IMPROVING THE ATTITUDES OF HIGH SCHOOL STUDENTS TOWARDS STATISTICS: AN ISLAND-BASED APPROACH

Minh Huynh, James Baglin and Anthony Bedford
School of Mathematical & Geospatial Sciences
RMIT University, Melbourne, Australia
minh.huynh@rmit.edu.au

This pilot study examined the use of an online virtual environment, known as the Island, at a secondary school level, and investigated its ability to help improve student attitudes towards statistics. The Island-based learning activity aimed to achieve this by focusing on the exploratory nature of the Island, allowing students to experience statistical problem-solving. Pilot data were obtained from 88 ninth and tenth grade students, who completed a learning activity that required them to conduct a statistical investigation on the Island. Before and after questionnaires were administered in conjunction with the Island activity. Results indicated that student attitudes towards statistics improved significantly after the Island activity. This paper summarizes these findings and discusses implications and strategies for active learning and improving student attitudes. In addition, the outcomes of this study will be utilized to plan follow-up studies.

INTRODUCTION

There is currently a decline in Australian mathematical and statistical graduates. A recent report by the Australian Academy of Science (2006) has stated that "*the supply of students and mathematical and statistical graduates is falling short of national needs.*" The report details that only a small percentage of secondary schools students graduate with the adequate mathematical skills to prepare them for a STEM (science, technology, engineering or mathematics) degree. Australian secondary school students are abandoning higher-level mathematics in favor of elementary mathematics, or discarding the subject completely, to secure a higher tertiary entrance score. Australia is now failing to produce mathematical and statistical scientists who possess the necessary quantitative skills needed by government, industry and tertiary education (Australian Academy of Science, 2006).

This decline in quantitative skills can be traced back to poor attitudes towards mathematics in secondary education. This is unfortunate however because positive attitudes are a key outcome of mathematical learning (Evans, 2007). Similarly, in statistics education, there exists a consistent positive relationship between statistics attitudes and achievement (Schultz & Koshino, 1998). Unfortunately, improving student attitudes towards mathematics and statistics remains a challenging task with many students finding the subjects uninteresting, difficult and tedious (Wenger, 1998). As an example, Murray (2011) investigated reasons for the decline in students taking mathematics as subjects in high school. Murray surveyed 92 students from an Australian institution and found that 57% of students reported mathematics to be difficult and 46% believed it to be 'boring and unenjoyable.' As such, there is a need to improve student attitudes towards quantitative subjects like mathematics and statistics. By improving student attitudes early on (e.g. in middle secondary school), we can enrich their high school experience, which may lead to improved tertiary and career pathways into mathematical and statistical disciplines.

Fortunately, the introduction of technology within the classroom has provided an enormous spectrum for new approaches to teaching driven by research that suggests enhanced learning through cognitive, metacognitive and affective channels (Barkatsas, 2005). One example of such technology is the Island (Bulmer & Haladyn, 2011). The Island is an open-ended virtual environment which allows students to design scientific studies and collect data from virtual humans, which overcomes the ethical and practical barriers presented by real research. This program actively engages students in a data investigative problem solving approach (PSA), which has shown to benefit students of all ages (Marriot, Davies & Gibson, 2009).

To date, the Island has been utilized at an undergraduate level with promising results (e.g. Linden, Baglin & Bedford, 2011; Baglin, Reece, Bulmer & Di Benedetto, 2013; Baglin, Bedford & Bulmer, 2013). These researchers have suggested that the Island is a novel approach to teaching students about statistics and experimental design. One of the major strengths of the Island program

is that it allows students to experience the entire process of statistical problem solving within an engaging context.

With that said, there is still a lack of studies investigating methods of attitude change towards statistics, particularly at the secondary school level. This paper aims to examine the impact of using the Island to implement a PSA learning activity within a secondary school environment. It was hypothesized that the implementation of the Island program for secondary school students will see improvements in statistical attitude in the short term. This paper summarizes these findings and discusses various implications for future research to be taken.

METHOD

Participants comprised of 88 ninth and tenth grade students with a mean age of 14.86 years (*SD* = 0.59) recruited from a city based institution in Melbourne, Australia. The participating school was a highly ranked select entry school known for training high achieving students. The study was carried out within a standard classroom of this school, with the assistance of a supervising teacher who helped to coordinate the students and pair them into groups of two. Four sessions ran during this pilot study, with approximately 20 students attending each session.

