AC 2005-1024: DEVELOPING AN INSTRUCTIONAL TECHNOLOGY SCAFFOLD FOR REINFORCING LEARNING OF PROBABILITY AND STATISTICS

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Developing an Instructional Technology Scaffold for Reinforcing Learning of Probability and Statistics

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Abstract

Multiple instructional technologies can be used to deliver both in-class and out-of-class materials. In order to facilitate active learning (*i.e.*, student interactions) and emphasize real-world applications in an introductory undergraduate biomedical engineering course on probability and statistics, we are developing a scaffold of multiple instructional technologies. These technologies include the course management system, BlackBoard®, MATLAB® problems using laptops, and the Classroom Performance System (CPS) technology that consist of remote controls for each student and a receiver that records student answers to questions posed by the instructor. This paper assesses how instructional technologies reinforce student learning and critical thinking.

1 Introduction

Using current research in cognition and learning theory as a guide, instructional technologies can be utilized to enhance classroom teaching.¹ While much of the early research found “no significant difference” with instructional technology, current research is moving beyond that simplistic premise in order to address appropriate coupling of pedagogical approaches and instructional technologies. The devices presenting material are merely delivery mechanisms and a more compelling issue is how do they facilitate learning and how do students’ confidence, ability, and willingness to engage with instructional tools influence the successful integration of these technologies into teaching and learning?

In this paper, we explore how instructional technologies influenced students in developing basic content understanding, but also in the development of critical thinking and reasoning skills (as categorized by an educational taxonomy). In the fall of 2004, we gathered pre- and post-class student survey data, observational data, technology usage data, and classroom performance results in BME 335 Introduction to Probability, Random Processes, and Statistics. These data are intended to lay the groundwork for a model of the interplay between instructional technologies, student thinking, and interactions in a probability and statistics course (Figure 1).

BME 335 is a core undergraduate course in Biomedical Engineering at The University of Texas at Austin. In the standard curriculum, the course is to be taken in the sophomore year. One of the UT BME program outcomes is that our graduates will be able to “design and conduct experiments and analyze and interpret data to support the understanding of biological systems and processes.” Our intent is that BME 335 contributes to this program outcome, particularly

with regard to the skills to analyze and interpret data. This outcome relates to ABET EC2000 criteria 3 b, e, and k.

Since our department was formed in 2001, the course had been taught only twice prior to fall 2004. One of us (MKM) taught BME 335 when it was offered for the first time in fall 2003 (N = 68 students) and collaborated with our College of Engineering Faculty Innovation Center (directed by KJS) to identify areas for improvement. In the next few paragraphs we summarize the changes made from fall 2003 to fall 2004 that are most relevant to this study of the role of instructional technology in learning statistics.

In BME 335 fall 2003, multiple choice homework assignments were administered through the assessment tools in BlackBoard® before and after each class session. Feedback from the students indicated that there was a perceived disconnect between the “post-class quizzes” and the questions asked on examinations, presumably due to the fact that the instructor was not adept at posing questions that reached the higher levels of Bloom’s taxonomy in a multiple choice structure as was used in BlackBoard®. In BME 335 fall 2004, similar BlackBoard®-based “pre-class quizzes” were retained, but the “post-class quizzes” were replaced by three “paper-and-pencil” problem sets. Each problem set was conducted shortly in advance of an exam and was intended to mirror the exam in terms of the level of difficulty and question structures.

In BME 335 fall 2003, student feedback indicated that they had difficulty in seeing the “real world” applications of the course material. It was decided that two major challenges needed to be overcome in order to address this problem: (1) insufficient class time and (2) numerous tedious calculations. In BME 335 fall 2004, weekly one-hour “lab” sections were added to the course. In these lab sections, the students were able to work on more in-depth problem sets in small teams under the guidance of a teaching assistant. Students performed necessary calculation in MATLAB® (using a laptop-cart mobile classroom system).

Each of the technologies used in this course was implemented to enhance student understanding in a specific way. BlackBoard® was mainly used as a course repository. Using BlackBoard®, students were able to download course materials, upload assignments, respond to quizzes/surveys, and view

Figure 1. Instructional Technology Scaffold

current grade status outside of structured class time. In the classroom, students viewed PowerPoint® lectures that were provided to enhance student understanding through visual explanations and to create a coherent course organization. Although there is a lack of research supporting the appropriate use of PowerPoint®, care was taken to incorporate what is known on how to design presentations that are compatible with how people learn.² Slides tried to present complementary material in both words and pictures and to avoid very dense, detailed information. Lectures were made interactive by the use of Classroom Performance System (CPS) where the instructor initiates a multiple choice question and the students using remote devices key in their answers. The results are saved in data file and the instructor can then display a histogram of class results. In order to promote the use of these questions and answers as a study

tool, the FIC designed an online application web site that provides a feedback loop for the instructor and students to examine their responses. Our site also provides data to the instructor about individual student performance, aggregate class response to topic areas and specific questions, and student participation and class attendance. During the lab sessions, students used laptop computers and MATLAB® in order to actively work through their understanding of statistical problems. Students were encouraged to work collaboratively in both the classroom and lab problem solving activities.

Statistics is generally a required course across engineering curriculums and students often want to see direct connections between theory and the statistical reasoning skills they will need to choose appropriate analysis procedures. Throughout the curriculum, biomedical engineering examples were utilized. Effort was made to review issues specific to teaching of statistics so that this course could incorporate best practices including the use of a Web site to extend learning³ and including small-group cooperative learning.⁴

2 Methods

IRB approval was obtained for this study and efforts were made to protect the students' interests. For example, the instructor did not have access to any study data not regularly used for instructional purposes until the final course grades were submitted and only had access to anonymized data (names removed). Each of methods used to probe students' learning and use of instructional technology is described the following sections.

