Using Low-threshold Applications and Software Templates to Improve Efficiency in an Introductory Statistics Course

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Using Low-Threshold Applications and Software Templates to Improve Efficiency in an Introductory Statistics Course

Jason K McDonald

Brigham Young University
Abstract

This study was an exploratory study in improving efficiency in university courses by using low-cost methods of design and development that can be easily managed by university faculty. To explore this issue, we developed a lesson for the Statistics department at Brigham Young University using low-threshold applications (uses of technology that are low-cost and easy to learn) and software templates. We evaluated the lesson as a possible method to decrease the number of hours instructors were required to spend teaching in class. We discovered that students responded positively to the lesson, and that the methods of lesson design and development did provide advantages to the faculty of the Statistics department. Students reported that they learned from the lesson, liked the lesson, and felt comfortable using the lesson. Students who were most likely to react positively to the lesson were those who had experience with similar instructional models, those who used advanced features of the lesson, and those who used practice problems provided with the lesson. The advantages of using low-threshold applications and software templates included a decrease in development and maintenance costs, as well as a method to quickly analyze possible design alternatives.
Using Low-Threshold Applications and Software Templates to Improve Efficiency in an Introductory Statistics Course

Since the late 1990s the administration at Brigham Young University (BYU) has been attempting to decrease the costs associated with educating a growing population of students anxious to attend the university. One of the alternatives in which they have invested a large amount of resources is technology-mediated education (Bateman, 1998, 1999). For the BYU department of Statistics this has meant a large redesign of the introductory course, Statistics 221. For over three years, the BYU Center for Instructional Design (CID) developed a series of thirty-nine multimedia presentations and interactive tools (first created in Microsoft PowerPoint™, then converted to Macromedia Flash™) which statistics instructors could use in the classroom to supplement their lectures.

By the fall of 2002 (when the redesign was complete) the university administration had begun to ask why the department had not returned the money for temporary employees loaned to them to help complete the redesign. The administration had been led to believe that because of the redesign, the department would be able to reduce the number of instructor hours required to teach the course and so have no continuing use for those funds. The department responded that despite their original belief that the redesign would save money, maintaining the presentations (to correct errors, add new examples, or otherwise make them reflect the latest research in how to teach introductory statistics) demanded a large, ongoing, investment of resources. Despite this reasoning by the department, however, the administration’s mandate was the same: find a way to reduce the number of instructor hours required to teach Statistics 221, using the materials that
had already been created in the first redesign, so they could return the loaned university resources.

In addition to their concerns about maintaining the presentations, the department had other reasons for not responding immediately to the administration’s request. Enrollments in Statistics 221 were increasing (currently at 3800 students a year), and the department did not want to impact what they felt were already too limited opportunities for student-faculty interaction. Because this course has been an important method of attracting students to the Statistics major, the department was highly motivated to provide easy access to Statistics instructors in order to minimize the unnecessary frustrations that can come with learning the subject. Additionally, faculty in the department wanted to explore how to use in-class time to teach concepts and skills of data analysis they had never had time to address before.

This conflict between administration and faculty is not new to BYU, or to this course. Essentially, the problem was one of efficiency. The department wanted to do more, and the administration wanted them to do it for less money. To solve this problem for other departments, the CID had already explored how computer-based instructional materials with high, initial fixed costs could eliminate future variable costs (e.g. Waddoups, Hatch, & Butterworth, 2003). However most departments at BYU had discovered what consumers of instructional technology have historically also discovered: technologically rich instructional products can be too expensive to be flexibly used in real-world contexts (see McDonald, 2003). Both the Statistics department and the university administration specifically requested the CID avoid another high-cost, high-maintenance product. The purpose of this study is to explore a particular low-cost
method of improving efficiency in both design and delivery of courses that can be easily maintained by the client department.

An important part of this low-cost method came from the work of Gilbert (2002) regarding the use of low-threshold applications (LTAs) of instructional technology. LTAs are inexpensive and easy-to-learn applications of technology that do not require instructors to fundamentally rethink how they teach. A growing community of online users is generating examples of LTAs that show promising initial results in terms of improving efficiency without sacrificing instructional effectiveness (Ansorge, 2003). Additionally, because LTAs are low-cost, their use helps justify the decision to rapidly cycle through iterations of instructional prototypes, giving the users opportunity to evaluate the effects of potential design decisions with little consequence in terms of time or cost (see Schrage, 2000). By developing methods of Statistics instruction using LTAs, the CID could decrease for the Statistics department the costs of ongoing development and maintenance of computer-based instructional materials.

