect, analyse, interpret and communicate statistical information within a biomedical context.

The course had been growing in popularity over the years. Masters students, who often have family and work commitments, were attracted by the flexibility of the online delivery. The course covered the usual introductory topics including descriptive statistics, probability, estimation, one-sample inference, two-sample inference, categorical data, nonparametrics, correlation and regression, basic epidemiology and one-way ANOVA. The course textbook was Bernard Rosner's *Fundamentals of Biostatistics 6th Edition* (Rosner, 2006). The course was delivered and administered online using the *Blackboard* course management system.

As the course was fully online; there was no face-to-face contact between students and the instructor. Learning activities that replaced face-to-face contact included textbook readings, summary PowerPoint slides, ongoing topic exercises and computer laboratory worksheets. The course had a strong focus on the use of technology to assist students with statistical calculations. The computer laboratory worksheets scheduled for each course topic developed students' ability to use *Excel*, *SPSS* and the *OpenEpi* website (http://www.openepi.com). Students were required to make regular use of the course discussion boards to seek assistance and work through their problems.

2.2 Assessment

The course assessment was broken up into three parts: weekly on-going assessment (10%), online tests (60%) and a major course project (30%). The on-going assessment consisted of weekly submission of students' solutions to the exercises set for each course topic. This typically included 10 exercises per topic taken from the textbook (Rosner, 2006). These submissions ensured students were working through weekly content. Submission deadlines were set so that students had regular progress targets toward which to work. Exercise submissions were graded on timely completion, not performance. Following the deadline, exercises solutions were provided to students for self-review. The tests, which made up 60% of the course grade, involved a mid-semester test 1 (15%), late semester test 2 (15%) and test 3 during the exam period (30%). The tests were composed of random pools of multiple-choice, calculation and short-answer formats, which were updated on a yearly basis. For tests 1 and 2, grades and answers were withheld until after all students had submitted. Answers and feedback were then provided to students to assist in their revision for test 3. Test 3 had the highest test weighting and served a more summative role in the course. Test 3 was also composed of random pools, but answers and feedback were not provided to students. This was done to protect the integrity of the final test, even though it was updated on a yearly basis.

2.3 *Island* Projects

In the years prior to this study, 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 students' 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 ever 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.*

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

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 approval from the course instructor. Remarkably, only one student in 2011 took up this offer. The *Island*-based projects required students to investigate a research topic 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 accessible online. No explicit instructions for using the *Island* were provided to students. Students were left to explore the *Island* in their own time and formulate a study to meet the objectives of the project using a topic and research design of their own choosing. This meant that students were given the experience of conducting an entire cycle of a simulated scientific study. A small sample of topics chosen by students is 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 self-selected, including correlational, observational and experimental.

3. METHOD

A sample of 42 volunteer students from the 2011 Semester 1 and 2 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. The average age of the sample was $M = 29$ ($SD = 3$). There were 15 (35.7%) males and 27 (64.3%) females. The sample were mostly international (28/42, 66.7%) students studying full-time (33/42, 78.6%).

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 α =.79, .62 and .90 for engagement, ease of use and contributes to understanding respectively.

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 interviewees were five student volunteers who indicated they would be willing to share their experiences in greater details after filling in the questionnaire. The interviews were conducted over telephone at a time convenient to the participant. The interview schedule aimed to elicit more detailed discussion about the *Island* projects. Specifically, participants were asked about what they enjoyed, what difficulties they had, how they felt the *Island* helped their learning, how engaged they were, if there were any surprising experiences, how their regular study habits were impacted, and how things may be improved. 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.

4. RESULTS AND DISCUSSION

The descriptive statistics of the quantitative responses to the *Island* questionnaire are shown in Table 2. These quantitative results will be discussed alongside themes identified in the qualitative thematic analysis to help explain and expand upon the forced-choice responses. The themes will be discussed around the three domains of the *Island* questionnaire, *engagement*, *ease of use* and *contributes to understanding*.

