Project Summary

The proposed project seeks to expand upon and evaluate the previous project "Online Statistics Education: An Interactive Multimedia Course of Study." This original project consists of a website for teaching introductory-level statistics. This website incorporates (a) 14 content chapters containing both text and multimedia presentations of the material, (b) interactive simulations and demonstrations (c) a set of 15 case studies, and (d) a collection of statistical analysis procedures and calculators.

One aim of the proposed project is to enhance the value of materials by making them easier to use them with learning management systems such as Blackboard. A learning management system typically offers features that assist instructional designers with the following tasks: importing and assembling of learning elements, serving training or learning events (i.e. courses) to learners, and testing and recording learner progress through the content. One aspect of this proposal is to make all the content currently on the website available as Shareable Content Object Reference Model (SCORM) modules. SCORM is a collection of specifications that enable interoperability, accessibility and reusability of Web-based learning content. The major learning management systems are compatible with SCORM. This means that any instructor using one of these learning management systems would be able to incorporate our SCORM elements easily into the course.

The second aim of the proposed project is to create a large bank of test items so that the materials can be used as part of a mastery-learning course. In such a course, students are asked to complete an on-line mastery quiz at the end of each section. When used in conjunction with a learning management system, students receive immediate feedback, and instructors are able to avoid the burden of grading thousands of tests.

More and more students are acquiring powerful mobile devices such as Apple's iPhone/iPod Touch or devices running Google's Android operating system. As a result, the demand for learning materials compatible with these devices that allow "anytime/anywhere learning" is growing. The third aim of the proposed project is to optimize the materials to run on these mobile devices and thus provide students with easy and constant access to learning materials. Finally, the proposed project seeks to assess the effectiveness of the materials across a range of types of educational institutions and classes. These evaluations will take place at Rice University, Tufts University, University of Houston (Clear Lake Campus), Kent State University, Ashland Community and Technical College (in Kentucky), and Westbury High School (Houston).

The intellectual merit of the proposal is reflected in the expertise employed to assure that the quality of the materials as well as the application of the latest theories and findings in cognitive psychology and the learning sciences to the development effort.

The broader impact of the proposed project will be the wider use and increased quality of the materials currently part of the Online Statistics project. The existing materials have been well received and are widely used. The site was featured as the "Hot Spot of the Month" by the Math Forum in October, 2008. One measure of its use and reach is that there were 181,792 unique visits to the site in the Fall, 2008 semester (8/24-12/24).

Results from Prior NSF Support

Award Number: 0089435
Amount: $401,990
Dates: 2/01/2001 - 01/31/2006

Title of Project: Online Statistics Education: An Interactive Multimedia Course of Study

The primary activity of this project was to develop a website to be used for teaching/learning statistics at an introductory college level. The website contains (a) 14 content chapters, (b) interactive simulations and demonstrations, (c) a set of 15 case studies, and (d) a collection of statistical analysis procedures and calculators. The site is in the public domain and can thus be used and/or copied freely. A portion of the work is also available as 78 modules on the Connexions website. Connexions is a repository for open source scholarly and educational materials.

In recognition of the finding that students differ in their preferences and learning styles (e. g., Cagiltay, 2008; Felder & Silverman, 1988, Riding & Grimley, 1999), the material is available in three modes: standard, condensed, and multimedia. We expect students will gravitate towards the multimedia option whenever available.

Chapters

Standard Mode
The standard mode of presentation resembles the presentation of a traditional paper textbook that includes realistic examples and material to capture the students' interest. Each section has links to prerequisite sections (if any), a list of learning objectives, and interactive self-test questions. There are two major advantages that the online presentation has over a conventional paper textbook. First, it includes an extensive glossary that is linked to words on the content pages. Second, it includes interactive self-test questions at the end of each content page that provide students with feedback as well as explanations of why some answers are wrong and others are correct. Some self-test questions generate data randomly for the student to analyze. Despite the advantages of online presentation, many students prefer reading printed text rather than reading a computer screen. To facilitate printing the material, we have provided PDF versions of the content for easy downloading.

Condensed Mode
The condensed presentation contains only the key information, without any of the examples or motivational material. Some students prefer to get to the heart of the material and do not wish to be distracted by applications. The condensed mode is especially useful for students reviewing the material.

Multimedia Mode
The multimedia presentation consists of a spoken lecture synchronized with a series of slides containing key points and/or graphics. This mode is designed to be as interesting and motivating as possible. Moreover, the presentation of a combination of visual and auditory information has

been found to expand effective working memory and to improve learning (Low & Sweller, 2005).

