FY15 Innovations in Teaching with Technology Awards: An Interactive Simulation Environment for Learning Statistical Concepts

FY15 Innovations in Teaching with Technology Awards

<table>
<thead>
<tr>
<th>Proposal Title:</th>
<th>An Interactive Simulation Environment for Learning Statistical Concepts</th>
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<tr>
<td>Investigators:</td>
<td>Sheila Barron</td>
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<td>Org Unit:</td>
<td>College of Education</td>
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<tr>
<td>Department(s):</td>
<td>Psychological and Quantitative Foundations</td>
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<tr>
<td>Funding Awarded:</td>
<td>$34,600</td>
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An understanding of descriptive and inferential statistics is important in many fields of study as well as in day-to-day modern life. However, students often report that statistics courses are difficult and unpleasant, and taking an introductory statistics class has been associated with a decrease in interest in the field of statistics. Many students take only a single statistics class so there is a clear need to create elementary statistics courses that are accessible and engaging for students. The proposed project will target the Elementary Statistics and Inference course which is cross listed in the College of Education (PSQF:1020) and College of Liberal Arts (STAT:1020). This course is taken by roughly 700 undergraduate students per year, and these students come from a wide range of backgrounds and have diverse interests as represented by a variety of majors. Currently, students are encouraged to do non-graded homework problems from the textbook. There is a critical need to put in place instructional reforms aimed at actively engaging students with the content in this course.

This project aims to develop an interactive simulation environment to introduce statistical concepts in the social sciences. There are a growing number of websites available on the Internet for demonstrating specific statistical concepts (see the Appendix A for links), however these are almost exclusively bare-bones programs that are likely to leave today’s tech savvy students unimpressed. There are no interactive simulation programs that allow students to conduct data collection and statistical analysis within a contextualized reality-based environment. For short, I will call this a statistics game, but the use of the term game is not meant in the competitive or point-oriented sense, but rather in the engaging and challenging sense.

Many students find learning statistics to be hard work. They have the desire to learn how to think statistically and use statistics to understand the world, but the traditional
methods of teaching and learning (e.g., lecturing and paper and pencil practice exercises) act as a barrier to fulfilling this desire. The statistics game would provide an alternate means for students to interact with the statistics concepts covered in the course. Introducing activities which would develop the same concepts covered in class through an interactive computer-based format has the potential to dramatically improve student engagement with the content in a number of ways. First, because the activities are contextualized and designed to engage students’ curiosity and creativity, it is expected that students will be more willing to spend time on the activities. Second, because the activities are online, it won’t be necessary to write out and solve problems or create graphs on paper. Instead students can engage in the more interesting aspects of statistics such as discovering new information and visualizing and interpreting results. Third, because the environment will be easy to interact with, students will be free to explore and make mistakes without feeling that a great deal of time and energy has been wasted. Fourth, because the environment is online, game-based activities could be incorporated into the evaluation of student learning.

Plan of Work
I propose a one-year study to demonstrate “proof-of-concept” for the use of a statistics game to facilitate learning in applied statistics. Hiring of programmers and creating a detailed game design document will begin in January. In June, we would hold a workshop for statistics instructors from across campus to discuss the game design, demonstrate the initial stages of the development, and get feedback. Participant feedback would be incorporated in the ongoing development work. Although the program won’t be developed in time to use in the Fall of 2015, prototypes of several modules will be ready, and I have approval to use the prototypes in a section of Elementary Statistics (N = 95). Student feedback will be collected and used to guide revisions. In December, a small group of interested instructors (3-5) from a variety of programs across campus (e.g., College of Public Health, Psychology) will be asked to participate in a focus group and provide detailed feedback on the game design and prototype modules.

Learning Objectives
There is an ongoing effort in statistics to shift instruction from a focus on procedural calculations to skills such as statistical thinking, problem solving, interpretation, and evaluation. Along with this shift, there is a growing understanding that students often gain only a superficial understanding of the foundational concepts in statistics (e.g., variability, sampling distributions, statistical inference) in traditional introductory statistics courses. An interactive simulation environment would allow students to focus on these higher-order skills and foundational concepts without getting bogged down by calculations.
We know from other fields that creating an interesting immersive interactive environment has the potential to dramatically increase students’ engagement with the content. In games, players learn through failure, which is the best route to excellence (Will Wright, 2011). In a simulation environment we can create a compelling problem space in which users can engage in self-direct exploration and knowledge building. In addition, students will be able to see immediate signs of achievement and progress. However, gamification of a learning process is no guarantee of increased engagement and achievement. We will carefully consider aspects of behavior design to optimize student engagement with the statistics game.

Framework
The statistics game will be created using four models: 1) Codecademy (2011); 2) Barbie Pet Rescue (Mattel, 2000); 3) High School Story (Pixelberry, 2013); and 4) Minecraft (Mojang, 2011). See the Appendix B for detailed descriptions of each of these programs. The statistics game (as yet unnamed) will share some features with each of these four programs. In terms of structure and appearance, the environment will be most similar to Codecademy. The content would be in modules that have specific learning goals. The user may go through the modules in an order, or explore based on needs/interests. Much like Codecademy, tasks within a module of the statistics game will be designed to break down complex problems and isolate specific learning targets in order increase the accessibility of the content. See the Appendix C for a mock-up of possible modules.

