SIMULATION IN A WEB-BASED, ASYNCHRONOUS LEARNING ENVIRONMENT

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Abstract *¾ Asynchronous learning environments for on-campus and remote students are now becoming common place. In many fields, and especially in engineering, it is important to give students realistic laboratory type experiences. This is particularly challenging with a class of students dislocated in time and space. In this paper, the authors discuss a number of efforts to enhance experiential learning using simulations of various forms that can be used by students over the World Wide Web. Simulations that have been developed for courses in total quality management and quality engineering will be described in the paper and demonstrated at the conference.*

INTRODUCTION

The University of Missouri-Rolla, especially the engineering management department, has opportunities to serve students in Rolla, throughout Missouri, the nation and the world. Many students that would otherwise seek degrees in residence in Rolla are place bound in locations away from Rolla for a variety of reasons. The university serves 4000+ daytime students on campus. In addition a very successful program is operated for officers in the Army at Fort Leonard Wood. There is a graduate engineering program in St. Louis, and engineering management delivers degree programs to a number of companies throughout the state. Courses are offered live, by taped delayed video, by two-way live video and over the World Wide Web [1-4]. Accordingly, a particular professor in a given course may have students in several locations in a given semester.

THE CHALLENGE

In a normal synchronous learning environment students come together at a predetermined time to meet the instructor and exchange mutually beneficial information. Typically, the instructor teaches (talks) and the students listen. Good instructors will usually encourage students to ask questions, both in class and at other times. These other opportunities for question and answer sessions may be during the instructor's office hours, or at pre-arranged help sessions, where all or most students attend. Office hours provide students with needed personal attention, but are not edifying to the class as a whole. Some students may feel that this type of interaction is unfair, since not all students hear the questions and answers, particularly if the class is large. The Internet has created even more convenient opportunities for student/teacher and student to student interaction. Personal e-mail communication seems to stimulate questions, but special care needs to be taken to ensure that all students profit from the interaction. Chat rooms can provide a convenient forum for interaction, and the instructor can log on as arranged to the mutual benefit of the class.

But how do we economically handle students that are dislocated from the instructor (the institution and on-campus students) in time and space? Experience suggests that students learn in different ways. Students have a variety of learning styles. On the other hand, almost all students enjoy and profit from interaction with their fellow students, and it is common to note that more learning occurs outside the classroom than in the classroom. It is also common for instructors to overestimate their personal impact on student learning. Instead, it seems more appropriate to view the instructor's main job as creation of a robust learning environment, where student achievement is consistently at a high level. This is the challenge!

THE MOTIVATIONAL POWER OF SIMULATION

Normally in engineering courses, students meet with the instructor or a laboratory assistant in the laboratory once per week to conduct experiments, which re-enforce relevant course material. Many students enjoy this "hands-on" approach, and the psychology of learning suggests that the more senses that are involved, the greater the probability that fundamental concepts will be placed in long term memory or "learned" [5]. When students are separated in time and space it is impractical to manage a course as if they were not! Accordingly, we must carefully consider the educational objectives of the course and provide appropriate (virtual) laboratory activities.

Simulation can provide significant motivation for students in a wide variety of courses. No one is hurt when a computer based simulation goes wrong, so there is a degree of freedom of experimentation that can not be replicated in a real laboratory. Computer simulations in physics, chemistry and engineering can stimulate students' spirit of inquiry, and bring them to levels of learning that are difficult to achieve any other way. Simulation can be fun!

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MULTI-MEDIA ON-CAMPUS, OFF-CAMPUS AND IN A WEB ENVIRONMENT

Courses in Engineering Management at UMR are offered live over the Internet using streaming video. These classes may be viewed live or later as the students' schedule dictates. Students can call in during the live broadcast to ask questions, if they wish. Web-based simulations are used in several courses in Engineering Management. Herein we give a brief discussion of several simulations and their impact on the relevant courses.

EMgt-375: Total Quality Management

Total quality management is required of all quality majors in the engineering management department, and is a popular technical elective course for other students in engineering management, mechanical and electrical engineering, computer science and other programs on campus. In addition, this course is a part of the quality engineering specialty track in our System Engineering (http://web.umr.edu/~syseng/) MS program, which is offered worldwide to employees of the Boeing company and other interested students.