2.1 Self-report Surveys

Students in BME 335 completed several surveys. For the items described in sections 2.1.1-2.1.6, data were collected such that identifiers could be used to match a student across other course data. By comparison, the items described in sections 2.1.7-2.1.9 were collected in a strictly anonymous manner such that they can be analyzed only in aggregate.

2.1.1 Demographics

At the beginning of the course, students completed a short demographic survey regarding background information such as age and academic status (Appendix A).

2.1.2 Learning Styles

In order to look at student preferences, we administered a learning styles inventory called the Felder-Solomon Learning Styles Index (ILS) standard questionnaire. Learning styles are not fixed personality traits, but are the results of unique individual programming.⁶ Learning styles are measured by self-report of preference rather than by tasks that differentiate abilities. Some research suggests that a person's professional orientation (due to training and a common set of beliefs) can shape learning styles and engineering students have been found to have some typical patterns. For example, they tend to be somewhat visual rather than verbal learners.⁷ The dimensions are as follows:

- Sensing learners (concrete, practical) or intuitive learners (conceptual, innovative)
- Visual learners or verbal learners
- Inductive learners (presentations from the specific to general) or deductive learners (presentations from general to the specific)
- Active learners (learn by doing and with others) or reflective learners (learn by thinking things through and alone)

- Sequential learners (linear, learn in small steps) or global learners (systems thinkers, learn in large leaps)

BME students responded to self-report online ILS to obtain their learning styles scores in the four categories. Scores on the ILS scale are forced-choice in that respondents must choose between one of two options, for each item, that best describes their preferences. For each category, scores are scaled from -11 to +11. For each category listed, the first category is the strong negative value (*i.e.*, for category “ACT/REF,” -11 equals strong ACT affinity and +11 equals strong REF affinity). The closer a score comes to +/- 11, the greater the affinity for that learning style. In general scores between one and three reflect pretty well-balanced preference between the two dimensions. Scores of five to seven reflect a moderate preference for the relevant pole. Scores between nine and eleven reflect a strong preference. (Only odd-numbered scores can result).

2.1.3 First Day Impressions

After the first day of class, students took a survey assessing their impressions of the first day of class. They were given a structured response survey developed at the University of Illinois.⁸ This multi-part survey contains 19 five point Likert Scale items that are intended to reveal how students’ react to specific attributes related to instructional style that are linked to global evaluations of teaching (Appendix B). On the survey the first two questions look at overall quality of the course and the instructor’s overall teaching effectiveness. The rest of the items are ratings of the instructor’s specific instructional attributes such as organizational skill, clarity, and the ability to generate interest. Results of this measure were used to make modifications to the course. Of the 19 questions asked, 16 were grouped into the four factors. Each question asked for a response on a scale from one (strongly disagree) to five (strongly agree).

2.1.4 Pre- and Post-Course Attitudes Toward Statistics

At the beginning and end of the course, students filled out an instrument known as the Attitudes Toward Statistics⁹ (ATS) by Wise in 1985 (Appendix C). While there are numerous instruments available to measure attitudes toward statistics, the ATS appears to be the most widely used.¹⁰ Items on the ATS are designed to measure attitudes towards statistics and not success with statistics concepts or problems. The reason to administer this instrument is to diagnose if students have any preconceived notions that inhibit their learning of statistics. By having the students take the ATS at the end of the semester, you can measure if their perceptions have changed. The two domains assessed are the course itself (student attitudes toward their statistics course) and the field (students’ attitudes toward the usefulness of statistics, either in general or in terms of their field of study).

2.1.5 Pre- and Post-Course Instructional Technology Experience

At the beginning and end of the course, students completed a survey that included both scaled and open-ended questions designed to assess their pedagogical experiences with instructional technologies (Appendix D).

2.1.6 Feedback on MATLAB® Tutorial Problem Set

As discussed later in the paper, one area of concern identified mid-course was with MATLAB® usage. The students were given an additional problem set (extra credit) to increase

their MATLAB® skills. On this problem set, the students were asked specific questions about the use of and their attitudes toward MATLAB®.

2.1.7 Midcourse Evaluation

In the middle of the semester, students were given a mid-course evaluation. The purpose of this survey was to identify potential problems while there was still time in the semester to make adjustments. Several items on this survey were chosen to be identical to those asked on the standard end-of-course evaluation.

2.1.8 End-of-Course Evaluation

At the end of the semester, the standard UT course evaluations were given to the students. This evaluation form includes eight Likert-scale items and space for open-ended responses. The scale is a five point scale ranging from strongly disagree (1) to strongly agree (5).

2.1.9 Students' Assessment of Course Activities by Bloom's Taxonomy

At the end of the statistics portion of the course, students were asked to complete a short survey which probed their perception of the thinking levels required by course activities (Appendix E). The survey questions were based on Bloom's Taxonomy⁵, which is described in section 2.4.

2.2 Observational Data

Course observations were made during the semester and after each visit, the instructor and the reviewer discussed how to adapt the course to meet students' needs and how to modify instructional strategies. For the second half of the semester, the teaching assistants wrote a synopsis of each lab session, which was sent to the instructor and FIC director so that they were current on lab activities and student concerns. After the responses to the midcourse evaluation were organized, the director of the FIC conducted a focus group with the students. During this session, students were able to openly discuss course concerns and issues.