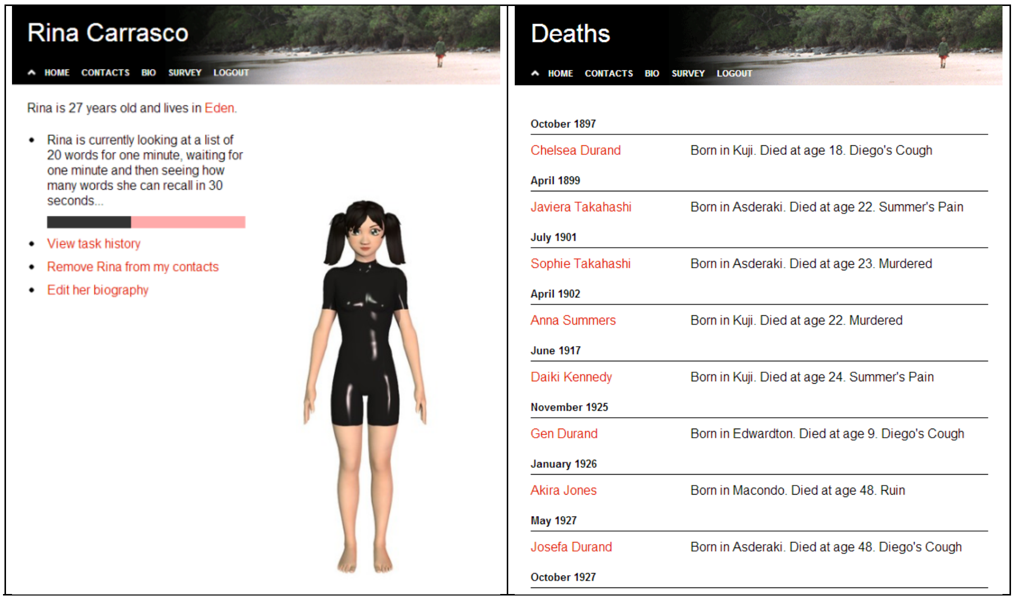
The results from the *Island* Questionnaire showed that 90.5% of students reported an overall positive experience of using the *Island* for course projects (Table 2). Qualitatively, when eliciting from students the reasons behind their positive experience, the major theme that emerged was the *Island's* ability to immerse students. Two major themes emerged to explain this engagement: *realism* and *contextualisation*. By far the most powerful feature 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.*" Time was also another important factor which students identified as adding to the realism, "*the most important thing was the realistic time frame*" (see Figure 4a.). Time made students think about the practicality of research and the cost of data.

Table 2: Island Questionnaire Descriptive Statistics (Both Semesters Combined)

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

Note. *N* = 42, R = reversed item, *M* = Mean, *SD* = Standard Deviation

The realism behind the *Island* appears to drives engagement; however, the *Island's* realism is not to be confused with reality. Bulmer and Haladyn (2011) discuss the tension between the *Island's* reality and fantasy. While it is possible to make the *Island* more realistic, there is a point at which doing so would violate the purpose of the tool. For example, Bulmer and Haladyn discuss the purpose of using unique disease names as opposed to using their real-world names (see Figure 4b.). Bulmer and Haladyn explain that doing so aims to promote a more open-ended research experience and discovery through simulated scientific investigation. The *Island* acts as bridge between the artificial classroom environment and real-world research, or as one student commented, "*It's obviously not real life, but it's probably as close as you're going to get using a website.*"



(a) Data collection costs real time *(b) Unique disease names*

Figure 4. Design features

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.*

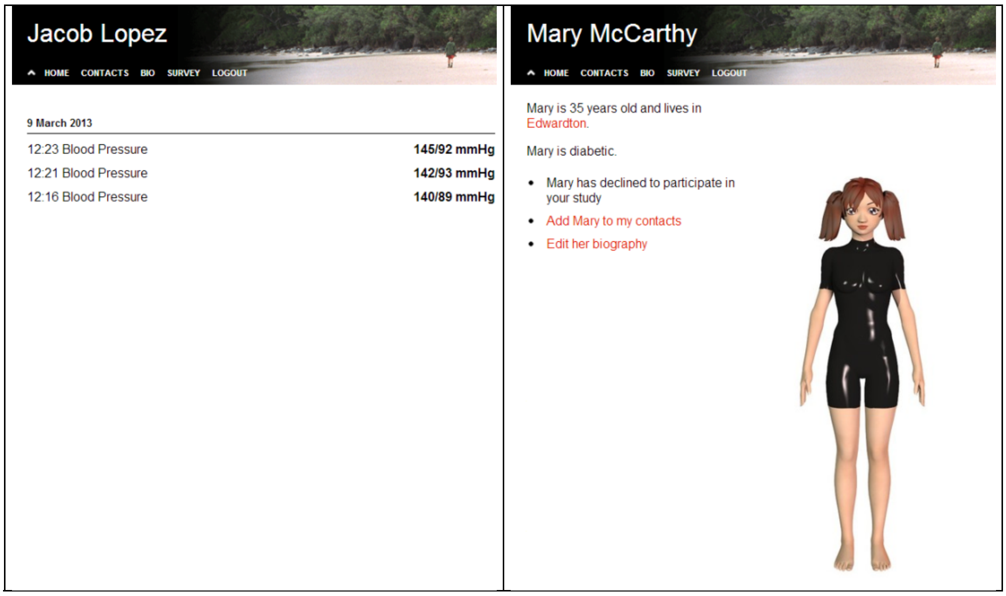
This student may otherwise never have been engaged in the course had it not been for the use of *Island*-based projects. This finding suggests that engagement with the *Island* may help change students' attitudes towards statistics.