Professor Ragsdell has developed and taught a course entitled Total Quality Management since 1989 at UMR [6]. This course is based on thirty plus years of interaction with industrial leaders in the US and Japan, such as General Motors, Ford, Xerox, Nissan, Nippon Denso, and government leaders in Missouri [7], the US and Asia, and in healthcare organizations [8,9]. The course has been given using every conceivable format. In fall 1999 the course was reorganized to a two lecture/one lab period per week format. A web page, which contains all handout material (course schedule, lab assignments, publications, etc.), lecture slides, and grade book, was created for the course. Interested readers can visit the web page at http://www.umr.edu/~design by selecting EMgt-375. One of the major objectives of this course is an understanding of variation propagation, and it's effect on product performance in the hand of the customer. Several of the laboratory assignments require the use of a virtual calculator, which is provided in a multi-media learning environment (BEST TQM) currently available to students on compact disks.

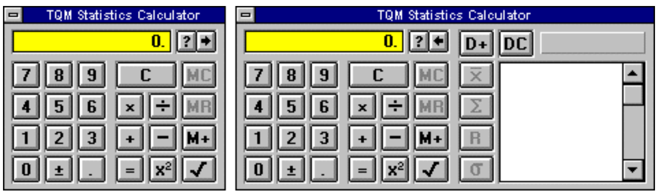


FIGURE 1
VIRTUAL CALCULATOR

The calculator is especially helpful to student learning teams as they complete the "ruler experiment" assignment.

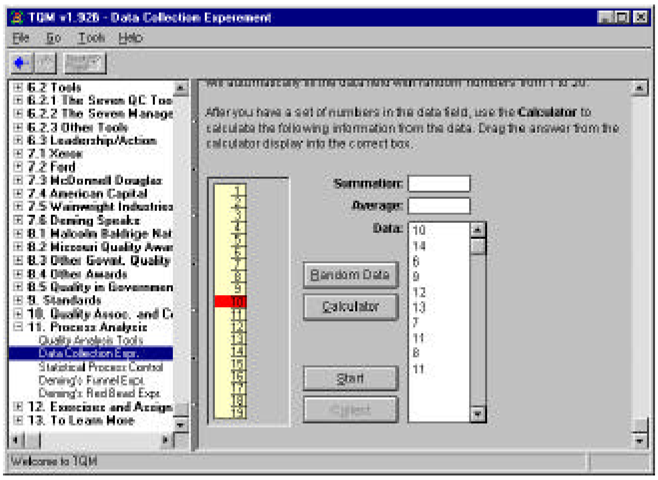


FIGURE 2
RULER EXPERIMENT

The goal of the ruler experiment is to demonstrate common and special causes of variation, and to give students the opportunity to deal with each type in an organized fashion. The assignment reads as follows:

This exercise has three objectives: team building, data collection, and examination of the implications of the old and new styles of management. Assign the following duties to team members: 1. dropper, 2. catcher, 3. Inspector / recorder, 4. manager, 5. dropper foreman, 6. catcher foreman.

Phase One Ground Rules: Droppers drop the yardstick with their eyes closed. Dropper foremen tell the dropper when to drop. Catchers catch the yardstick with their eyes closed. Catcher foremen tell the catcher when to catch. The inspector / recorder inspects and records the point on the ruler where the catcher catches. The manager's role is to tell everyone what to do; to condemn "off-target" performance and praise "on-target" performance. Otherwise, the manager does nothing! Catcher and dropper are not allowed to communicate with anyone except their foreman; certainly not each other. Foremen can speak to their respective workers, the inspector / recorder, but not each other. They must go through the manager to send messages to each other. Proper protocol must be used at all times. The ruler is held by the dropper and the catcher's hand is placed in the initial catching range. The dropper foreman tells the dropper to drop the ruler. The catcher foreman tells the catcher when to catch in order to hit the target. The inspector/recorder observes and records the results.

Phase Two Ground Rules: Same as Phase One, but dropper and catcher open eyes and can communicate with anyone they choose. Foremen do as the dropper and catcher say. Manager goes home and remaining members work as a team to complete task in most efficient and reliable fashion, so as to produce on-target performance with minimum variation.

Assignment: As a team collect 50 data points using Phase One and 50 data points using Phase Two ground rules. Assume a target of 20 inches and use the catcher / dropper protocol discussed in class. Hint: record all information that will help you to see random and assignable causes in the analysis assignments to come.