The students were told that they would be investigating the effects of a benzodiazepine drug (e.g. Diazepam) on burst sprinting ability. Each pair of students was given a school laptop to access the Island and complete this activity. Originally, it was intended for students to pick their own scenarios to investigate, however, given the time constraints, students were given a pre-assigned topic for this pilot study. The pilot was interested in examining *how* the students went about solving the research question on their own using the Island and as such, did not provide them with explicit or detailed instructions. Instead, the students were encouraged to explore the Island in their groups and discover the various features of the program through self-direction. This activity usually required 60 minutes for all groups to complete.

In determining current perceptions and attitudes towards statistics, a 22 item questionnaire was administered (prior to completing the Island activity) which followed a five point likert scale format (with a response of 1 indicating 'strongly disagree' and a response of 5 indicating 'strongly agree'). The three items on the questionnaire that examined statistical attitudes were: (1) *I enjoy learning about statistics*, (2) *I am interested and willing to gain further knowledge about statistics* and (3), *statistics is important in everyday life*. Once all the students had completed the activity, each group presented their method and results to the class. The presentation was very informal and was more an overall class discussion, sharing their findings and method. After the discussion session, the students completed a follow up questionnaire which was similar in nature to the initial survey, however, having the addition of three open ended qualitative items relating specifically to the Island: (1) *What did you enjoy about using the Island*, (2) *How difficult did you find using the Island? What factors impacted that difficulty* and (3), *if you could change or improve anything on the Island what would it be?*

RESULTS

This pilot study was interested in examining the changes in attitudes towards statistics before and after completing the Island-based activity. The table below provides descriptive statistics for the three items examining statistics attitudes in the questionnaire (*n* = 86).

Table 1. *Descriptive Statistics for the Pre and Post Responses for Statistics Attitude Items*

	Pre-test		Post-test	
	M	*SD*	*M*	*SD*
I enjoy learning about statistics	2.50	0.97	3.22	1.07
Statistics is important in everyday life	3.76	0.88	3.99	0.85
I am interested and willing to gain further knowledge about statistics	2.91	1.13	3.42	0.97

A Wilcoxon signed-rank test was utilized to investigate the first statistical attitude statement: "*I enjoy learning about statistics.*" Results indicated that there was a significant difference ($Z = -5.524$, $p < .001$, $r = 0.60$) between the initial response ($M = 2.50$, $SD = 0.97$) and

follow up response (*M* = 3.22, *SD* = 1.07) of the students. A second Wilcoxon signed-rank test produced significant results for the statement: *statistics is important in everyday life*, *Z* = - 2.005, *p* = 0.045, *r* = 0.217, with the initial responses (*M* = 3.76, *SD* = 0.88) being slightly lower than the follow up responses (*M* = 3.99, *SD* = 0.85). A final Wilcoxon signed-rank test was carried out for the statement: *I am interested and willing to gain further knowledge about statistics* and also produced significant results, *Z* = - 4.743, *p* < .001, *r* = 0.514, with initial responses (*M* = 2.91, *SD* = 1.13) being lower than the follow up responses (*M* = 3.42, *SD* = 0.97). The figure below summarizes these analyses.
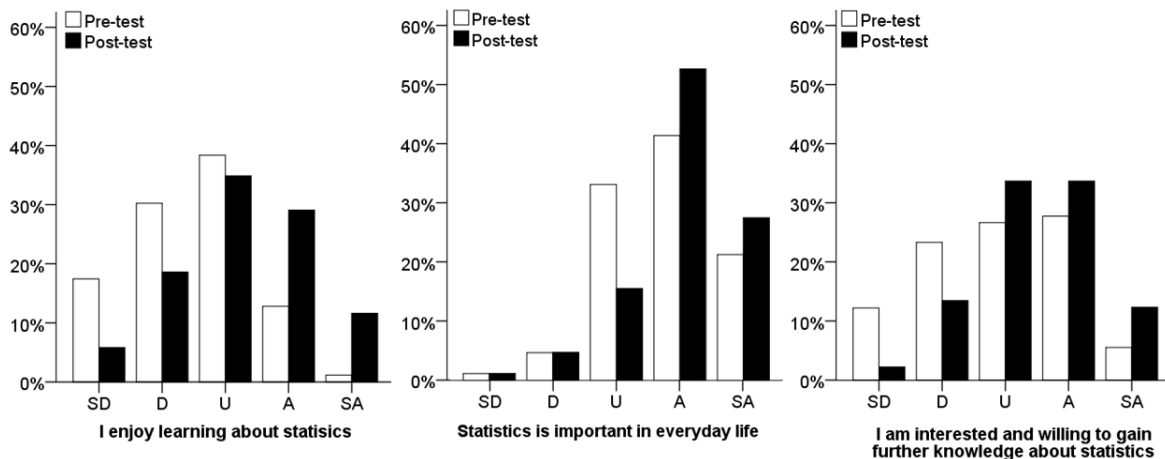

Figure 1. Bar charts comparing the percentage of pre and post responses for statistical attitudes

Qualitative analyses from the present study found that *all* participants enjoyed using the Island program. Of note, one student mentioned that she enjoyed "*collecting the data because it felt like conducting a real experiment*." Usually, collecting data is a tedious activity for high school students because of the age and ethical limitations set upon them. The Island program is able to overcome these restrictions by allowing the students to experiment on their own virtual islanders, in a scientific manner. One of the student participants from this study summarized this best when she said: "*It was a great way to test otherwise unethical theories*." In addition, this pilot found that when completing the Island activity, most students were able to go about designing a simple comparative experiment without input from the researcher or teacher.