In terms of ease of use, there were some mixed perceptions. While students felt the *Island* was relatively easy to use (92.9%), conflictingly, about a quarter (26.2%) of students also reported that the *Island* was difficult to use. That most students agreed that more instructions were needed (57.1%), provided some explanation for this inconsistency and the 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 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) explain 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 also possibly degrade the realistic experience imparted by the *Island's* real-time nature. Regardless, instructors 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, 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 his confidence in his ability to conduct scientific research. Before using the *Island*, this student explained that he was dreading the commencement of his masters research project. After one project on the *Island*, however, the student admitted that he was 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. He explained that the concepts and activities completed in the *Island* projects encompass what he does 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 he unknowingly experienced simulated natural biological variability (e.g. see Figure 5a.), *"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*" (e.g. see Figure 5b.).



(a) Blood pressure variability *(b) An Islander refusing consent*

Figure 5. Realism

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 task of marking the projects was already very time-consuming prior to the introduction of *Island*-based projects, but the instructor did not report any substantial change in the time required for this task. In terms of instructor preparation, familiarity with the *Island* and how it operates was important. Students made good use of the online discussion forums to ask questions about difficulties they encountered conducting their studies. Familiarity with the *Island* was crucial for providing feedback on proposals to ensure students would be able to deliver on what they proposed.

The *Island*-based projects felt more authentic due to the individualisation and diversity of topics. Student activity logs available to instructors from the *Island* website made it possible to confirm students had collected the data presented in their projects. This was perfect for checking the authenticity of the students' work. The students' data sets were also a good source for examples and assessment items to be used in the future. The *Island*-based project also broke down ethical barriers, allowing students to conduct realistic simulated studies using virtual human beings. Such studies would not have been possible under normal course constraints. Students conducted all types of high level research designs including randomised controlled trials and retrospective case-control studies.

While students may have felt that more instruction was needed initially to learn to use the *Island* for their projects, doing so might have unwanted effects. The instructors believe that providing too much direction can stifle students' exploration and lead to decreased creativity. Anecdotally, in a following semester, an exemplar of an *Island* project from a previous semester was made available to students prior to submitting their project proposals. This project was a very elegant randomised-controlled experiment looking at the effect of exercise on anxiety. The instructor received a disproportionate number of proposals outlining controlled experiments that semester, where in the past the distribution of experimental and correlational designs was relatively even. Instructors might not find the right level of guidance first time round.

From an assessment perspective, the projects provided unique insight into the students' ability to think statistically by getting students to carry out scientific research design and analysis from the ground-up. The entire process of the project also allowed students to practice their ability to communicate statistics information in a professional manner. While the use of online slideshow presentations served its purpose, the authors encourage other instructors to explore different mediums, e.g. reports or posters. In summary, the authors cannot think of a more practical method of engaging students to think statistically within the constraints of an online introductory statistics course.

5. 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 to understand how *Island*-based projects can improve assessment methods and student learning outcomes. Studies that map specific learning outcomes to *Island*-based projects would help explain the education benefits of its use. Studies that compare *Island*-based projects to alternate 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.

REFERENCES

American Statistical Association. (2005). *Guidelines for assessment and instruction in statistics education*. Washington, DC: Author. Retrieved from http://www.amstat.org/education/gaise/GAISECollege.htm

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Bulmer, M. (2005). Virtual humans for teaching and learning statistics. In I. MacColl (Ed.), *Evolution: Universities, students and technology: Proceedings of the Apple University Consortium Academic and Developers Conference*(pp. 1–8). Hobart, Tasmania.