On-campus students are allowed to use a physical ruler or to use the virtual ruler in BEST TQM. Remote students typically use the virtual ruler, and must improvise (recruit family members or friends) in order to complete the assignment with the required team approach.

EMgt-376/475: Quality Engineering

Quality Engineering is offered in two versions, one designed as a capstone design experience for undergraduate quality majors in the department (EMgt-376), and a more advanced version designed primarily for MS and PhD students in Mechanical and Electrical Engineering, and Engineering Management. The advanced version was offered in spring 2002 to a class of students on campus, to remote students over the Internet, and to a class of Army captains at Fort Leonard Wood. Live lectures were given three times per week, and were available on the Internet using live streaming video or later from the course webpage.

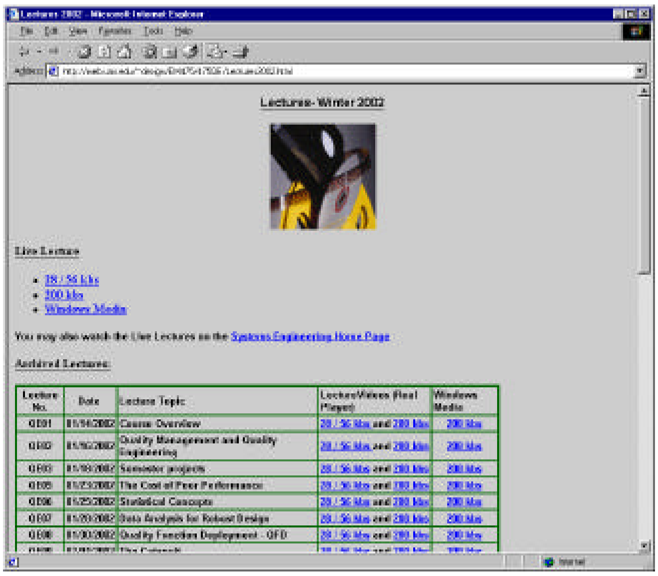


FIGURE 3
QUALITY ENGINEERING LECTURES

All lecture slides and other materials are available to students in advance on the course webpage. Many remote students are unable to view the lectures live, so an additional study aid is available using the course management tool, Blackboard [10]. Blackboard is a very useful tool for course management, especially for large classes or for small groups of remote students in several locations. A fully functional advanced Quality Engineering course (EMgt-475) is now available on Blackboard [11]. Students can view lectures prepared as Flash movies [12]. Most lectures contain animated slide presentations (using Flash) with coordinated

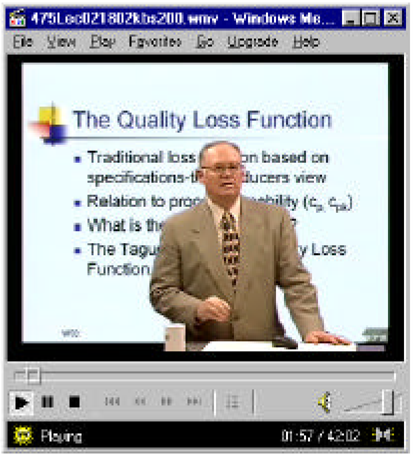


FIGURE 4
EXAMPLE VIDEO LECTURE

audio. Interested readers can view a sample presentation at http://blackboard.umr.edu/ (use 475guest as username and password). This format is especially useful when students cannot view the live or delayed video lectures (the spring 2002 lectures can be viewed at http://web.umr.edu/~design/EM475/475QE/Lectures2002.html). This is often the case when remote students must use slow corporate local area networks, or low speed modems. Blackboard offers many other advantages for both on-campus and off-campus course management, such as the digital drop box, and automated testing and surveys.