The results of initial attempts to use LTAs by the CID made it apparent that all of the goals given by the Statistics department and administration could not be reached without some additional method. LTAs alone did not provide the department with an acceptable user interface for their instruction, nor did LTAs eliminate the requirement for at least some complex programming in order to use the materials from the first Statistics redesign. Because of these factors the CID chose to explore an additional method of low-cost development. The use of software templates emerged as the method to solve these problems. Software templates provide a reusable container for basic visual and programmatic elements (Heinich, Molenda, Russell, & Smaldino, 1999). By developing a software template for the Statistics department, the CID could
perform once the high-cost work associated with interface development and multimedia programming. The department could then use the template to develop future lessons with very little incremental cost.

Our hypothesis is that the use of both LTAs and software templates will provide a method to lower the costs of instruction in Statistics 221, by reducing the number of instructor hours required to teach the course and by reducing the costs of developing and maintaining the instructional materials. We chose to use the method of a design study in order to investigate our hypothesis. As explained by Gibbons and Bunderson (in press), a design study is a study that:

[takes] place in live settings, and are iterative, cyclical applications of a process of design, implement, evaluate, [and] redesign. Design studies often aid in exploring a domain and possible treatments, and thus may be largely qualitative, producing narrative accounts of intense, iterative, often ideographic observations over each cycle. . . . [They] may begin to use theory to guide both the design interventions and the explanations of the processes operative in the domain. However, they may not provide adequate warrant for causal claims, nor do they fully rule out alternate explanations.

It appeared reasonable to use a design study because it was not practical to attempt to improve the course outside of the context of the course administration itself. Indeed, the original redesign was not as successful as it could have been because not enough attention had been paid to the real-life situations in which the materials would be used.

Additionally, since design studies are usually conducted in an iterative fashion, this method would provide the department opportunities to continually improve the course over time rather than attempting to make major revisions in a short period of time. This study is the first
iteration of the larger design study. To conduct this study we created one lesson to replace one in-class meeting of Statistics 221, and administered the lesson during the students’ regular course on the subject. We then gathered data on three specific questions: How will students in Statistics 221 react to this lesson? What are some of the factors that affect the students’ reaction to the lesson? Finally, do LTAs provide the Statistics department with the ability to rapidly test multiple potential designs with little consequence in terms of time and cost?

Method

Materials

We based our lesson on a model of instruction that has become quite popular at BYU. One of the computer-based courses at BYU that has generated a lot of interest among faculty is the introductory Accounting course, Accounting 200. The course consists of a series of 30 – 60 minute lessons that instruct students in the basic course content. The instruction in each lesson is delivered through a small window that contains a video of the instructor explaining the course material. This video is synchronized with another window containing textual (and occasionally animated) supplementation of the instructor’s explanation. This Accounting course significantly reduces the amount of time required of the instructor each semester, and student outcomes are as high as they were when the course was taught exclusively face-to-face (Galbraith, 2000).

It appeared that a similar instructional model would be appropriate for Statistics 221 because of similarities between the content of the two courses. For example, both are introductory courses and both rely heavily on instruction in how to use procedural formulas. But we also modified the model in one important way. Accounting 200 attempts to focus student attention on the video of the lecturer, supported by animated presentations. We chose to focus
student attention on a window containing the animated presentations from the original Statistics redesign, supplemented by a recording of an instructor. This change was based on two factors. First was a practical factor—we had been directed by the university administration to use the presentations as the starting point for this project. Second, the presentations have been already used as a successful method of instruction by in-class Statistics instructors. In a study of the use of the presentations as the basis for in-class lectures, Hilton & Christensen (2002) concluded that they were as effective in instructing students as were other methods used by the department.

In order to test two varieties of LTA configuration, we created two versions of the instructor supplementation: one video recording and one audio recording. We created multiple versions of the supplementation because of a disagreement that arose among the design team during the course of the project. Some members of the team wanted to supplement the lesson with a video of the instructor throughout. They reasoned that the developers of Accounting 200 attributed much of their success to the fact that students could see the instructor and so relate to him better. Other members of the team felt that the expense of video could only be justified for instructional purposes that could not be met by simply showing the instructor speak. “Effective video . . . is video that shows content, not someone discussing content” (Schaefermeyer, 2000, pp. 26-27). These team members felt an audio-only commentary would be sufficient supplementation to the instruction provided by the animated presentations.