Simulations and Demonstrations

An important part of the project is the integration of 33 Java simulations and demonstrations into the written content. Research has shown that students do not necessarily learn well from simulations that put them in the position of passive observers. However, positive results have been obtained when students are asked to answer specific questions about how a simulation will turn out before interacting with it (de Jong, Hartel, Swaak, & van Joolingen, 1996; delMas, Garfield, and Chance, 1999). Therefore, in this project we present simulations and demonstrations using the "query first " method. Before viewing a simulation, students are presented with a short set of questions. Most of the questions are multiple choice, although some require numerical answers. Students are asked to answer each of the questions even if they have to guess. Feedback is not given initially to individual questions although the proportion correct is shown after the last question is answered. After the simulation, students are then asked to answer the questions again, this time using the simulation experience to help them discover the correct answers. Since it may not be apparent to a student exactly how to best use the simulation to discover the answers, the simulation allows the student to view (a) general instructions, (b) step-by-step instructions, and (c) a summary. The general instructions provide information on how the simulation works and how to operate it, but do not instruct the student on how to use the simulation to discover the answers. Students for whom the general instructions are insufficient can choose to view the step-by-step instructions, which show exactly how the simulation can be used to discover the answers. The summary reviews the important principles that the simulation demonstrates. When a student answers a question for a second time, detailed feedback is given about which response is correct and why.

As an example, the "Confidence Interval Simulation " begins by asking the following four questions:

1. What proportion of confidence intervals for the mean do not contain the population mean?
2. Which is wider, a 95% confidence interval or a 99% confidence interval?
3. Does sample size determine the probability the interval will contain the population mean?
4. Is it possible for the 95% confidence interval to contain the population mean while the 99% confidence interval does not?

We have found that students often get these questions wrong, especially question three. After guided interaction with the confidence interval simulation, students find it easy to determine that sample size does not affect the probability of containing the parameter but, instead, affects the widths of the intervals.

Case Studies

The influential GAISE report (GAISE, 2005) sponsored by the American Statistical Association concluded that:

> "It is important to use real data in teaching statistics, for reasons of authenticity, for considering issues related to how and why the data were produced or collected, and to relate the analysis to the problem context. Using real data sets of interest to students is also a good way to engage them in thinking about the data and relevant statistical concepts."

In order to provide students with real data, our site contains 15 case studies based on real data. These data are used to illustrate the various concepts and statistical procedures used in the text. Each case study presents an overview of the original research project, its experimental design, the research questions, the data, and exercises. Many of the case studies have links to associated materials on the web. Each case study also contains a list of exercises that can be performed with the data from the case study.

The content chapters and the case studies are highly integrated. Many of the concepts presented in the standard mode are presented in terms of examples based on the case studies and many of the end-of-chapter exercises are based on the case studies.

Statistical Calculators

The statistical analysis capabilities are based upon the 10 statistical distribution calculators of the "Analysis Lab" originally developed as part of the Rice Virtual Lab in Statistics (Lane, 1999) as well as additional procedures for Chi Square Tests, Normal Quantile Plots, and Complex Analysis of Variance Designs. The procedures are designed to be very easy to use. None require the student to enter any commands. The site also contains calculators for nine statistical distributions and a calculator for converting between Pearson's r and Fisher's z. The statistical procedures are all easily accessible from the case studies, so that a student can copy the data from the case study and paste it into the Analysis Lab to the calculations.

Assessment

The value of the site was assessed in the following six ways: a survey of students who had used the site in a course, an assessment by faculty with experience teaching statistics, a survey of student assessments of individual simulations used in an in-class activity, feedback from users of the website, and usage statistics. It should also be noted that the site was featured as the "Hot Spot of the Month" by the Math Forum in October, 2008. Finally, the sampling distribution simulation from the Rice Virtual Lab in Statistics (a project that preceded the Online Statistics site and is now incorporated as part of it) won the Multimedia Educational Resources for Learning and Online Teaching (MERLOT) classics award for statistics in 2007.

Student Survey

A survey was distributed to 16 students whose professors had used the site as a part of their statistics course. Students responded to questions on a five-point scale (strongly disagree, disagree, neutral, agree, strongly agree). In general, the students' viewed the site very positively: 87% of the students agreed or strongly agreed that the interactive simulations helped their understanding of the material; 94% agreed or strongly agreed that the examples in the text were helpful; 81% agreed or strongly agreed that, for the most part, the concepts were clearly explained.

In-Class Evaluation of a Simulation

To investigate students' impressions of the simulations and demonstrations, surveys were distributed to classes immediately after the presentation of a lecture using the Confidence Interval Simulation demonstration (http://onlinestatbook.com/chapter8/ci_sim.html). In the lecture, the instructor first introduced the fundamental concept of a confidence interval and then went through the "pre-simulation" questions with the entire class. The instructor read the question aloud and then had the class select the answer based on a class vote, i.e., whichever answer received the most votes was used.