FIGURE 5
COURSE MANAGEMENT USING BLACKBOARD

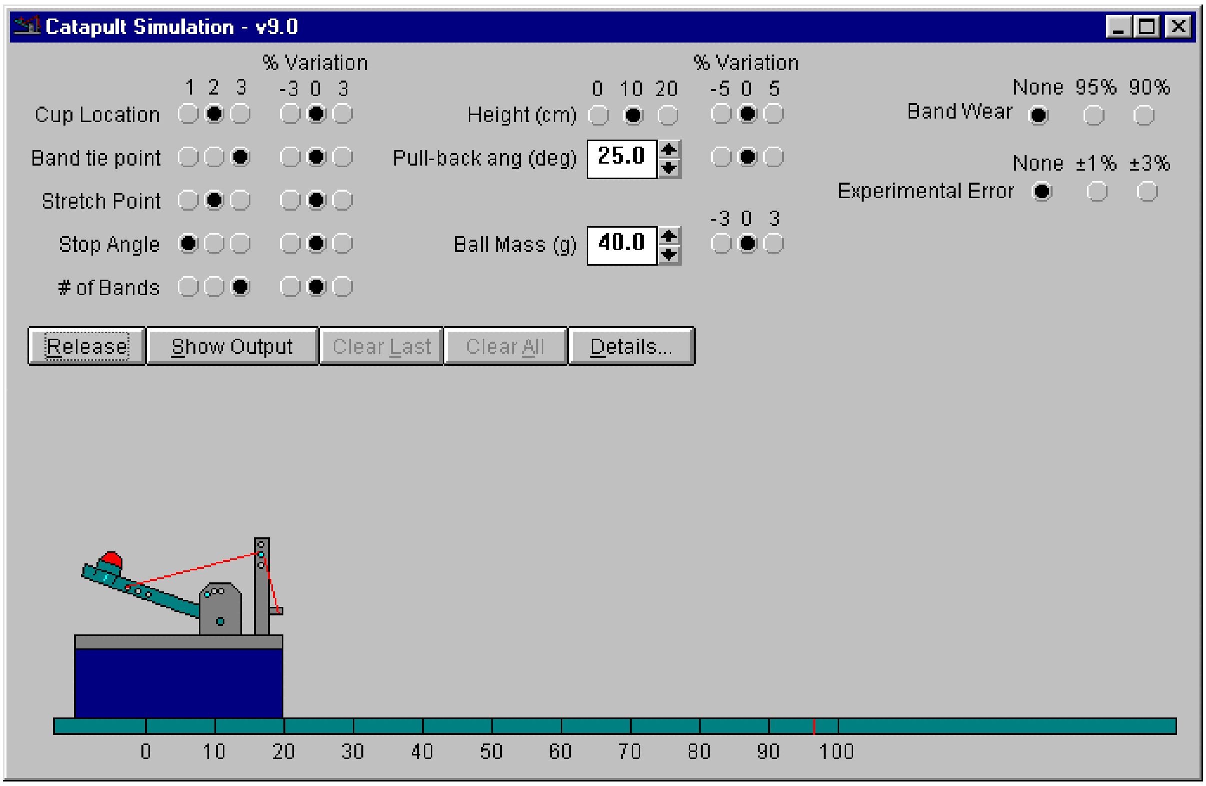
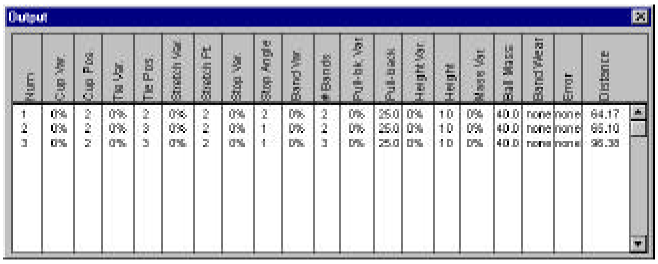


FIGURE 6
THE CATAPULT

All students in the quality engineering courses must complete a semester project. In spring 2002, students selected one of four project assignments, except for one distance student group that decided to work on a work related project. The students chose one of the following projects: catapult, Wheatstone bridge, automotive disk brake system, or design of a cool drink. Students that chose the catapult or disk brake system projects were provided with simulations that facilitated experimentation. We briefly describe one of the simulations here.

The Catapult: The Catapult is a device designed to throw a projectile to reliably hit a distant target. The key word here is "reliably hit". A good discussion of the mechanics of the catapult is given by Fowlkes and Creveling [13]. A simulation of the catapult, as shown in Figure 6 is provided to students. The simulation provides a fully functional catapult with a wide range of selectable parameters, and a resulting wide range of potential target locations. Ease of use and safety are two major advantages of the simulation. In addition, the simulation package contains several additional useful features. Each time the catapult is fired the settings and results are displayed in tabular form by selecting the output button.