2.3 Access and Assessment Data

Use of BlackBoard® was tracked by using its' course statistics tool. We were able to see which sections of the course were accessed by whom and when. The course statistics can reveal such specifics, for example, as which days of the week had the most "hits" and which student uses the most frequently. With CPS, we had statistics on usage as well. The FIC developed a customized website called Copernicus to record student responses to the questions asked in class using CPS. Copernicus can be used to track attendance and as a review tool for students.

2.4 Bloom's Taxonomy

Beyond the statistics on usage, we were able to ascertain the levels of thinking promoted by the course's instructional technology tools. By using Bloom's Taxonomy, we were able to categorize the CPS questions, the discussion question from BlackBoard®, and the problem sets (including those that used MATLAB®).

Categorizing thinking abilities can be tricky and the use of a taxonomy can clarify thinking levels. A highly recognized taxonomy to assess foundational thinking skills was developed by Bloom and associates in 1956.⁵ Bloom's taxonomy classifies cognitive behaviors into six categories ranging from simple to complex. The behaviors are hierarchical, with learning at high levels dependent upon attaining prerequisite knowledge and skills (Table 1). We used this

taxonomy to guide us in going beyond the vagueness implied when we sought to qualify what we meant by student “understanding” and instead we relied upon the six major levels of thinking as listed below.

Table 1 *Six Major Levels of Bloom’s Taxonomy*

Level	Characteristic Student Behaviors
Knowledge	Remembering; memorizing; recognizing
Comprehension	Interpreting; describing in one’s own words
Application	Problem-solving; applying information to produce a result
Analysis	Subdividing to show how something is put together; identifying motives
Synthesis	Creating a unique, original product
Evaluation	Making value decisions about issues; resolving controversies

3 Results

The course enrollment this semester was less than would typically be expected. The small sample size severely limits the analyses that can meaningfully be employed. Consequently, the results presented in this paper are of a descriptive nature and should be taken as preliminary data that can be used to generate hypotheses for future larger studies.

Summary statistics are provided to describe responses to the demographic questions and to the ordinal- and interval-scaled items. Responses to the open-ended questions on the pre- and post-tests are summarized qualitatively. Common themes underlying responses were sought and then summarized using verbal description. Given that this class covers statistics, probability and random processes, data analysis on classroom interactions and instructional technology tools for this paper looks specifically at the statistics section of the course (eight sessions).

3.1 Self-report Surveys

3.1.1 Demographics

Table 2 lists the demographic information for the students enrolled in BME 335 in the fall 2004 semester. There were 17 students enrolled, but only 14 responded to each of the survey and questionnaire instruments. Therefore, all tables show results for total of 14 participants (the participants for whom all categories of data is available).

While BME 335 is a “sophomore” level course, all of the fall 2004 students who completed the demographic survey had achieved at least “junior” status. There are two likely reasons for this fact. Admission to the BME program is selective and many of our students have advanced placement credit. Also, since our program is new, there is still some fluctuation as to which course can be offered which semester and this affects students’ schedule planning.

Table 2 *Demographic information describing students in BME 335*

Sex	
Male	10 (71 %)
Female	4 (29%)
Major	
BME	9 (64%)
Other	3 (21%)
Unknown	2 (14%)

Academic Status	
Junior	9 (64%)
Senior	5 (36%)
Average Age	20 (50%)
Average GPA	3.6
Average Final Grade in Course	3.5

3.1.2 Learning Styles

Table 3 shows the mean and standard deviation of the students' scores on each of the four learning styles dimensions. On average, this class had a moderate preference toward a reflective learning style. The other dimensions were balanced when averaged across all the students.

Table 3 *Statistics Describing Students' Learning Styles*

Learning Style Dimension	Mean (SD)
Active/Reflective	5.4 (4.5)
Sensing/Intuitive	-0.1 (5.3)
Visual/Verbal	-3.2 (5.3)
Sequential/Global	0.2 (5.3)

3.1.3 First Day Impressions

The first day impressions survey (Table 4) indicated that students felt reasonably comfortable with the instructor and her desire to teach this as well as her concern for students' success in this class. They felt that she was able to convey information in an organized and knowledgeable manner and that the course would increase their general knowledge and help them to develop career skills. The lowest reaction the students felt under the factor of expectations that addressed these three concerns: student expectations in the class, whether or not the workload is reasonable, and the fairness of the course grading. As a result, the instructor made extra efforts to clarify these issues throughout the semester. For example, each student was sent an email giving an explicit summary of his/her progress to date following each exam.

Table 4 *Statistics Describing Students' First Day Impressions*

FIRST DAY IMPRESSIONS	
Factor	Mean
Concern for students	4.36
Communicative competence	3.98
Expectations	3.44
Benefits	4.03

3.1.4 Attitudes Toward Statistics

The results of the survey of attitudes toward statistics are summarized in Table 5. For each of four categories, pre-survey responses were subtracted from post-survey responses. Responses

were matched by study participant. The differences (+/-) for each response to each question in all four categories were averaged. The responses are synthesized into four categories: affect (AFF) – positive and negative emotions concerning statistics; cognitive competence (COG) – positive and negative attitudes about intellectual knowledge and skills when applied to statistics; difficulty (DIF) attitudes about the difficulty of statistics as a subject, and value (VAL) – positive and negative attitudes about worth and usefulness of statistics in students’ personal and professional lives. Little difference between the pre- and post-course responses was observed in any of the categories.