The scope of our lesson was the topic of probability. We chose this topic because the faculty in the Statistics department felt that if students’ had trouble learning from the replacement lesson they could receive proper remediation with the assistance of the course teaching assistants. The topic of probability is expressed as thirty-six objectives by the Statistics
department, and takes three in-class hours to address using traditional methods. The design team and subject matter experts identified twelve objectives to be included in the lesson. The objectives selected to remain in class were those that were necessary to the basic understanding of the topic. The objectives selected to be included in the out-of-class lesson were those that were further elaborations on the basic knowledge of the topic (for example, new applications of already-learned formulas).

The user interface for the lesson included playback controls (play, pause, fast-forward, rewind), a table of contents representing major content divisions in the lesson, and buttons for the user to access help, a glossary of statistical terms, and a calculator. We also included buttons to accelerate the playback of the lesson, which is a popular feature of the Accounting 200 course. To build the interface we used Apple’s QuickTime Pro™ media player. We chose QuickTime Pro because the software has many simple-to-learn features that will allow the department to build future lessons themselves. Because the software is low-cost and reduces the skill level necessary to build a lesson, QuickTime Pro qualifies as a good example of an LTA. The completed user interface, created using QuickTime Pro, became our software template. The CID built into this template as much of the complex multimedia programming as possible, to allow the Statistics department to reuse the template for future lessons without having to reprogram the underlying logic. After completing the first template which included a window for video of the instructor
throughout (version A) we modified the template to only present the audio recording of the instructor (version B). An diagram of the components making up the user interface is shown in Figure 1, and representative images of the two interfaces are shown in Figures 2 and 3.

*Figure 1. Diagram of the Lesson User Interface.*
Figure 2. The User Interface for Template Version A.

Figure 3. The User Interface for Template Version B.

The remaining lesson development consisted of compiling the content for the lesson, recording video and audio supplementation of a Statistics instructor, and combining the content and supplementation together into the lesson templates. To help demonstrate that the department could create the lessons on their own, most of this development was done either by faculty in the Statistics department or by student employees who were of similar skill to the students available for hire by the department. Compiling the lesson content was done by decompiling the three existing presentations on probability and extracted from them the content for our lesson objectives. An experienced instructor in the department provided the recorded supplementation. We used a small web camera and lapel microphone, which were low-cost equipment and were able to be learned easily by the Statistics department. The final lesson ran about 49 minutes. The lesson was burned to CD, along with two practice problems (to give students a chance to apply what they viewed in the presentation), an interactive sample size calculator (a tool from the original redesign to help students practice the skill of computing sample sizes), and all necessary software to run the lesson.

After the lesson was compiled we began to have some concerns about its production quality. The audio track of the narration was grainy and sometimes difficult to understand. We also found the video to be blurry in some places. Despite the problems we noticed, we decided to continue with the trial of the lesson with students. We saw this as an unanticipated opportunity to
measure some of the side effects that faculty are likely to encounter when using LTAs, namely quality levels that are not the same as lessons produced by professionals with professional equipment.

**Participants**

Our participants were students enrolled in two of the nine Statistics 221 lecture sections taught during the Winter Semester, 2003. 377 students were enrolled in the two sections. The students were told that by completing the replacement lesson and the accompanying evaluation they would receive points equivalent to one in-class quiz. The two sections chosen to participate were not chosen at random, but were chosen because the instructors of those sections were the most interested in using the lesson. Because the enthusiasm of the instructors could have potentially affected the outcome of the lesson evaluation, we took steps to minimize this risk. The two instructors emphasized to their students that the lesson was under evaluation, and encouraged them to respond honestly to the evaluation items. The instructors also emphasized that the students would receive the quiz points simply for completing the evaluation, and not based on their specific responses. In providing this information, the instructors were careful to not reveal their personal feelings about the lesson, so as to not bias the students in any way.

Observations of our participants by their instructors suggested the participants’ demographics were very similar to other students who typically enroll in Statistics 221 (Patti Collings, personal communication, November 3, 2003). The students who take Statistics 221 come from many majors on campus, and have a wide variety of interests and talents. A small group (about 15%) typically has some previous experience with statistics. Most of the students come to the class with a neutral attitude towards the subject. Most students can use a computer
without difficulty, but the department has traditionally provided extra help for those students who
have trouble with the statistical software package used in the class. The department has identified
two main types of students who have difficulty with the subject. The first group is those who do
not have the prerequisite math skills for Statistics. These students are encouraged to take the
appropriate math courses before attempting Statistics 221. The second group has difficulty
understanding the logic behind statistical concepts (such as hypothesis testing). Typically the
Statistics instructors provide remediation to these students as the situation arises.