Num	Cup Var	Cup Pos	Tie Var	Tie Pos	Stretch Var	Stretch Pt	Stop Var	Stop Angle	Band Var	# Bands	Pull-bk Var	Pull-back	Height Var	Height	Mass Var	Ball Mass	Band Wear	Error	Distance
1	0%	2	0%	2	0%	2	0%	2	0%	2	0%	25.0	0%	10	0%	40.0	none	none	64.17
2	0%	2	0%	3	0%	2	0%	1	0%	2	0%	25.0	0%	10	0%	40.0	none	none	65.10
3	0%	2	0%	3	0%	2	0%	1	0%	3	0%	25.0	0%	10	0%	40.0	none	none	96.38

FIGURE 7
OUTPUT WINDOW

The details button gives the free body diagrams for the catapult system, and all equations of motion for the catapult system elements and the projectile (see Figures 8 and 9). Students find the catapult simulator fun to use, and they typically begin to use it with little or no instruction or encouragement. The simulator is designed to demonstrate the effects of variation propagation. Manufacturing and operational variation can easily be demonstrated. The value of this simulator as a tool to encourage students to experience "real" quality engineering problems can not be overstated.

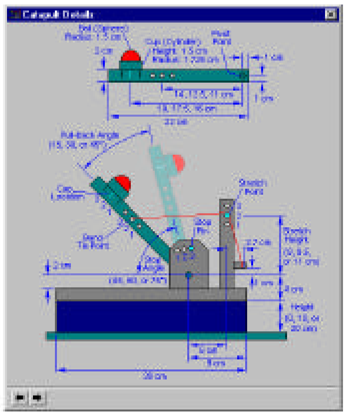


FIGURE 8
EXAMPLE FREE BODY DIAGRAM

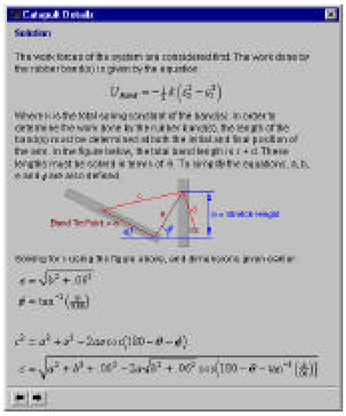


FIGURE 9
EQUATION OF MOTION VIEW

An Experiment

EMgt-475 has now reached a degree of maturity, which allows experiments in delivery. Many forms of delivery style have been attempted over the last decade. In Spring 2002 a class of 20 Army officers at Fort Leonard Wood enrolled in an accelerated 8 week version of the course (same course as on-campus, but faster pace), which is an elective in their MS program. Typically, UMR classes are delivered in person by senior faculty at Fort Leonard Wood. A normal class involves the instructor lecturing for most, if not all, of the class period. Students ask questions in class, but have little time for small group discussion, or one-on-one discussions with the instructor. Students work on homework, read the book and other assigned material, and work on laboratory assignments and the semester project in small groups (learning teams), or individually. We do not have space to discuss the learning team concept here, but interested readers can learn more at the course webpage. Ragsdell decided to ask the class to consider a rather radical experiment in delivery style at the first class meeting. The proposal involved turning the course style upside down. “Let us work together (the class was divided into learning teams, which were assigned to work together on laboratory assignments and the semester project) in class on the labs and the semester project”. Students were then assigned to view the lectures in video format using RealPlayer or Windows Media Player, and to view the lectures on Blackboard using animated slides via Shockwave with coordinated audio. Each student was assigned to keep a log of his or her experience with Blackboard and the streaming video material. One of the semester laboratory assignments was to review each of these delivery formats. Two surveys of student opinion were conducted using Blackboard, which allowed anonymous responses. The students were asked to respond to fifteen statements with one of five responses; strongly agree, agree, neutral, disagree, or strongly disagree. The fifteen statements are:

1. I find the content of this course to be of interest.
2. I enjoy the discussion style of this course.
3. I find the instructor to be knowledgeable.
4. I find that working with the instructor in class on the project is useful.
5. I found the instructor to be open to questions and discussion.
6. I find that working with the instructor in class on the project is useful.
7. I found the material provided on the course webpage to be helpful.
8. The lecture videos on the web are helpful.
9. The blackboard presentation of this course is helpful.
10. I prefer the lecture videos to the blackboard (shockwave) presentation.
11. I prefer the blackboard (shockwave) presentation to the lecture videos.
12. I would prefer a traditional presentation, where the instructor lectures, and lab and project work is done outside the class time.
13. I think this course will help me after my military career.
14. I think this course will help me in my future military career.
15. The instructor appears interested in students and this course.