Table 5 *Students’ Responses to the ATS*

AFF	0.27
COG	-0.04
DIF	-0.04
VAL	-0.57

3.1.5 Pre- and Post-Course Instructional Technology Experience

The average difference in the ratings from the pre- and post-course surveys of experience with instructional technologies are summarized in Table 6. While no striking changes were seen with this sample, some interesting trends were observed that should be investigated in future semesters. The data suggest that students may have experienced greater feedback from the way that Blackboard® was used in this course relative to its use in previous courses. The use of CPS and MATLAB® seemed to improve students’ perception of the “real world” value of this course. An interesting finding was that students did not always distinguish between the use of PowerPoint® and CPS, as suggested by the fact that PowerPoint®, rather than CPS, was seen to have increased contribution to problem solving practice. In the future, wording will be more specific on any class questionnaires in order to assess students’ reactions to these devices. Another unexpected observation was that CPS was perceived as improving student knowledge of course deadlines although no effort was made to use CPS in that fashion. It is possible that the increased interactivity in the classroom made students more comfortable asking course management questions as well and they attributed that to CPS.

Three main issues emerged from the open-ended comments solicited by this instrument. (1) Students felt they had a lack of training/preparation for using instructional technology tools with their most specific concern about MATLAB®. They felt they were assigned rather complex tasks with MATLAB® yet they lacked sufficient preparation. Some were not all that comfortable with Blackboard® despite its campus-wide usage. (2) They felt a lack of perceived value of CPS relative to the cost but this same complaint diminished as the semester progressed. (3) There were some perceptions that instructional technology can result in communication problems. Several comments reflected a worry that instructors might disseminate important instruction information via Blackboard and students would not be left unaware unless they frequently checked their computers.

Table 6 *Average Difference (Post – Pre) in Ratings of Student Experience with Instructional Technologies*

QUESTION	BB	CPS	PP	MATLAB
1. Prior experience in-class	-0.21	0.36	-0.07	0.29
2. Prior experience out-of-class	-0.15	-0.29	-0.29	0.14
3. Prior comfort	0.21	0.21	0.14	-0.21
4. Communication with instructors	0.07	-0.21	0.50	0.14
5. Communication with peers	-0.64	0.29	0.36	0.86
6. On-going feedback	0.86	0.00	-0.57	0.14
7. Reviewing course material outside of class	0.36	0.15	0.29	0.50
8. Understanding of “real-world” value	-0.43	0.86	0.29	0.86
9. Problem-solving practice	-0.43	-0.07	0.86	0.50
10. Knowledge of course deadlines/requirements	-0.29	0.86	0.64	0.57

3.1.6 Feedback on MATLAB® Tutorial Problem Set

In response to the student feedback from the midcourse evaluation (Section 3.1.7) and the subsequent focus group session (Section 3.2), an extra credit problem set designed to serve as a MATLAB® tutorial was administered to the students. Based on the 15 students that completed the problem set and associated survey, doing the problem set raised a student’s self-reported skill level by an average of 1.5 points on a scale of 1 to 10. The responses to the essay questions indicated that students were very supportive of the idea of using this MATLAB® tutorial problem set as the first assignment in the future offerings of BME 335.

3.1.7 Midcourse Evaluation

The midcourse evaluation results are summarized in

Table 7 and Table 8. The midcourse evaluation proved to be critical to the successful use of instructional technologies in this course. By and large, the response to lab sessions was positive. For example, they were asked on a short essay question to describe how the combination of lecture and lab influenced their learning. Their answers varied but most of them saw the connection between lectures and labs and one noted that, “with time to think about what I learned in class, I was able to use the lab as place to ask questions.” However, a couple of students wrote about their frustrations with MATLAB® and one wrote, “I never really learned anything new in lab sessions except Matlab syntax” and another said, “...the lab sessions are mostly spent trying to decipher the Matlab problem sets.” The identification of these concerns about MATLAB® and our subsequent efforts to address them were of key importance to student learning. While the midcourse evaluation survey drew our attention to certain problems, it was the observational data, as described later in the paper, which was most valuable in identifying solutions.

Table 7 *Mid -Course Evaluation Questions on Instructor and Methodologies*

Item	Scale				
	Most time	Some time	Rarely	Never	
Student ability to keep up with in-class activities	44%	56%			
Professor is available outside of class.	63%	37%			
Professor is helpful outside of class	75%	19%		6%	
Course workload	Excessive 6%	High 25%	Average 56%	Light 12%	
Average amt of time spent on course outside of class	1-2 hr week 25%	3-4 hr week 50%	5-6 hr week 12%	>6 hr week 12%	
Amt of material covered during lectures	High 44%	Average 56%	Light		
Amt of time spend on in-class lectures	Too much	About right 81%	Too little 19%		
Assignments and tests are graded promptly	Strongly disagree 6%	Disagree	Neutral	Agree 50%	Strongly agree 44%
Student feels free to ask any type of question in class		12%	25%	56%	6%
Student feels free to disagree with professor in class	6%	18%	56%	18%	
Course has been a valuable course so far	6%	6%	37%	44%	6%
The prerequisite quiz helped in understanding what background skills/knowledge would be needed	31%	37%	25%	6%	
The pre-class BlackBoard®, assignments encouraged being more prepared for class	31%	25%	25%	6%	12%
Using CPS in class encourages participation		12%	25%	25%	37%
Using CPS for exercises provides useful feedback		12%	6%	50%	31%
Working on problem sets with the TAs aids learning	12%	25%	12%	44%	6%
The MATLAB® problem sets help with understand real-world applications	25%	6%	37%	12%	19%