Procedure

The evaluation instrument created for this lesson included items to measure how students
used the lesson, any problems that arose while they were using the lesson, and any differences
between students who used different versions of the lesson. Most of the evaluation items were
either multiple-choice or along a five-point Likert scale ranging from “Strongly Agree” to
“Strongly Disagree.” We also included four open-ended survey questions.

We randomized the two versions of the lesson CDs and distributed them to students after
a normal class period. We also distributed a page of instructions on how to install and use the
lesson, and how to complete the lesson evaluation. When we distributed the CDs to the students
we let them ask any questions they had about how to use the lesson. We also let them ask
questions about problems they encountered in each subsequent class period until the evaluation
was complete. Students were given six days to complete the lesson and its evaluation.

Initial data analysis was conducted by computing one-sample t-tests of results measuring
student satisfaction, and regression equations of interactions between results measuring student
satisfaction and the features of the lesson. However as the analysis proceeded it became apparent
that this type of analysis was not appropriate for the nominal and ordinal data that had been collected in the evaluation. We turned to analysis methods more appropriate for this type of data to complete the analysis. We computed frequency tables to count how many students responded to each option of each question measuring student satisfaction. For comparisons between questions we computed crosstab tables, and (depending on the type of data gathered by the question) calculated either the Spearman correlation coefficient or the Contingency coefficient. For each type of correlation coefficient we used a significance factor of $p = .05$. We also examined the data from the four open-ended questions by coding the responses into categories derived from patterns noticed in the data. We then utilized multiple raters to confirm the validity of the coded responses. Inter-rater reliability on the four questions ranged between 85% and 91%.

Results and Discussion

227 students completed our evaluation of the replacement lesson, for a response rate of 60%. Some students did not attend class during the week of the evaluation, and others received a CD but decided not to complete the lesson. We do not believe any students completed the lesson and then failed to complete the evaluation. 121 students reported receiving lesson version A and 103 reported receiving lesson version B. Three students who completed the survey did not report which version of the lesson they used. 122 of the respondents were men and 105 were women. 201 had not had any course in Statistics prior to this one. The remaining data analysis and accompanying discussion is organized according to the three questions investigated in this study.
Student Satisfaction

The first question under investigation was: How will students in Statistics 221 react to this lesson? Response frequencies of survey questions measuring student reaction to the lesson are reproduced in Table 1.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>This lesson helped me learn the subject matter as well as I usually learn in class</td>
<td>29 12.9%</td>
<td>96 42.9%</td>
<td>53 23.7%</td>
<td>28 12.5%</td>
<td>18 8%</td>
<td>224</td>
</tr>
<tr>
<td>Overall, I liked this computer administered lesson</td>
<td>21 9.4%</td>
<td>78 35%</td>
<td>52 23.3%</td>
<td>43 19.3%</td>
<td>29 13%</td>
<td>223</td>
</tr>
<tr>
<td>I felt comfortable doing this computer administered lesson</td>
<td>36 16.4%</td>
<td>105 47.9%</td>
<td>37 16.9%</td>
<td>25 11.4%</td>
<td>16 7.3%</td>
<td>219</td>
</tr>
</tbody>
</table>

Table 1. Summary of Response Frequencies Measuring Student Reactions to the Replacement Lesson.

It appears that students responded positively to our replacement lesson. 79.5% of students strongly agreed, agreed or were neutral when asked whether or not they learned from this lesson as well as the normal class. 44.4% strongly agreed or agreed when asked if they liked the lesson, and 64.3% strongly agreed or agreed that they were comfortable completing the lesson.