A three-item survey was presented to 50 students. Eighty per cent of the students strongly agreed, or agreed that interacting with the simulation helped in understanding the concepts; 78% strongly agreed or agreed that explanations of why their answers were incorrect were helpful; and 78% strongly agreed, or agreed that it was helpful having questions before the simulation.

Faculty Assessment

All four faculty members were positive about the site. All stated that they planned to incorporate different aspects of the site into their own lectures and web pages for future classes.

User Feedback

We have received considerable feedback on the website, the vast majority of which has been very positive. The two latest emails we received are shown below., The first is from a professor and the second from a student. Permission was granted to include the first email. Since the name and email of the second one are not shown, permission was not asked for.

> December 9, 2008
>
> My name is Brian Castellani, and I am an associate prof of sociology at Kent State University, Kent Ohio. This Spring I am taking my statistics course online--yeah! I have used your fantastic HyperStat website as supplemental material in my regular stats and research methods courses. students absolutely love it! I wanted to know if students have permission to download the Online Statistics Education book as the textbook for my spring course and if I may put a link to the website in my WebCT online course. I know your website states that most of the materials are in the public domain, but I just wanted to check because of all the hard work you have put into making such an excellent product.
>
> Respectfully,
> Brian Castellani
>
> December 23, 2008
>
> Thanks a million for your kind help. Don't have words to appreciate your great work. This site is a blessing for students eagerly looking for some authentic material on statistics. Found it extremely helpful. Wish you all the best.

Thanks once again,

Anna.

Usage Statistics

The website had 222,632 visits and 181,792 absolute unique visitors in the Fall 2008 semester (8/24/08 – 12/24-08). As mentioned previously, much of the content on the site is also available at the Connexions website. The total number of views of the associated Connexions modules since the beginning of the project through 12/31/2008 is 2,234,650. Since the content is in the public domain and is available for download, there are other users not included in these statistics.

Publications from the NSF Award

Lane, D. M. & Peres, S. C. (2006) Interactive simulations in the teaching of statistics: Promise and Pitfalls. *Proceedings of the Seventh Annual Meeting of the International Conference on the Teaching of Statistics*, Salvador, Brazil.

Lane, D. (2003). Online Statistics Education: A Multimedia Course of Study. In D. Lassner & C. McNaught (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003, 1317-1320. Chesapeake, VA: AACE.

Project Description

The proposed project seeks to further develop the "Online Statistics Education: An Interactive Multimedia Course of Study" project in order to accomplish the following four specific aims:

(1) facilitate the use of the "Online Statistics Education: An Interactive Multimedia Course of Study" (OSE) materials in courses by (a) enabling the development of mastery-learning courses through the creation of a large bank of test items and (b) making them compatible with learning management systems;

(2) revise and improve selected content, develop additional case studies, improve the usability, and increase the production value of the multimedia components;

(3) optimize the materials to run on mobile devices to provide students with easy and constant access to learning materials; and

(4) assess the effectiveness of the materials across a range of educational institutions.

Facilitating Use in Courses

Learning Management System Compatibility

A Learning Management System (LMS) is server-based software that automates the administration of training and education events. The LMS provides the capability to register users, host learning content (including content in various media formats), track courses in a catalog, provide communication capabilities within a learning context, and record data from learners. It also provides appropriate reports to management. The database capabilities of the

LMS extend to additional functions such as institutional management, online assessments, personalization, and other resources.

In an LMS an instructor can add annotations (via a link) to any piece of the course including lectures, topics within lectures, discussions, actual discussion postings, etc. In addition, students can also add their own annotation links to anything in a course and, optionally, they can make their annotation links available to the instructor or other students.

Learning management systems have powerful features for automating testing. An LMS can randomize questions, set time limits, permit multiple attempts, and allow students to review past attempts at a quiz. Instructors can specify whether correct results are shown as feedback, create their own test banks, import test banks from other sources, and provide analyses of test items. A wide range of item types are available in an LMS including multiple choice, multiple answer, matching, ordering, calculated, fill-in-the-blank, and short answer.

An alternate term, Content Management System (CMS), when used in the context of learning delivery systems, is usually synonymous with LMS. However CMS can also refer to a back-end database management system for managing general content for standard web sites.

Learning management systems are very widely used in higher education in the United States and their use is growing rapidly. Although precise figures are not available, a report from the Department of Education (Persad, Lewis, & Tice, 2008) found that during the 2006–07 academic year, two-thirds of 2-year and 4-year Title IV degree granting postsecondary institutions reported offering online, hybrid/blended online, or other distance education courses. It is likely that the vast majority of these institutions were using an LMS. Moreover as long ago as 2004 (US News and World Report, October 19, 2004) the Blackboard LMS was reported to have been used in more than 150 of the 239 schools included in the U.S. News & World Report ranking of top tier national universities and liberal arts colleges. Recently Young (2009) stated that just about every college has an LMS.