DISCUSSION AND CONCLUSION
This pilot study discovered that secondary school students' attitudes towards statistics significantly improved after completing an Island-based learning activity. This supports the notion that innovative, technology-assisted, problem-based learning activities can impact attitudes towards statistics in the short-term. Naturally, a follow up of these students will be required to examine if the change in attitudes remains consistent. When presenting their findings during the discussion session, student responses were quite varied - ranging from graphical representations, to comparing means and, even one student (who had work experience in a clinical setting) attempted to "*show that the mean difference between the two groups was too small to be significant*." These initial findings were quite encouraging for such young students (aged 14 to 15) who were also able to raise limitations such as sample size, random selection and experimenter bias.

With that being said, the quality of the students recruited for the pilot included only high achieving students from a highly ranked school. Future research will be planned to determine if this effect is consistent across diverse school settings and if this effect is unique to the "Island-based" element of the learning activity. Future research will also investigate the merit of providing open-ended research topic choices for students and controlling for a potential "Hawthorne effect" by having the activities delivered during regular classes. To do so, teacher partnerships and training for the development and delivery of the innovative sessions will also be required with the eventual goal being to offer the innovative "Island-based" learning resources to all mathematics and science secondary school teachers in Australia.

In conclusion, the lack of quantitative skills in Australia has much to do with poor attitudes towards mathematics during secondary education. There is a need to improve students' attitudes towards quantitative subjects. Enriching their secondary school experience may help improve attitudes and increase the uptake of mathematical and statistical pathways in tertiary education and industry. This pilot has demonstrated preliminary evidence that innovative technology, paired with sound pedagogical practice, may help assist in changing student attitudes at the secondary school level. This pilot study provides promising evidence to suggest such a change; however more studies are required as this area of research is still lacking in number. We will utilize the results of this investigation to carry out future studies examining more diverse school settings and the possibility of running the Island activity during a regular class.

REFERENCES
Australian Academy of Science (2006). Mathematics and statistics: Critical skills for Australia's future. *The National Strategic Review of Mathematical Science Research in Australia*. Retrieved from http://www.review.ms.unimelb.edu.au/FullReport2006.pdf
Barkatsas, A. (2005). A new scale for monitoring students' attitudes to learning mathematics with technology (MTAS). In *Building Connections: Research, Theory and Practice*. Proceedings of MERGA Conference, July 7-9 2005, Melbourne, Australia (pp. 129-136). MERGA.
Baglin, J., Reece, J., Bulmer, M., & Di Benedetto, M. (2013). Simulating the data investigative cycle in less than two hours: Using a virtual human population, cloud collaboration and a statistical package to engage students in a quantitative research methods course. In *Proceedings of the Joint IASE/IAOS Satellite Conference, August, 2013*. Macao, China.
Baglin, J., Bedford, A., & Bulmer, M. (2013). Students' experiences and perceptions of using a virtual environment for project-based assessment in an online introductory statistics course. *Technology Innovations in Statistics Education*, *7*(2), 1-15. Retrieved from http://www.escholarship.org/uc/item/137120mt
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*. Retrieved from http://escholarship.org/uc/item/2q0740hv
Evans, B. (2007). Student attitudes, conceptions, and achievement in introductory undergraduate college statistics. *The Mathematical Educator*, *17*, 24-30.
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.
Marriott, J., Davies, N., & Gibson, L. (2009). Teaching, learning and assessing statistical problem solving. *Journal of Statistics Education*, *17*. Retrieved from http://www.amstat.org/publications/jse/v17n1/marriott.pdf
Murray, S. (2011). Declining participation in post-compulsory secondary school mathematics: Students' views of and solutions to the problem. *Research in Mathematics Education 13*, 269-285.
Schultz, K. S., & Koshino, H. (1998). Evidence of reliability and validity for Wise's attitude toward statistics scale. *Educational and Psychological Measurement*, 82, 27-31.
Wenger, E. (1998). Communities of practice: Learning, meaning, and identity. Cambridge: Cambridge University Press.