Examining the qualitative data revealed some of the reasons students reacted positively. One student said, “I paid better attention to the presentation than I sometimes do in class. I felt like it was a lesson just for me and I could go at my own speed.” Another student responded, “I liked the parts where I could practice myself and check my answers the best. In the stats class there [aren’t] too many [opportunities to do] a problem then check it on your own, i.e. the homework. The lesson helped a lot in this aspect to see if I understand the concepts.” 79 students made some type of comment about how the flexible features of this lesson helped them to learn. It seems reasonable to assume that this was one of the situations where giving students more control over their learning had a positive impact (see Clark & Mayer, 2003). Future evaluations could measure the specific impact of flexible lesson features by making them compulsory for all.
students to use, then gathering data on how they impacted student performance. Those features that show a strong positive benefit should then be integrated more fully into out-of-class lessons, in order to possibly improve the levels of student response over what was observed in this study.

Some students were not satisfied with the lesson. 20.5% either strongly disagreed or disagreed that the lesson helped them learn as well as class, 32.3% did not like the lesson, and 18.7% were not comfortable using the lesson. One student’s passionate response was, “I have always hated ‘talking head’ lessons. . . . I get a LOT more out of a classroom setting, even if the class is large. . . . I am NOT a fan of how BYU keeps moving to these online class situations. They should ALWAYS keep an option open to take the class in a classroom, and make it obvious which is which when you register.” 63 students made similar comments, including some who had also mentioned liking some other features of the lesson. When asked how much of the course should utilize out-of-class lessons, 22.3% of students wanted the entire course to remain in-class, 69.6% wanted some percentage of the course delivered out-of-class, while 8% reported wanting the entire course delivered through out-of-class lessons.

The high enthusiasm shown by some students and the antagonism shown by a few suggests value in exploring how to offer multiple-tiers of in-class versus out-of-class instruction. Other departments who have been asked by the university administration to decrease instructor time have, across the board, decreased the in-class hours for the course. Given that it appears some students are very enthusiastic about a course completely delivered out-of-class, and some would prefer a course completely in-class, it may be wise to offer students multiple options. Acceptable levels of efficiency may still be achieved by allowing some students to take the entire
course out-of-class, keeping some sections of the course completely in-class, and offering some blend of in-class and out-of-class sections.

Lessons Features that Affect Student Reaction.

The second question we investigated was: What are some of the factors that affect the students’ reaction to the lesson? Three questions in our evaluation that directly measured student reaction to the lesson were:

- This lesson helped me learn the subject matter as well as I usually learned in class.
- Overall, I liked this computer-administered lesson.
- I felt comfortable doing this computer-administered lesson.

We compared responses to these three questions to responses to the following questions:

- How much total time in minutes did you take to do this lesson?
- Which statement best describes your use of the practice problems?
- I had trouble finding a computer where I could complete this lesson.
- I found the Sample-Size Calculator helpful.
- I found the video of the professor engaging (version A only).
- I found the video of the professor distracting (version A only).
- I felt I was able to pay attention to the lesson with the audio commentary only (version B only).
- I felt that I would have been more engaged in the lesson if there were video of the instructor throughout (version B only).
- Did you use the variable speed option?
• What speed did you prefer?

• In general, I feel comfortable doing computer-administered lessons

• What other experiences do you have in taking computer-administered lessons and/or courses?

Most of these comparisons were not significant at p = .05, and so are not reported in detail. Table 2 reports the crosstab for the first significant comparison, between responses to the questions “this lesson helped me learn the subject matter as well as I usually learned in class,” and “what other experience do you have in taking computer-administered lessons and/or courses.” The factors reported in the first column of the table are other computer-administered lessons believed to be commonly experienced by students.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
<th>Correlation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>13 14%</td>
<td>42 45.2%</td>
<td>20 21.5%</td>
<td>11 11.8%</td>
<td>7 7.5%</td>
<td>93</td>
<td>C = .481</td>
<td>.036</td>
</tr>
<tr>
<td>Accounting 200 (since Fall 2000)</td>
<td>5 7.5%</td>
<td>34 50.7%</td>
<td>12 17.9%</td>
<td>10 14.9%</td>
<td>6 9%</td>
<td>67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry 105 (since Winter 2003)</td>
<td>1 20%</td>
<td>1 20%</td>
<td>3 60%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASLP 133</td>
<td>0 0%</td>
<td>0 0%</td>
<td>2 66.7%</td>
<td>0 0%</td>
<td>1 33.3%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An Independent Study web course</td>
<td>1 33.3%</td>
<td>0 0%</td>
<td>2 66.7%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Another BYU Semester Online Course</td>
<td>4 16%</td>
<td>7 28%</td>
<td>11 44%</td>
<td>2 8%</td>
<td>1 4%</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An online course from another university</td>
<td>1 25%</td>
<td>2 50%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>1 25%</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting 200 &amp; Another BYU Semester Online Course</td>
<td>3 20%</td>
<td>8 53.3%</td>
<td>0 0%</td>
<td>3 20%</td>
<td>1 6.7%</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASLP 133 &amp; Another BYU Semester Online Course</td>
<td>0 0%</td>
<td>2 66.7%</td>
<td>1 33.3%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting 200 &amp; An Independent Study web course</td>
<td>0 0%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>1 100%</td>
<td>0 0%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An Independent Study web course &amp; Another BYU Semester Online Course</td>
<td>1 100%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Comparing the Question “This Lesson Helped Me Learn the Subject Matter as Well as I Usually Learned in Class” With the Question “What Other Experience Do You Have in Taking Computer-Administered Lessons and/or Courses?”