3.1.8 End-of-Course Evaluation

The results of the mid-semester and end-of-course evaluations are summarized in Table 8. In comparing the end-of-course evaluations for Fall 2004 and Fall 2003, some improvements apparently related to better use of instructional technology were seen. The educational value of the course, value of the course assignments, level of intellectual stimulation, and value of the course to date are likely tied to the introduction of the lab sessions using MATLAB®. It is reasonable to suppose that the improvement in the overall instructor rating and related sub-items (communication, interest in students, etc) stem at least in part from more effective use of

PowerPoint® in the second course offering, especially with regard to more appropriate pacing of the course content.

Table 8 *Average Course Evaluation Results. Items indicated by “-” were not included on the midcourse evaluations.*

	Fall 2003 Midterm	Fall 2003 End-of-Course	Fall 2004 Midterm	Fall 2004 End-of-Course
Course well-organized	4.0	4.0	-	4.4
Communicated information effectively	3.5	3.3	-	4.0
Showed interest in student progress	3.5	3.5	3.8	4.5
Assignments and tests returned promptly	4.9	4.4	4.3	4.6
Student freedom of expression	4.4	3.7	-	3.9
Objectives/assignments clearly stated	-	4.1	-	4.5
Instructor well prepared	-	4.0	-	4.6
Instructor had thorough knowledge of subject	-	4.0	-	4.5
Genuinely interested in teaching course	-	3.6	-	4.6
Availability outside of class	-	3.5	-	4.3
Student performance evaluated fairly	-	3.0	-	3.6
Adequate instructions for assignments	-	3.5	-	3.3
Course was made educationally valuable	-	3.5	-	4.1
Instructor increased student knowledge	-	3.3	-	3.9
Intellectually stimulating	-	2.7	-	3.5
Assignments usually worthwhile	-	2.8	-	3.1
Course of value to date	3.3	2.9	3.4	3.7
Overall instructor rating	3.5	3.2	3.8	4.0
Overall course rating	3.1	2.8	3.4	3.5

3.1.9 Students' Assessment of Course Activities by Bloom's Taxonomy

The students' assessment of the types of thinking required by different course activities in the statistics portion of BME 335 is summarized in Table 9. While this sample size was small, these data clearly suggest that the students' perceived a striking difference in the types of thinking required on "pre-class quizzes" administered through BlackBoard® as compared to those asked in class (frequently reported back by CPS) or in the lab (often requiring MATLAB®). As intended, the former emphasized more foundational processes of knowledge and comprehension. Less difference was reported between the kinds of problems solved in class and in lab, but the general trend was that the lab problems required more analysis, synthesis, and evaluation, as was the course design.

Table 9 *Students' Assessment of the Types of Thinking Required by Different Course Activities*

	BlackBoard®	In-Class Problems (Typically CPS)	Problem Sets (includes MATLAB®)
Knowledge	98%	53%	68%
Comprehension	37%	68%	84%
Application	0%	95%	74%
Analysis	10%	58%	69%
Synthesis	32%	47%	53%
Evaluation	21%	47%	50%

3.2 Observational Data

While understandably qualitative in nature, the observational data collected over the course of the semester were extremely helpful in addressing student concerns. Following the midcourse evaluation, the teaching assistants were instructed to submit brief synopses of lab sessions and the instructor and FIC director observed several lab sessions at random. From the process, improved lab practices were identified and implemented. For example, it was observed that if announcements were made after distributing laptops, the students were too distracted by the computers to listen. Perhaps the most important component to the success of this course was the "focus group" that the FIC director ran in response to the midcourse evaluation. From the focus group feedback, we were able to identify specific approaches to addressing student concerns, particularly with regard to knowledge of MATLAB®.

3.3 Access and Assessment Data

3.3.1 BlackBoard®

Within BlackBoard®, there are ways to track students' usage. We were able to gather the number of hits made to each area (Table 10 and

Table 11). For clarification, within the Content Area, course documents (i.e., syllabus, objectives, solutions, PowerPoint lectures, and so on) are stored. In the Tools Area, students are able to view their grades and they can also go directly to their grades via the Student Gradebook. In the Groups, students communicate with by using the Discussion Board or sending emails.

Table 10 Overall Summary of Blackboard Usage by Number of Hits and Percentage

Announcements	Content Area	Tools Area	Groups	Student Gradebook
427 (38%)	29 (9%)	1 (.3%)	70 (21%)	103 (32%)

Table 11 Total Access to Blackboard Area by Number of Hits and Percentage

Course Documents	Assignments
332 (98%)	8 (2%)

BlackBoard® is the standard courseware at UT and students entered BME with prior exposure to it. Even though it is UT's standard, not all professors utilize it and one student commented, "With Blackboard, a homework system, and individual web pages, there is not enough unity between professors and the technology for an effective use of the Internet." Another student stated, "Sometimes new things are posted that I don't know about because there are not any alerts." Concerns about its stability "will it be working right now" were voiced by a student. On the post-instructional technologies questionnaire, there weren't many comments about BlackBoard® but one student did state, "Feedback was sent through email so I never used the Discussion Board." Another student felt that "It would be nice if when instructors post homework assignments, they are added to your "task" panel and due dates are indicated on the calendar."