Bulmer, M. (2010). Technologies for enhancing project assessment in large classes. In C. Reading (Ed.), *Proceedings of the Eighth International Conference on Teaching Statistics*.Ljubljana, Slovenia. Retrieved from http://www.stat.auckland.ac.nz/~iase/publications/icots8/ICOTS8_5D3_BULMER.pdf

Bulmer, M. (2011). *Island*. Retrieved from http://island.maths.uq.edu.au/access.php?/index.php

Bulmer, M., & Haladyn, J. K. (2011). Life on an Island: A simulated population to support student projects in statistics. *Technology Innovations in Statistics Education*, *5*(1). Retrieved from http://escholarship.org/uc/item/2q0740hv

Chance, B. L. (1997). Experiences with authentic assessment techniques in an introductory statistics course. *Journal of Statistics Education*, *5*(3). Retrieved from http://www.amstat.org/PUBLICATIONS/JSE/v5n3/chance.html

Chance, B. L. (2002). Components of statistical thinking and implications for instruction and assessment. *Journal of Statistics Education*, *10*(3). Retrieved from http://www.amstat.org/publications/jse/v10n3/chance.html

Chance, B. L., Ben-Zvi, D., Garfield, J. B., & Medina, E. (2007). The role of technology in improving student learning of statistics. *Technology Innovations in Statistics Education*, *1*. Retrieved from http://escholarship.org/uc/item/8sd2t4rr

Creswell, J. W. & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Garfield, J. B. (1995). How students learn statistics. *International Statistical Review*, *63*, 25–34.

Garfield, J. B. & Ben-Zvi, D. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International Statistical Review*, *75*(3), 372–396.

Garfield, J. B. & Gal, I. (1999). Assessment and statistics education: Current challenges and directions. *International Statistical Review*, *67*(1), 1–12. Retrieved from http://www.jstor.org/stable/1403562

Griffiths, P. & Sheppard, Z. (2010). Assessing statistical thinking and data presentation skills through the use of a poster assignment with real-world data. In P. Bidgood, N. Hunt, & F. Jolliffe (Eds.), *Assessment methods in statistical education: An international perspective* (pp. 47–56). Chichester, WS: John Wiley & Sons.

Holmes, P. (2002). Teaching, learning and assessment: Complementary or conflicting categories for school statistics. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching Statistics, Cape Town, South Africa* [CD-ROM]. Voorburg, The Netherlands: International Statistical Institute. Retrieved from http://www.stat.auckland.ac.nz/~iase/publications/1/04_ho.pdf

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Linden, M.,Baglin, J. & Bedford, A. (2011). Teaching clinical trial design and management using an online virtual environment. In M. Sharma, A. Yeung, T. Jenkins, E. Jonhson, G. Rayner, & J. West (Eds.), *Proceedings of the Australian Conference on Science & Mathematics Education (17th Annual UniServe Science Conference)* (pp. 107 – 113). Melbourne, Australia. Retrieved from http://escholarship.library.usyd.edu.au/journals/index.php/IISME/article/viewFile/4812/5570

MacGillivray, H. (2010). Variety in assessment for learning statistics. In P. Bidgood, N. Hunt, & F. Jolliffe (Eds.), *Assessment methods in statistical education: An international perspective* (pp. 21–34). Chichester, WS: John Wiley & Sons.

Rosner, B. (2006). *Fundamentals of biostatistics* (6th ed.). Belmont, CA: Thomson Higher Education.

Smith, G. (1998). Learning statistics by doing statistics. *Journal of Statistics Education*, *6*(3). Retrieved from http://www.amstat.org/publications/jse/v6n3/smith.html

Snee, R. D. (1993). What's missing in statistics education. *The American Statistician*, *47*(2), 149–154.

Spinello, E. F., & Fischbach, R. (2004). Problem-based learning in public health instruction: A pilot study of an online simulation as a problem-based learning approach. *Education for Health*, *17*(3), 365–373.

Stafford, R., Goodenough, A. E., & Davies, M. S. (2010). Assessing the effectiveness of a computer simulation for teaching ecological experimental design. *Bioscience Education*, 15. Retrieved from http://journals.heacademy.ac.uk/doi/pdfplus/10.3108/beej.15.1