Although this table reports significant results, it was very difficult to discern a pattern in the data because so many of the rows contained only a few responses. To help detect a pattern, we isolated the effect Accounting 200 had on how well students reported learning from the lesson.

We chose to make this specific comparison because many students, in their responses to open-ended questions, mentioned how our lesson compared to the Accounting lessons. A crosstab of these results is found in Table 3.

Table 3. Comparing the Question “This Lesson Helped Me Learn the Subject Matter as Well as I Usually Learned in Class” With Whether or Not the Student Had Taken Accounting 200.

More students were likely to strongly agree or agree that they learned if they had previous experience with Accounting 200 (58.1% versus 54.3%). They were also more likely to either strongly disagree or disagree that they learned if they had experience with the Accounting lessons (26.7% versus 16.6%). Essentially, previous experience with Accounting 200 acted to polarize students. Students do not experience instruction in isolation from their prior experiences (National Research Council, 2000). Some aspect of the students’ experience in Accounting 200 apparently transferred to their experience with this lesson. Perhaps some of those who had experience with the similar Accounting lessons focused less on how to use the software and more on learning the material. And perhaps other students were unfavorably affected by some of the
surface differences between the different lessons. In order to help students best prepare and take advantage of the technology-mediated instruction they receive, the university needs to investigate how to capitalize on how the effects of one technology-mediated course can affect students’ reaction to other courses.

The next finding of significance was between responses to the question, “did you use the variable speed option?” and responses to the two questions, “this lesson helped me learn the subject matter as well as I usually learn in class,” and “I felt comfortable doing this computer-administered lesson.” Crosstabs of these related comparisons are reported in Tables 4 and 5.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
<th>Correlation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>24 15.3%</td>
<td>69 43.9%</td>
<td>34 21.7%</td>
<td>22 14%</td>
<td>8 5.1%</td>
<td>157</td>
<td>C = .216</td>
<td>.027</td>
</tr>
<tr>
<td>No</td>
<td>4 6.1%</td>
<td>27 40.9%</td>
<td>19 28.8%</td>
<td>6 9.1%</td>
<td>10 15.2%</td>
<td>66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 4. Comparing the Question “This Lesson Helped Me Learn the Subject Matter as Well as I Usually Learned in Class” With the Question “Did You Use the Variable Speed Option?”*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
<th>Correlation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>31 20%</td>
<td>76 49%</td>
<td>21 13.5%</td>
<td>20 12.9%</td>
<td>7 4.5%</td>
<td>155</td>
<td>C = .243</td>
<td>.008</td>
</tr>
<tr>
<td>No</td>
<td>5 7.9%</td>
<td>29 46%</td>
<td>15 23.8%</td>
<td>5 7.9%</td>
<td>9 14.3%</td>
<td>63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 5. Comparing the Question “I Felt Comfortable Doing This Computer-Administered Lesson” With the Question “Did You Use the Variable Speed Option?”*

Students were more likely to strongly agree or agree that they learned (59.2% versus 47%) and that they were comfortable (69% versus 53.9%) if they tried the variable speed option. We speculate that the variable speed option was used more by students who were already at ease with either the subject or the instructional model. This is similar to our earlier finding, that student experiences with methods or technology can potentially transfer from one course to
another. The developers of Accounting 200 had recommended to us the use of the variable speed option as a popular feature of their course, and our findings seem to confirm it has some value. If design teams share experiences with what they find works, particularly if their projects will affect the same population of students, instruction may become more efficient because students’ time can be spent focusing on their learning rather than on how to use the software or other tools.