3.3.2 CPS

Data collected on CPS was both quantitative and qualitative. Students were asked CPS data for four class sessions pertaining to statistics was collected as listed in Table 12.

Table 12 CPS Usage Results

CPS Data						
Class Session	Number Present	% Present	No. of Questions	No. Potential Responses	No. Actual Responses	% Correct Responses
Nov. 4	12	71%	2	24	24	88%
Nov. 9	13	76%	5	65	69	66%
Nov. 16	12	71%	14	168	176	77%
Nov. 18	11	65%	12	132	107	64%

On the pre-instructional technologies questionnaire, students were able to write comments about their experiences with CPS. One student wrote, “I don’t like it when students try to look over and put the same answer as I did.” Another found it annoying to pay a fee to use CPS and another suggested that CPS just be included in the course fees. Students did not add any additional comments about CPS on the post-instructional technologies questionnaire.

3.4 Bloom’s Taxonomy

It was the intent of the professor to challenge students with the questions and an effort was made to use instructional technologies that promote the range of thinking skills. The different tools and software encouraged student engagement at different levels of challenges and effort. The director of the FIC independently rated questions from the statistics portion of BME 335 according to Bloom’s Taxonomy (Table 13).

Table 13 *Summary of Bloom’s Question Level Type by Instructional Technology Tool*

Tools	Bloom’s Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
CPS -27 questions		4	4	14	5	
Blackboard - quizzes		15	18	7		
MATLAB				3	6	4

4 Discussion

The role of statistical thinking in the discipline of engineering is a significant one and as such there is concern about the approaches to effectively teaching statistics. This paper documented both discipline specific and instructional technology specific approaches to the teaching of biomedical engineering statistics and explored to what extent the technologies supported scaffolding.

Students’ perceptions as reported on a survey of the types thinking required by different class activities in BME 335 suggest that our scaffold is a promising approach for using combinations of instructional technologies to reinforce learning of statistics. Students need to be able to work at all thinking levels and the use of technologies can help provide scaffolds, the structures that students need to support learning. Key areas for improvement and additional study were identified and we want to explore how to more effectively use the technologies to help make students’ thinking more visible and to help them work together to develop and critique their ideas.

A consistent theme we noted in qualitative survey responses and observational data was that students did not appear to make the same distinctions as the study authors between the technologies employed. For example, student comments typically did not distinguish between how their experience was impacted by MATLAB® as opposed to the laptop cart system on which they used MATLAB® in the lab. Likewise, student feedback appeared to combine the delivery of questions with PowerPoint® with the collection of responses to those questions by CPS. This suggests that more care will be needed in writing survey questions for future studies but also that it may be interesting to investigate how students think about technology in supporting learning of statistics.

The discussion board aspect of BlackBoard® was not effectively utilized in BME 335 in fall 2004. Using BlackBoard®’s bulletin board feature can facilitate students writing and their reviewing of peer’s efforts. The inclusion of more opportunities for the students work on writing in their discipline would improve BME 335 and strengthen our curriculum. This kind of writing can help not only writing skills, but writing for learning.

One concern about BlackBoard® that we heard several times from students was the fear that the site would change in some important way and that they would be unaware of it. The majority did not like the “pull” aspect of the technology that required them to go to the site and look for updates. Instead, they repeatedly asked for greater use of a “push” technology; they wanted to receive information and notification of content changes by email. In response, we tried to compel the teaching assistants in the second half of the course to send an email every time the BlackBoard® site was changed, but this was cumbersome and compliance with low. An automated solution is needed to address student desire for information to be “pushed” to their mailbox. We envision that such an approach could be tailored for each student in much the same way that one can set up “search alerts” on news websites such that an email is received when a new article contains specified keywords. Another implication is that, while the study authors had not been conceptualizing email as an “instructional technology”, our students clearly were. In future work it may be valuable to explicitly integrate email into our scaffold model and to pose questions specifically about its use in aiding learning of statistics.

Student learning of statistics may be further enhanced if greater emphasis was placed on “community building” in developing the BlackBoard® sites. Both email and discussion board features could be better used for this purpose. It is reasonable to suppose that fears and confusions about evaluation, for example, may inhibit students from seeking assistance when needed. Using instructional technologies to increase interpersonal interactions and support may help alleviate such anxieties that were expressed on the first day impressions survey, many of which were still lingering at the time of the midcourse evaluation.

Student feedback indicated that they do not like the “pre-class quizzes” administered through BlackBoard®. However, the quizzes seem to serve a useful function in encouraging students to keep up with the material and visit the BlackBoard® site regularly. Additional study is needed to determine if the questions could be changed in some way that would make them more palatable (*e.g.*, frequency, difficulty, etc).

An on-going question in our minds is how and when PowerPoint® slides should be distributed to students. This is particularly tricky when, as in our case, problems to be solved and reported by CPS are presented in PowerPoint®. Our current strategy is to distribute PowerPoint® slides on the BlackBoard® site in advance of class, but to use “hyperlinks” to separate files containing the exercise descriptions, which are not available before class. Moreover, we are currently exploring greater use of hyperlinking to create interconnected “non-linear” PowerPoint® files, which will hopefully aid students in appreciate the relationships between course concepts. It could also be valuable to include links to MATLAB® based problems in order to emphasize the close ties between the lecture and lab portions of the course. Richer use of PowerPoint® in BME 335 may warrant extension of the scaffold to model its role and interactions with other instructional technologies in learning statistics.