Benefits of LMS Compatibility for OSE. Currently OSE materials can be used with an LMS by simply having the LMS link to the website. However, since the materials are not fully integrated with the LMS, this use does not take full advantage of the power of the LMS. We see two important advantages of integrating the OSE materials with an LMS: annotation capabilities and automated testing management.

Annotation. Instructors often have things to say about the textbooks they use in their courses. For example, an instructor may wish to point out the relationship between something in the text and material covered in class or in other reading material. The instructor may wish to let the class know which sections are critically important and which are not. Further the instructor may want to motivate students by pointing out that a certain section is difficult and that they should not be discouraged if they do not understand it the first time through. One of the important features of many learning management systems is that they allow the instructor to annotate the learning materials so that the instructor comments are integrated with the learning materials themselves. Thus, if the OSE materials were contained within an LMS, then an instructor's annotations of the material would be integrated into the material and would be conveniently available to students as they view the material.

There are many ways students can benefit from the ability to make their own annotations of the learning materials. For example, they might want to write a short note to themselves indicating that they should review a particular section. Or, they might explain a concept in their own words so that, when reviewing the material for a test, they are better able to understand it. Optionally, students can also make their annotations available to other students in a course or learning event. This is especially useful when collaborating with other students on group projects or initiatives as a part of the learning experience or as a deliverable for a course.

Automated Testing Management. The OSE currently contains exercises at the end of each chapter and, as described in the section on mastery learning, we plan to develop many more test items. The automated testing features of an LMS would allow an instructor to make full use of our items with a minimum of effort. The instructor could select from among our items, mix and match our items with those that are provided with other textbooks or from other sources, and/or modify out items as desired. The statistical analysis of items could reveal which aspects of the material were easily understood and which were problematical. Moreover, it would be helpful for redesigning tests to achieve higher reliability. The automatic grading of test items saves time and makes it possible to develop a mastery-learning course in much less time than it would otherwise take.

Technical Considerations. In order to make the OSE materials compatible with LMS's, we propose to make all the material available as Shareable Content Object Reference Model (SCORM) modules. SCORM is a collection of specifications that enable interoperability, accessibility and reusability of Web-based learning content. The major learning management systems are compatible with SCORM. This means that any instructor using one of these learning management systems would be able to incorporate our SCORM elements easily into the course.

In more technical detail, SCORM is an XML-based framework used to define and access information about learning objects so that they can be easily shared among different learning management systems (LMSs). SCORM was developed in response to a United States Department of Defense (DoD) initiative to promote standardization in e-learning. SCORM-compliant tools and applications serve to enhance content portability and interoperability among various hosting environments and systems for sharing distance learning courses among various learning management systems.

Dr. Giguere at Tufts University will utilize an LMS (Angel) to export the OSE modules to a SCORM compliant package that can be imported into most commercial LMS environments. A side benefit of this process will be the opportunity to ensure that all learning materials are Section 508 compliant with the American with Disabilities Act/U.S. Rehabilitation Act.

Mastery Learning

Mastery learning is based on a very simple yet powerful concept: students must master material at a defined and high level before proceeding to new material. Two important elements of mastery learning are self pacing, repeated testing, and prompt feedback.

Mastery learning is well established as an effective paradigm and is arguably the most effective way to learn. For example, Kulik, Kulik, and Bangert-Drowns (1990) conducted a meta-analysis of the effect of mastery learning and concluded that "few educational treatments of any sort

were consistently associated with achievement effects as large as those produced by mastery teaching (p. 292). Unfortunately, mastery learning is not used as frequently as one would expect for a method of such proven effectiveness. The most common reason for the relative lack of use of mastery learning is likely the amount of time required for initial development and the time required to grade the large number of quizzes invariably associated with mastery learning. Fortunately, learning management systems greatly reduce the effort required to develop and administer a mastery-learning course. Of particular value is the ability of LMS's to automatically grade and give immediate feedback to students.

This proposal seeks to develop a large item bank for the OSE material in a format compatible with LMS's. The availability of the large item bank will reduce the development time for a mastery-learning course and the use of an LMS will reduce the administrative burden. Specifically, we propose to develop enough items for at least three quizzes on each of the 14 chapters in the OSE materials. These items will be of several types including multiple choice, numeric and short answer. All will be written so that they can be scored automatically. Note that if a short answer question is written so that the answer is sufficiently constrained, it can be graded automatically by an LMS.

Revisions and Improvements

We propose to revise and improve the content of the chapters, develop additional case studies, improve the usability of the website, and increase the production value of the multimedia components. Details are presented below.