Responses to the related question, “what speed did you prefer?” were also significant when compared to responses to “I felt comfortable doing this computer-administered lesson.”

Data for this comparison is reported in Table 6.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
<th>Correlation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not use the variable speed option</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>52</td>
<td>C = .379</td>
<td>.002</td>
</tr>
<tr>
<td>1.0</td>
<td>3</td>
<td>23</td>
<td>15</td>
<td>4</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.8%</td>
<td>44.2%</td>
<td>28.8%</td>
<td>7.7%</td>
<td>13.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>23</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.8%</td>
<td>60.5%</td>
<td>5.3%</td>
<td>10.5%</td>
<td>7.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>13</td>
<td>43</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16%</td>
<td>53.1%</td>
<td>16%</td>
<td>9.9%</td>
<td>4.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>9</td>
<td>13</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>31</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29%</td>
<td>41.9%</td>
<td>12.9%</td>
<td>9.7%</td>
<td>6.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31.3%</td>
<td>18.8%</td>
<td>12.5%</td>
<td>37.5%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Comparing the Question “I Felt Comfortable Doing This Computer-Administered Lesson” With the Question “What Speed Did You Prefer?”

Students who preferred the normal playback speed of the lesson were also those most likely to strongly agree or agree that they were comfortable with the lesson (76.3%). We believe that students were most comfortable with the lesson at the normal playback speed because the poor-quality audio was harder to understand at higher speeds. 60 students in their open-ended responses (including some who otherwise were very enthusiastic about the lesson) complained about the audio recording. Other research has also found that audio problems in technology-mediated lessons can also cause the most significant problems for students (Lester, 2000). This appears to be one area where the gain in efficiency has unacceptable consequences for students.
Exploring the increased costs associated with higher-quality audio equipment, while leaving the rest of the lesson unchanged, could provide guidance on how much design and development can realistically be done with LTAs without negatively affecting other aspects of the educational experience. The same could also be done with a study using the services of professional audio engineers, or using a professional voice actor. Each of these configurations will be associated with different costs of production and maintenance. Understanding these differences can help in the construction of decision guides to help developers find the right balance between costs and outcomes for any particular situation.

The final significant comparison was between responses to the question, “I felt comfortable doing this computer-administered lesson,” and responses to the question, “Which statement best describes your use of the practice problems?” A crosstab of this comparison is reported in Table 7.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
<th>Correlation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not use either practice problem</td>
<td>19 19.4%</td>
<td>33 33.7%</td>
<td>19 19.4%</td>
<td>16 16.3%</td>
<td>11 11.2%</td>
<td>98</td>
<td>C = .317</td>
<td>.018</td>
</tr>
<tr>
<td>I did both practice problems</td>
<td>12 15.2%</td>
<td>46 58.2%</td>
<td>12 15.2%</td>
<td>8 10.1%</td>
<td>1 1.3%</td>
<td>79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did practice problem 1 but not 2</td>
<td>3 9.1%</td>
<td>20 60.6%</td>
<td>5 15.2%</td>
<td>1 3%</td>
<td>4 12.1%</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I did practice problem 2 but not 1</td>
<td>2 28.6%</td>
<td>5 71.4%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Comparing the Question “I Felt Comfortable Doing This Computer-Administered Lesson” With the Question “Which Statement Best Describes Your Use of the Practice Problems?”
The students who were most likely to strongly disagree or disagree that they were comfortable with the lesson were also those who did not complete any of the practice problems (27.5%). It is generally accepted that practice helps improve learning (Driscoll, 2000), but little work has been done on the value of practice in helping students feel comfortable with instructional experiences. Of course, another interpretation of this data could be that students who were not comfortable with the lesson were also less willing to spend time practicing. Both interpretations have interesting implications for instructional designers who want to help students feel comfortable with instructional experiences. One interpretation suggests that if instructors find students are not comfortable with the instruction they receive, some type of practice may help them become more at ease with the instructional experience, and so potentially receive more benefits from the rest of the instruction. The other interpretation suggests that if students are not comfortable completing practice situations they will lose the potential instructional benefits that come along with the practice.

**Comparing Multiple Design Iterations**

The third question we evaluated was: Do LTAs provide the Statistics department with the ability to rapidly test multiple potential designs with little consequence in terms of time and cost? We investigated this question through the comparison between lessons version A and B.