Twenty students responded to this opinion survey, which was given on 19 March 2002. A summary of the responses is given in Figure 10. From these responses we see that a majority of the students found the course to be interesting and the instructor knowledgeable, enjoyed the discussion style of the course, and generally found the materials provided over the web to be useful. Let us examine the responses to items 12 and 10 and 11 more carefully. We see from the results that 9 students agree or strongly agree that they would prefer a traditional presentation of the course. This means that 11 students either don’t care or would not prefer a traditional presentation of the course! The responses to item 10 and 11 show that exactly half of the class preferred the lecture videos to the blackboard presentation of the course. Comments in class suggested that the preference for the videos was much stronger, but many students said that the choices given in the opinion survey were complicated by the slow modems available to them during the course. That is, they said they may have responded differently if a high speed line had been available on a 24/7 basis.

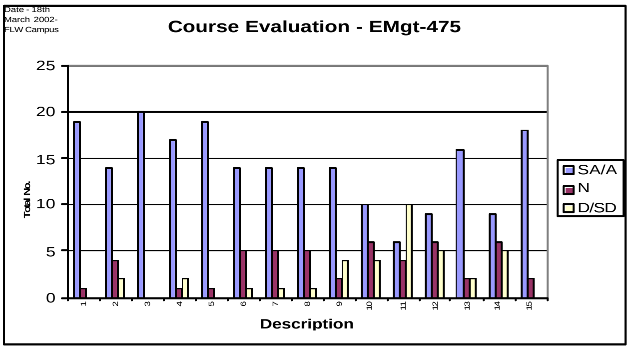


FIGURE 10
STUDENT OPINION SURVEY AT FLW, 19 MARCH 2002

We then wondered if these opinions might be correlated to personality type. All students were asked to take the Myers-Briggs Personality Type on-line test [14], and another survey (exactly the same questions) was given on 18 April 2002, with the exception that each respondent was asked to provide their Myers-Briggs Personality Type. This time only 17 of the 20 students responded. One student failed to report his/her Myers-Briggs Personality Type. A summary of the student responses is given in Figure 11.

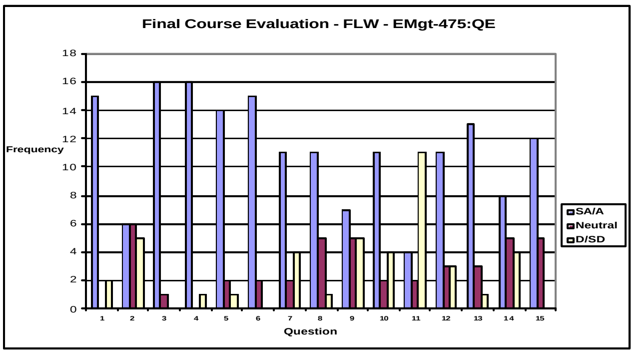


FIGURE 11
STUDENT OPINION SURVEY AT FLW, 18 APRIL 2002

The results are generally the same as before except that one student has developed doubt concerning the knowledge of the instructor, and the preference for the video lectures over the blackboard presentation is now much more pronounced. Be aware that this survey was completed on the last day of class, which was also the day that all students gave their final oral presentation of the semester project, and handed in their written project reports. In his class there were 5 ENTJ's and 5 INTJ's. The results show that 100% of the ENTJ's felt that working with the instructor in class on the project was useful (item 6), whereas only 60% of the INTJ's had this opinion (40% were neutral). We also observe that 80% of the INTJ's would prefer a traditional presentation, but only 40% of the ENTJ's had this opinion. Interesting, don't you think! The complete results are on the course webpage which can be located at www.umr.edu/~design. The reader is warned not to draw conclusions from this very limited sample.

THE FUTURE

We hope the future will hold opportunities for us to gather additional data on student opinion of course delivery format, and more specific data on simulator interfaces. We can imagine the time when interfaces for the course and simulators used in the course can be designed to adapt to student personality or other indicators of preference.

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