Content of the Chapters

We propose to review all existing material in detail and make improvements where we can. Dr. Scott will play an important role in this review. Two of us (Dr. Peres and Dr. Lane) have used the OSE materials extensively in their own teaching and have a good sense of where students have difficulty. For a more objective indication, we plan to review tests and quizzes we have given in order to reveal concepts that were not adequately understood by the students. Finally, as will be described in the section on assessment, we propose to do both formative and summative evaluation. The formative evaluation will point us to sections in need of improvement

Additional Case Studies

As noted in the section "Results from Prior NSF Support," there are good reasons for using real data in the teaching of statistics (GAISE, 2005). The 16 case studies in the OSE materials were chosen so that they would be easy to understand, motivational to students, and illustrative of important concepts in statistics. Many of the case studies have links to outside material for students wishing to explore a topic in more detail.

We propose to develop an additional 16 case studies so as to provide instructors with a larger base of examples from which to choose. Although the current set of case studies cover a range of topics, the emphasis was on research in psychology. The additional case studies will be taken from a wider range of disciplines. One discipline we will feature is nutrition, a specialty of Dr. Hauser (who will play a major role in the development of the case studies), and a topic with considerable intrinsic interest and one in which experiments can be found that do not require

students to master complex theoretical concepts in order to understand them. We plan to develop all 16 new case studies the first year so they can be evaluated and revised in the second year.

Improving Usability

Although we believe that, overall, the OE website is relative easy to use, there is no doubt room for improvement. We are already planning two important changes. The first involves the interface to the interactive simulation; the second involves navigation of the multimedia presentations.

As described in the "Results from Prior NSF Support" section, simulations are much more effective when students are asked to answer questions about the concept being demonstrated before experimenting with the simulation. Students interacting with simulations in the OSE begin by answering a series of questions. No feedback is given for specific questions although the total number answered correctly is presented at the end. Students are then asked to use the simulation to help answer the questions which are presented a second time, this time with feedback on each question. In the present implementation, the simulation is shown in one window and the questions in another. This requires students to switch back and forth between windows as they interact with the simulation and answer questions. This is clearly a somewhat clumsy process. The reason the simulations were designed this way is that when the interactive simulations were first developed, a large proportion of the users had screens that were 800 x 600 pixels across. Since we designed the site to work well with that screen size, it was impractical to have the questions and the simulation in the same window. Screen sizes have increased greatly over the past several years: Our web logs for December, 2008 show that less than 3% of users have screen sizes smaller than 1024 x 768 pixels. This justifies redesigning the simulations to be optimized for this larger size, a change that would allow the simulations and the questions to share a window. Users with smaller screen sizes would still be able to use the simulations. However, they would have to do a fair amount of horizontal scrolling.

A second manner in which we propose to improve the user interface is to provide better controls for the multimedia presentations. The presentations are stored as .mov files and are played by Apple's free QuickTime browser plug-in. QuickTime controls allow the user to move to a point in the presentation (using a slider) play, pause, fast forward, fast reverse, step frame by frame (using arrow keys), and control the volume. Although these controls are adequate, we found that several students reported that they would have liked to be able to jump to specific sections of a presentation. This is a good idea since it would allow students to replay and review specific sections without searching using the slider. Therefore, we propose to build this capability into the revised version. Technically this is feasible since QuickTime movies can be controlled by JavaScript. It does, however, take time to implement since the precise timing of the beginnings of each section must be determined and included in the code.

We also propose to conduct systematic usability tests to uncover other areas that could be improved. Dr. Peres, PI of the University of Houston Clear Lake (UHCL) portion of the project, will have primary responsibility for the usability testing. This testing will be done for two users groups: students and instructors. The usability testing for both groups will follow steps of traditional user centered design: creating user profiles and task analyses, establishing usability

goals, and finally conducting user testing. The user testing will be designed to evaluate whether the site meets a high standard of usability. Both performance (including verbal protocols) and subjective reactions will be measured. Among the measures will be the System Usability Scale (SUS) developed by (Brooke, 1996). The SUS can be administered very quickly and has been shown to have good reliability (Bangor, Kortum, & Miller, 2008). Further, this instrument has proven to be effective for identifying usability improvements with the same interface over many iterations of that interface.

The results from the first round of user testing will be used to inform revisions to the website. After the initial changes are made, iterative testing and revisions will be conducted until the desired high level of usability is achieved.

Production Value of Multimedia Presentations

Multimedia presentations can be a good alternative to written text. In an effort to maximize the positive effects of multimedia presentations, we propose to increase the quality of the OSE multimedia presentations.