Frequency tables describing student reaction to both versions are found in Table 8.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found the video of the professor engaging (version A)</td>
<td>6</td>
<td>24</td>
<td>49</td>
<td>22</td>
<td>19</td>
<td>120</td>
</tr>
<tr>
<td>I found the video of the professor distracting (version A)</td>
<td>7</td>
<td>15</td>
<td>48</td>
<td>37</td>
<td>11</td>
<td>118</td>
</tr>
<tr>
<td>I felt I was able to pay attention to the lesson with the audio commentary only (version B)</td>
<td>17</td>
<td>37</td>
<td>24</td>
<td>18</td>
<td>5</td>
<td>101</td>
</tr>
<tr>
<td>I felt that I would have been more engaged in the lesson if there were video of the instructor throughout (version B)</td>
<td>8</td>
<td>23</td>
<td>36</td>
<td>24</td>
<td>9</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 8. Measures of Student Response to Lessons Version A and B.

These results are mixed on the value of the video in influencing students’ reaction to the lesson. Only 25% of students with version A strongly agreed or agreed that the video was engaging, but only 18.6% either strongly agreed or agreed that the video was actually distracting. 31% of students with version B strongly agreed or agreed that a video of the instructor would have helped engaged them in the lesson, but 53.4% strongly agreed or agreed that they were able to pay attention with the audio commentary alone.

To help clarify our understanding of the value of the video, we computed crosstabs to compare which version of the lesson students used with responses to three questions of student reaction to the lesson:

- This lesson helped me learn the subject matter as well as I usually learned in class.
- Overall, I liked this computer-administered lesson.
- I felt comfortable doing this computer-administered lesson.

None of these comparisons were significant at p = .05, signifying that the presence of the video was not a major factor in students’ positive reaction to the lesson. Additionally, there was no significant difference between the two versions in how much time (in minutes) it took students to complete the lesson. Given the relative difficulty involved in creating video, and the increased costs of production and delivery that video require, it appears to be a justifiable decision to explore limiting the use of video in future lessons.

The findings reported in Table 8 also provide a good argument for using LTAs to rapidly test multiple potential designs with little effort in terms of time or cost. The issue of whether or
not to include video could potentially have been a costly one for the design team to resolve, in terms of time spent discussing alternatives. But using LTAs as a prototyping tool only required about 15 more minutes of effort after version A was created, and led to a finding that united the design team. Even in situations where the final product will not be produced using LTAs, it appears to be wise to use LTAs to develop prototypes of alternatives throughout the design process, rather than using potentially more expensive methods of decision making.

Conclusion

It may be of interest to the reader to become acquainted with some of the events transpiring since the completion of this study. At the time of this writing (January 2004), the Statistics department has been able to use replacement lessons to eliminate eight in-class instructor hours in a lecture section of Statistics 221 (multiplied by the eight sections typically taught each semester this represents a decrease of 64 instructor hours for the entire course). By this fall they also hope to have at least one section that only meets for one hour a week, for the purpose of answering student questions or addressing new topics of data analysis.

The Statistics department has also taken complete management of the development of replacement lessons, freeing the CID to use their resources to impact more departments on campus. They have hired a student employee to maintain the lesson templates, and are now conducting an on-going evaluation of how to best use the lessons with their students. These evaluations are addressing some of the limitations of this study, for example evaluating student response to multiple lessons throughout the semester. Additionally, the evaluators are observing students completing the lessons, to gather information that cannot be discovered through the students’ self-reports. They are also beginning to evaluate learning outcomes between the
students who use the replacement lessons and those who do not, which will provide a true
measure of learning effectiveness that also cannot be discovered through a self-report. Some of
the most recent lessons created by the Statistics department are available as Appendix F.

In conclusion, this study should be of interest to all those who are trying to create
efficient instruction in the context of the real-world constraints placed upon them by university
administration or department faculty. In this study we used an approach to design and evaluation
that capitalized on low-cost methods of investigating real-world design situations. We concluded
that the costs of development and maintenance can be decreased by using low-threshold
applications that are inexpensive and easy to learn. We also concluded that some methods of
efficient development can cause quality problems that decrease levels of student satisfaction, and
design teams should carefully consider what types of LTAs will be most appropriate for their
design situations. But overall, LTAs and software templates are an effective method of
investigation that can help investigators handle unexpected situations that can arise during the
course of a design study. For designers who hope to meet the needs of their clients at the lowest
cost possible, LTAs and software templates present an attractive alternative to making design
decisions.
References