One unexpected comment concerning CPS that came out in the midcourse survey and subsequent focus group session was that students did not like it when CPS was used to take attendance. This may be related to the small size of this class or to the fact that most of them are relatively new to college (and proud of their new found freedom). We were, however, pleasantly surprised by the overall positive response to the use of CPS, even in such a small class. Our experience suggests that it can be a valuable active learning tool in a statistics course. By subjectively comparing BME 335 as taught in fall 2003 and fall 2004, we suspect that the impact of CPS is modulated by the pace of the lecture. Despite the fact that CPS was used in a very similar way (*i.e.*, many of the same questions) in both course offerings, the response was better

the second time, possibly because a slower lecture pace allowed students more time to solve the posed problems. A major limitation of CPS as used here was the unwieldy nature of tracking student progress. Additional work is needed to enable students and instructors to easily review questions and responses. It would be especially beneficial if this could be achieved on the BlackBoard® site.

6 Conclusions

In future semesters we also plan to explore ways that instructional technologies can be used to help students review prerequisite material. A MATLAB® tutorial problem set developed this semester is a good start, but additional work is needed to create materials to support review of relevant mathematics. Many of these students enter this course expecting they have the prerequisite skills and when their expectations are unrealistic, it presents problems. Efforts will be made to make sure they have not forgotten what they need to know as well as provided them instructional support for topics they do not already know.

An interesting study question for future work is the possible interaction between learning styles and benefit derived from a particular instructional technology. For example, it is possible that the learning of reflective learners may be more or less enhanced by the use of CPS as compared to that of active learners. Likewise, we would like to study whether any aspects of using instructional technologies are specific to different pre- or post-course attitudes about statistics.

In conclusion, this pilot study of an instructional technology scaffold suggests that it is a useful model for exploring how combinations of instructional technologies can reinforce the learning of statistics in biomedical engineering. While the class size was small, our results suggest that the introduction of computational labs can help students recognize and be prepared to address real-world applications of statistics in biomedical engineering.

7 Appendices

7.1 Appendix A – Demographic Survey

Instructions:

The purpose of this survey is to collect demographic data to help us better understand how student characteristics interact with teaching approaches so that we can continue to improve this course in future semesters. Your UTEID is needed to match up the results of this survey with others used in the course, but will then be removed from the record. The professor and teaching assistants will not have access to any survey data with UTEID attached and will not have access until after the final course grades are assigned. You may choose to not answer any questions.

UTEID: _____

Academic Status (circle one):

Freshman Sophomore Junior Senior Graduate Student

Number of Years at UT Austin: _____

Major:

Biomedical Engineering

Other: _____

Sex (circle one):

Male Female

Age in years: _____

Approximate undergraduate GPA: _____

Previous math courses (please indicate high school vs. college):

Grade you expect to earn in this course: _____

7.2 Appendix B – First Day Impressions Survey

		Strongly Disagree		Neutral		Strongly Agree
		1	2	3	4	5
1	The professor is well prepared.					
2	The professor is well organized.					
3	The professor has command of the subject.					
4	I understand the expectations for this course.					
5	The professor shows enthusiasm.					
6	The professor creates interest.					
7	The professor's desire to teach is apparent.					
8	The workload for this course is adequate.					
9	The professor makes ideas clear.					
10	The professor shows concern for students.					
11	The professor is nice.					
12	The professor is friendly.					
13	The course will increase my knowledge.					
14	The course will increase my career skills.					
15	The course will be graded fairly.					
16	The professor speaks clearly.					
17	The course will be taught at an appropriate level.					
18	The professor has a lively speaking style.					
19	The course feedback will be helpful.					

7.3 Appendix C – Survey of Attitudes Toward Statistics

DIRECTIONS: The questions below are designed to identify your attitudes about statistics. The item scale as 7 possible responses; the responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). Please read each question. For the 7 point scale, carefully mark one response that most clearly represents your agreement or disagreement with our items. Try not to think too deeply about each response. Record your answer and move quickly to the next item.

		Strongly Disagree			Neutral			Strongly Agree
		1	2	3	4	5	6	7
1	I like statistics.							
2	Statistics requires concentration.							
3	I feel insecure when I have to do statistics problems.							
4	I have trouble understanding statistics because of how I think.							
5	Statistics formulas are easy to understand.							
6	Statistics is worthless.							
7	Statistics is a complicated subject.							
8	Statistics should be a required part of my professional training.							
9	Statistical skills will make me more employable.							
10	I have no idea of what's going on in statistics.							
11	Statistics is not useful to the typical professional.							
12	I am interested in statistics.							
13	I get frustrated going over statistics tests in class.							
14	Statistical thinking is not applicable in my life outside my job.							
15	I use statistics in my everyday life.							
16	I am under stress during statistics class.							
17	I enjoy taking statistic courses.							
18	Statistics conclusions are rarely presented in everyday life.							
19	Statistics is a subject quickly learned by most people.							
20	Statistics is useful in evaluating the claims in advertisements.							
21	Learning statistics requires a great deal of discipline.							

22	I will have no application for statistics in my profession.							
23	I can explain basic statistical concepts to others.							
24	I make a lot of math errors in statistics.							
25	I am scared by statistics.							
26	Statistics involves massive computations.							
27	I can learn statistics.							
28	I understand statistics equations.							
29	Statistics is irrelevant in my life.							
30	Statistics is highly technical.							
31	I find it difficult to understand statistics concepts.							
32	Most people have to learn a new way of thinking to do statistics.							