The original version of the OSE site was developed before broadband access was prevalent. Therefore, the presentations were designed to work well even when students were connected using 56k phone modems. This was accomplished through using software employing excellent compression algorithms. Nonetheless, some audio quality was sacrificed to achieve low bandwidth versions. Low bandwidth was also achieved by making the size of the movies relatively small (504 x 360 in most instances). In order to achieve a higher production value, we plan to redo the movies using the more sophisticated H.264 codec. Although most of the original audio we developed will be able to be used, some may have to be re-recorded to increase the quality. The revised videos will be 600 x 400 pixels. Naturally, the original versions will remain available for use by students with slower internet connections.

Optimizing for Mobile Devices

The number of options available for hosting our materials is expanding as more and more students are acquiring powerful mobile devices such as Apple's iPhone/iPod Touch or devices running Google's Android operating system. According to Clothey and Schmitt (2008) a large majority of college students have and use an iPod on a daily basis. Consistent with this assertion, Evans (2008) found in a survey of students that 74% owned a digital media player and another 7% intended to purchase one in the near future. Although most of the players owned by these students are not as powerful as the iPhone or iPod touch, these devices are being sold by the millions.

Students appear to be very positive about the prospect of using their mobile devices as learning tools. For example, Evans (2008) found that that students believe that podcasts are a more effective tool for reviewing material than either their textbooks or their own notes. He also found that students are more receptive to learning material from a podcast than from a traditional lecture or textbook.

Recently Camille Peres of University of Houston-Clear Lake emailed students in her statistics course using the OSE materials about how likely they would be to view the multimedia

presentations on a handheld device if that were possible. Of the 13 students who responded, 12 were very excited about the idea. Excerpts from each of the 13 responses are shown below. These responses show that there is strong interest among the students for mobile learning.

> "I would use it for sure", "I think it would be helpful", "I think it would be great", "I probably wouldn't use it much because I'd end up tuning it out and have to listen to it multiple times.", "I think that it's an excellent idea", "I have such a hectic schedule that having a way to study in between appts, ect [sic] would be helpful.", "That'll be awesome", "I would definitely use it", "I don't have an Ipod but would definitely use it if I had one.", "I think something like this would be nice to have.", "Sounds like a good idea especially for busy people who study on the run", "I would definitely go for it", "I would most definitely use it."

Formatting the standard presentation mode for mobile devices will require only that we create a new style sheet and recreate some of the graphs to avoid distorting due to rescaling. The interactive self-test questions at the end of each section pose a more difficult problem since they are currently presented using a Java applet and Java is currently not supported on the iPhone/iPod touch, although it may be sometime in the future. However, there would still be the possibility of performance and compatibility problems with Java. Therefore we plan to use JavaScript to present the self-test questions.

As noted in the section on improving the production value of the multimedia presentations, we plan to redo these presentations using the H.64 codec. We will do this using Apple's iMovie software. Once the movie is created in iMovie, it can be compressed in other sizes such as the 480 x 320 pixels of the iPhone/iPod Touch. Thus, the major effort for optimizing the multimedia presentations for mobile devices will be done as we improve the production value. Besides, the iPhone/iPod touch, the other major "smart" mobile devices including T-Mobile's G1 (based on the Google Android OS) and the Blackberry Storm support H.264.

National Science Digital Library

According to the mission and scope of the National Science Digital Library (NSDL), the field of statistics is an appropriate topics for inclusion in the library. In terms of making this proposed statistics education website accessible in NSDL, the project plans to use NSDL collection tools. These tools will assist in the generation of metadata records and in the ability of transmitting metadata records to NSDL. The project will create metadata records that catalogs each chapter of the proposed OSE website with the following information: title, URL, description, resource creator, education level and subject keywords. Once these metadata records are ingested into NSDL, the proposed statistics education website will be accessible to NSDL users. The Rice University psychology graduate student Sebastian Thomas, supervised by David Lane and assisted by an undergraduate research assistant, will create the metadata records.

Assessment

The assessment will have both an external and an internal component. The external component will provide objectivity and evaluation expertise; it will be under the direction of an external

evaluation specialist, Dr. Michael L. Connell. Dr. Connell has served as external evaluator for prior NSF and DOE projects and will oversee the ongoing evaluation and development of the external evaluation. Dr. Connell is based in Houston so communication with the Rice and UHCL investigators can be done without logistical problems.

The internal component will supplement the external by providing detailed information on selected aspects of the project. Naturally, there will be some overlap between the external and internal evaluations.

External Evaluation

The effectiveness of the Online Statistics Education (OSE) project will be measured on the basis of both formative and summative evaluations drawn from a mixture of quantitative and qualitative data. Interim evaluation data will be made available to project directors to provide a continuous feedback loop for modification or refinement. The evaluation plan is comprised of four themes: 1) Platform stability, 2) Content validity, 3) Student usability, and 4) Instructor usability.