Like High School Story, the game will take place in a virtual community populated with people who differ in ways that are similar to real life differences. A college campus seems like a natural setting for this virtual world. If the user can understand the setting for the activities, it will be one less hurdle for knowledge construction. The activities will focus on topics commonly discussed in the mainstream media (e.g., wellness, healthcare, psychology).

Similar to Barbie Pet Rescue, this will be a task-oriented role-playing environment with many opportunities for feedback. For example, the user may be an intern in the office of the Recreation Services Director. There will be information that needs to be collected and analyzed in order for the Director to make informed decisions, and the user will design the data collection, conduct analyses, and make recommendations. The goal is to foster users’ self-concept as problem solvers and critical thinkers. In addition, we want users to see themselves as successful at the common statistical tasks encountered in real jobs.

The final learning platform that we would like to emulate is Minecraft because of its focus on open-ended, self-directed activity. A key part of the statistics game will be a large database with many variables as well as data simulation capabilities. This has the
potential to allow the users to play the role of researcher and construct their own research questions. Whereas in Minecraft the tools are things like an ax and the resources are things like gold, the tools available in the statistics game will be statistical tools (e.g., a histogram, t-test) and the resources will be data. Initially, this feature may be limited, but it is an important part of the long-range goals for the project.

Once the statistics game has been deployed and evaluated in the Elementary Statistics class, my hope is that there will be interest in incorporating it into other statistics classes on campus. I expect that it could be adopted as is for other introductory courses, and, with extensions, it would be useful in more advanced courses.

I am running out of space, so I will put the Evaluation Plan in the next section.

Evaluation Plan
In order to conduct ongoing evaluation of the product development, data will be collected from students and instructors.

Prototypes of several modules will be tested with volunteer students in Elementary Statistics in the Fall of 2015. Students will be asked pre-and post-test questions about their understanding of the covered concepts. Feedback will be collected from students to guide revisions using both structured questions as well as open-ended discussion. Data files will be created when students use the program, and we will be able to analyze variables like time spent per activity and student success rate per activity. In addition, students will be asked to complete the Survey of Attitudes Toward Statistics-36 (SATS-36). Data will be collected at multiple time points. Student volunteers will be offered a small amount of compensation for participation – possibly $10 gift cards to Iowa City businesses like Molly’s Cupcakes and Aspen Yogurt. We expect due to the use of volunteers and the small amount of compensation that approval from IRB will not be a problem.

As noted earlier, statistics instructors from around the university will be invited to provide feedback in the middle of the year and at the end of the year. Results from both students and instructors will be written up for publication to illustrate the efficacy and validity of this approach to promoting student engagement and statistics learning.

Current Resources
The Statistical Outreach Center (SOC) has adequate PC computational and data resources to support the development of the statistics game for a PC platform. A research assistant in the SOC will be able to provide some assistance (10 hours per week). My expertise in applied statistics and teaching will serve as the foundation for this project (see Appendix D for more information). I am not a web developer, but I do use computer programming to run statistical analyses, and I have taken computer
programming classes. I am well positioned to work with web developers to create a simulation environment that helps students develop a firm understanding of the foundational concepts in applied statistics. Kathy Schuh will provide input on instructional design and cognitive science aspects of the project. Dr. Schuh’s expertise is in learning theory and instructional design.

Needed Resources
We will need one half-time (or two quarter time) undergraduate computer programmers to write the code. We will also need some time from a professional web developer to guide the programming. I believe 20 hours per month will be adequate. In addition, we will need some money to supply incentives to student volunteers.

Additional Resources
If funded, I will use this project as a springboard to obtain funding for projects that would be integrated with this project. My long term goal is to do a series of studies investigating how differences in classroom instruction (including the use of games) are related to important learner outcomes like interest and achievement in applied statistics coursework.

Planned Phase II
In the “proof-of-concept” phase (Year 1), it will only be feasible to develop a small number of modules for use on a PC and only with a single role option (e.g., Intern to the Recreation Services Director). As part of Phase II (Year 2+), we plan to: 1) adapt the software for different devices; 2) add additional role-playing options (e.g., intern in the Provosts office, intern at the Performing Arts Center); and 3) develop additional modules. Funding for Phase II will be sought from multiple sources.

### What is your rough estimate of costs?

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<th>Cost Item</th>
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<tr>
<td>One half-time or two quarter-time student programmers</td>
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<tr>
<td>Part-time professional web developer (20 hrs/mo)</td>
<td>$16,000</td>
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<td>Incentives for student volunteers</td>
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<td>Total</td>
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With this level of funding, we can develop several prototype modules to demonstrate the power of this platform to improve student learning and interest in statistics. However, if the committee thinks it would be better to cut back on the development goals for Year 1, we could make do with less student programmer time and/or professional web developer time. Funding the student and professional programming lines at 75% of what I propose would result in a total project cost of $26,100.