7.4 Appendix D – Pre-Course Technology Experience Survey

Please indicate on scale of 1 to 3 the extent to which you have used the following instructional technologies in previous courses at UT Austin *during in-class sessions* where: 1: never, 2: sometimes, 3: frequently. Please indicate N/A if you haven't used the instructional technology before.

BlackBoard

N/A 1 2 3

Classroom Performance System

N/A 1 2 3

PowerPoint

N/A 1 2 3

MATLAB

N/A 1 2 3

Please indicate on scale of 1 to 3 the extent to which you have used the following instructional technologies in previous courses at UT Austin *outside of in-class sessions* where: 1: never, 2: sometimes, 3: frequently. Please indicate N/A if you haven't used the instructional technology before.

BlackBoard

N/A 1 2 3

Classroom Performance System

N/A 1 2 3

PowerPoint

N/A 1 2 3

MATLAB

N/A 1 2 3

Please indicate on scale of 1 to 5 the extent to which you are comfortable with the following instructional technologies, where: 1: strong negative, 2: moderate negative, 3: neutral, 4: moderate positive, 5: strong positive. Please indicate N/A if you haven't used the instructional technology before.

BlackBoard

N/A 1 2 3 4 5

Classroom Performance System

N/A 1 2 3 4 5

PowerPoint

N/A 1 2 3 4 5

MATLAB

N/A 1 2 3 4 5

Comments:

Please indicate on scale of 1 to 5 the extent to which **BlackBoard** influenced the listed aspects of your learning as used in previous courses at UT Austin, where: 1: strong negative, 2: moderate negative, 3: neutral, 4: moderate positive, 5: strong positive. Please indicate N/A if you haven't used the instructional technology before.

Communication with instructors

N/A 1 2 3 4 5

Communication with peers

N/A 1 2 3 4 5

On-going feedback about your progress in the course

N/A 1 2 3 4 5

Reviewing course material outside of class

N/A 1 2 3 4 5

Understanding of "real-world" value of course material

N/A 1 2 3 4 5

Problem-solving practice

N/A 1 2 3 4 5

Knowledge of course deadlines and requirements

N/A 1 2 3 4 5

Comments:

Please indicate on scale of 1 to 5 the extent to which **Classroom Performance System** influenced the listed aspects of your learning as used in previous courses at UT Austin where: 1: strong negative, 2: moderate negative, 3: neutral, 4: moderate positive, 5: strong positive. Please indicate N/A if you haven't used the instructional technology before.

Communication with instructors

N/A 1 2 3 4 5

Communication with peers

N/A 1 2 3 4 5

On-going feedback about your progress in the course

N/A 1 2 3 4 5

Reviewing course material outside of class

N/A 1 2 3 4 5

Understanding of "real-world" value of course material

N/A 1 2 3 4 5

Problem-solving practice

N/A 1 2 3 4 5

Knowledge of course deadlines and requirements

N/A 1 2 3 4 5

Comments:

Please indicate on scale of 1 to 5 the extent to which **PowerPoint** influenced the listed aspects of your learning as used in previous courses at UT Austin, where: 1: strong negative, 2: moderate negative, 3: neutral, 4: moderate positive, 5: strong positive. Please indicate N/A if you haven't used the instructional technology before.

Communication with instructors

N/A 1 2 3 4 5

Communication with peers	N/A	1	2	3	4	5
On-going feedback about your progress in the course	N/A	1	2	3	4	5
Reviewing course material outside of class	N/A	1	2	3	4	5
Understanding of “real-world” value of course material	N/A	1	2	3	4	5
Problem-solving practice	N/A	1	2	3	4	5
Knowledge of course deadlines and requirements	N/A	1	2	3	4	5

Comments:

Please indicate on scale of 1 to 5 the extent to which **MATLAB** influenced the listed aspects of your learning as used in previous courses at UT Austin, where: 1: strong negative, 2: moderate negative, 3: neutral, 4: moderate positive, 5: strong positive. Please indicate N/A if you haven't used the instructional technology before.

Communication with instructors	N/A	1	2	3	4	5
Communication with peers	N/A	1	2	3	4	5
On-going feedback about your progress in the course	N/A	1	2	3	4	5
Reviewing course material outside of class	N/A	1	2	3	4	5
Understanding of “real-world” value of course material	N/A	1	2	3	4	5
Problem-solving practice	N/A	1	2	3	4	5
Knowledge of course deadlines and requirements	N/A	1	2	3	4	5

Comments:

7.5 Appendix E – Students' Assessment of Course Activities by Bloom's Taxonomy

1. Thinking about the statistics portion of BME 335, the pre-class assignments (BlackBoard® quizzes) usually require me to ...(check all that apply)
recall, define, list
understand, interpret, summarize
calculate, solve, apply
analyze, explain, see patterns
predict, generalize, draw conclusions
compare/contrast, assess, make choices, explain
2. Thinking about the statistics portion of BME 335, the in-class exercises (sometimes reported by CPS) usually require me to ...(check all that apply)
recall, define, list
understand, interpret, summarize
calculate, solve, apply
analyze, explain, see patterns
predict, generalize, draw conclusions
compare/contrast, assess, make choices, explain
3. Thinking about the statistics portion of BME 335, the problem sets (MATLAB and paper/pencil) usually require me to ...(check all that apply)
recall, define, list
understand, interpret, summarize
calculate, solve, apply
analyze, explain, see patterns
predict, generalize, draw conclusions
compare/contrast, assess, make choices, explain

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9 Biographies

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