The data sources designed to address issues arising within each theme will be drawn from the following participating pilot sites: (1) Rice University, (2) University of Houston-Clear Lake, (3) Tufts University, (4) Ashland Community and Technical College, a part of the Kentucky Community and Technical College System, (5) Kent State University, and (6) an AP statistics class in Westbury High school of the Houston Independent School District. These data sources will allow for a rich evaluation of the project across a variety of student populations ranging across High School, two year and four year universities. Among these colleges and universities, the University of Houston-Clear Lake is the most diverse ethnically. In the Spring of 2008, 21.8% of the students were Hispanic and 8.4% were Black. A major focus of the external evaluation effort will be to facilitate the ongoing collection of information across sites and sharing of all findings in a timely fashion to each of the participants.

1. Platform Stability

    a. To what degree do the OSE materials provide a stable learning environment?

        Data will be collected from students using each format of the materials and a listing of reported “bugs” will be generated from students and instructors using a standard reporting form.

        Errors will be classified as internal errors (such as problems in programming/code) or infrastructure errors (such as unexpected bandwidth requirements). These error reports will be used to provide feedback for refinement and program improvement.

    b. What is the recommended IT infrastructure necessary to successfully implement the OSE?

        Faculty and student feedback will be combined with the analyzed bug reports to

prepare a suggested minimal IT infrastructure to insure successfully implementation and replication. Categories will be created to cover each of the project formats with separate suggestions for each format.

2. Content Validity

    a. Does the content presented in the OSE materials cover the needed elements for success in statistics?

    An external board consisting of university faculty with extensive experience in distance education, statistics, and evaluation will be formed to examine the materials within the OSE. This report will be combined with feedback gathered from students at each of the participating pilot sites and areas of strength and weakness will be documented and shared with program participants.

    b. Is there sufficient depth in the OSE materials to allow for student learning?

    Together with the content analysis, the external board will make suggestions for areas of further development as well as topics that are overly represented. These suggestions will be combined with feedback from instructors using the materials at each of the participating pilot sites to create both formative and summative reports.

    c. Are there areas of content misalignment or unexpected student performance gaps?

    Student data from quizzes and tests will be analyzed using Sato's Student-Problem analysis to identify unexpected patterns of student and item differentiation. Content items with a modified caution index ≥ 0.25 will be identified for follow up evaluation and forwarded to the external board for further consideration. Students with a modified caution index ≥ 0.25 will be identified for follow-up interviews.

3. Student Usability

    a. Does the OSE create a positive learning environment for students?

    Ongoing feedback from student surveys will be used to gather measures of student satisfaction with the OSE, student suggestions for improvement, areas for additional support, etc. Given the ongoing nature of the pilot phase it is expected that these surveys will reflect the emerging themes reported by the students themselves. Formative reports will be shared will participating sites for program improvement.

    b. Which formats and features of the OSE are perceived of highest value by students?

    During their instruction students will be surveyed concerning their valuation of

key program features. Results will be grouped by format of the OSE the students received and results shared. Features receiving highly negative feedback will be identified for further consideration

4. Instructor Usability

    a. To what degree do the OSE materials provide a usable set of teaching tools for instructors?

       Ongoing surveys and interviews will be conducted with each of the participating instructors. Emergent themes will be identified and strengths and weaknesses reported.

    b. What additions or deletions should be made to the OSE?

       The reports generated by the external evaluation board will be combined with instructor and student feedback to create a prioritized listing of suggested changes to the OSE. These suggestions will be prepared on a monthly basis for ongoing program development and a summative end of year report will be prepared.

As the OSE project is implemented, it is probable that unintended outcomes, both positive and negative, will occur. As these outcomes become apparent, they will be documented for evaluation purposes and, if necessary, adjustments will be suggested to the project to maximize project potential. As evaluation results are collected and compiled, they will be shared with all stakeholders so that decisions and refinements can be made to maximize project success. The resulting adjustments will be documented and reported in all annual reports.

Internal Evaluation

Dr. Peres regularly teaches statistics courses using the OSE materials at UHCL. As described in the section on usability, Dr. Peres will conduct a usability analysis of the OSE. She will also investigate the mobile learning component of the project. To evaluate this component, students in the class will be loaned an Apple iPod Touch to use for the semester. iPod Touch is essentially an iPhone without the wireless phone capabilities. However, it does have Wi-Fi capabilities.

Testing of the mobile learning component will begin in the latter half of the first year or in the second year to give us time to format the materials. The iPods loaned to the students will contain both the multimedia and standard presentations of the OSE material so access to the internet will not be necessary in order to view them. Students will fill out weekly surveys covering how much time they used the iPod (for both standard and multimedia presentations), how they were using it (review, learning for the first time, and where (on the road, while exercising, etc.). Data on student reactions to the mobile learning including their judgments of the effectiveness, ease of use, and satisfaction with the experience will be conducted.

At Rice a graduate student supported by this project and supervised by Dr. Scott will teach a small section of the introductory statistics class. The course will use the OSE materials as the main text and students will be asked to provide detailed feedback on all aspects of the materials.

Dissemination Plan

The primary means of disseminating the materials will be through the OSE website. We have found this to be a very effective means of dissemination. As we noted in the "Results from Prior NSF Support" section, we had 181,792 unique visitors in the Fall, 2008 semester. Our site is very easy to find with search engines. As of this writing, it comes up first in a Google search for the terms "online statistics" (quotes not needed in the search). We also plan to continue to develop our Connexions modules which have received a total of over 2,200,000 page views since the OSE project began. As with the current OSE materials, the new materials will be in the public domain so they will able to be freely distributed. To facilitate distribution, we will make it easy to download the entire site for off-line work. PDF versions of the standard presentations will be available for those who wish to print the material.

We plan to distribute the multimedia version through Apple's iTunes University. According to Apple, iTunes University contains over 75,000 educational audio and video files from top universities, museums and public media organizations from around the world. UHCL has submitted an application to join Apple's iTunes University and we are confident that the application will be accepted. Universities have seen excellent results with this distribution method. For example, a press release by Open University states that 1,000,000 items were downloaded in the four months since it joined.

We also plan to contribute our materials to the MERLOT.org and CAUSEweb.org websites. MERLOT contains a vast collection of peer-reviewed educational materials for higher education whereas CAUSE is a national organization whose mission is to support and advance undergraduate statistics education.

In order to publicize this project we plan to submit articles to journals such as the *Journal of Statistics Education*, *Teaching in Psychology*, and the *American Statistician* and to submit papers and/or posters to conferences such as the United States Conference on the Teaching of Statistics.

Broader Impact

This project will make it easy for a statistics instructors to include a textbook, interactive simulations, case studies, a large test item bank, and a set of statistical analysis routines in their courses. The materials have been developed in accordance with recommendations of GAISE (2005) as follows: (1) The case studies allow instructors to teach using real data, (2) conceptual knowledge rather than procedures is stressed throughout the work, (3) the interactive simulations facilitate the use of active learning in the classroom, (4) the project uses technology for developing understanding and analyzing data through the interactive simulations and statistical calculators, and (5) the test item bank integrated with a learning management system uses assessment to evaluate student learning. The broader impact will be the increased use of effective teaching methods and improved teaching/learning at a large number of institutions.

References

Catiltay, N. E. (2008) Using learning styles theory in engineering education, *European Journal of Engineering Education*, *4*, 415-424.

Clothey, R. & Schmitt, C. (2008). Education in Motion: Innovating with iPods. In *Proceedings of World Conference on Educational Multimedia*, Hypermedia and Telecommunications 2008, 629-639.

de Jong, T., Hartel, H., Swaak, J., & van Joolingen, W. (1996). Support for simulation-based learning; the effects of assignments in learning about transmission lines. In A. Diaz de Ilarazza Sanchez & I. Fernandez de Castro (Eds.), *Computer aided learning and instruction in science and engineering*, 9-27, Berlin: Springer Verlag.

delMas, R., Garfield, J., & Chance, B. (1999) A model of classroom research in action: Developing simulation activities to improve students' statistical reasoning. *Journal of Statistics Education*, 7, retrieved December 2, 2008 from http://www.amstat.org/publications/jse/secure/v7n3/delmas.cfm

Evans, C. (2008) The effectiveness of m-learning in the form of podcast revision lectures in higher education, *Computers & Education*, *50*, 491–498.

Felder, R.M. & Silverman, L.K., (1988) Learning and teaching styles in engineering education, *Engineering Education*, *78*, *7*, 674–681.

GAISE: Guidelines for Assessment and Instruction in Statistics Education College Report (2005) American Statistical Association. Retrieved December 2, 2008 from http://www.amstat.org/Education/gaise/GAISECollege.htm (2005)

Kulik, C. C., Kulik, J. A., & Bangert-Drowns, R. L. (1990) Effectiveness of mastery learning programs: A meta-analysis. *Review of Educational Research*, Vol. *60*, 265-299.

Low, R. & Sweller, J. The modality principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning*, 169-182, Cambridge University Press, Cambridge, New York.

Persad, B., Lewis, L., & Tice, P. (2008) Distance Education at degree-granting postsecondary institutions: 2006–07, *NCES 2009-044,* Department of Education.

Riding, R., Grimley, M. (1999). Cognitive style and learning from multimedia materials in 11-year children. *British Journal of Educational Technology*, *30*, *1*, 43-59.

Young, J. R. (2009) College 2.0: A Wired Way to Rate Professors—and to Connect Teachers. *The Chronicle of Higher Education*, Thursday, January 8, 2009