ASSESSMENT OF A HYBRID, ONLINE/IN-CLASS COURSE DEVELOPED AT MULTIPLE UNIVERSITIES

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ABSTRACT – In Fall 2007, a coalition of four universities was awarded an NSF CCLI grant to support the development of a curriculum with the goal of cultivating *systems thinking* in students. Systems thinking, as defined in this project, is the ability to envision architectures of complex-engineered systems and the principles that underlie them. The effort, deemed MUSE – Multi-University Systems Education – has developed a unique course to instill such systems skills. This undergraduate course, *Wireless Sensor Network Design*, not only introduces students to a timely technology but utilizes this topic to bring together material from a variety of subject matters that students had heretofore studied in isolation. To develop the course, faculty at each institution contributed online modules in topics of their expertise but with the material refocused to emphasize relevance to sensor networks and interaction with other electrical engineering subdisciplines. These modules were created utilizing Tablet PCs and Camtasia Studio screen recording software. In Fall 2008, the course was piloted at Northern Arizona University. A hybrid lecturing approach was employed where students interacted with online content the equivalent one lecture per week and then discussed the material in-class, once a week. In this paper, assessment results of the initial course offering are reported in three areas. First, students evaluated the content delivery method along with the course content quality and engagement. Second, students were evaluated pre- and post-course with a systems-oriented task to evaluate whether holistic skills were being developed. Finally, the course developers were evaluated on the collaborative aspects of the project along with the approach for creating content.

Introduction

The hybrid, online/in-class course described herein is one component of a larger, NSF-sponsored curriculum development effort that seeks to encourage *systems thinking* in our students. Engineering curricula tend to be compartmentalized leading to topics (e.g., electronics, power, communications in electrical engineering) being taught in isolation without providing connections as to how they are dependent in real-world systems. Our project strives to give students experience in making these connections. The course placement in the curriculum is just prior to the student's Capstone/senior project. The trend is that Capstone projects are becoming more interdisciplinary thus creating a greater need for students to have a systems perspective. This trend is certainly true in today's workforce, where engineering that can be performed in isolation has often become commoditized and thus outsourced, and where work which designs, specifies and/or integrates systems to meet specific customer needs provides a competitive advantage.

The collaborative development of the course was in itself a case study in systems thinking. The participants represent a broad distribution geographically and in professional training: Northern Arizona University (NAU) and the University of Vermont (UVM) contributed expertise in wireless networks, communications and online delivery; the University of Hawaii (UH) and the University of South Florida (USF) provided knowledge in microwave hardware and systems; and Magnolia Consulting developed and executed the course assessment. Just as the course content attempts to weave together a broad array of technical concepts and emphasize the important system-level interdependencies, so were the developers required to consider the interplay of student background, departmental policies, resources and schedule restrictions that varied across the participating universities. A portion of this paper is dedicated to describing some of the lessons learned from this experience.

Course Format and Assessment Criteria

The purpose of this study was to evaluate the effectiveness of the pilot offering of the *Wireless Sensor Network Design* course offered at NAU in Fall 2008 in a hybrid in-class/online format, also referred to as an inverted classroom format (Lage, Platt, & Treglia, 2000). In this format, students viewed online modules developed by the faculty for an equivalent of one class period a week. Once a week, students met with the instructor (Flikkema) to discuss online material, conduct assessment and introduce subsequent modules. The modules were developed using Tablet PCs and Camtasia Studio screen recording software. The faculty developer first created a set of partially completed slides pertaining to the module's subject matter. Employing Camtasia, the developer then captured the ink strokes made using a Tablet as he discussed the material being presented. Modules were rendered as either QuickTime or Flash videos for easy viewing by the students. Modules created along with additional course information can be found at the project website: www.uvm.edu/~muse.

Specifically, the study presented herein addressed the following overarching questions:

1. From the student view, was the course successful in content and format?
2. From both the instructor and student view, does the 'inverted classroom' format (lectures online, discussion in class) result in improved student engagement, participation, and performance?
3. After this course, are students better prepared to deal with systems-level issues that they will face in senior design and on the job?
4. Lessons learned:
   i. What are the benefits and challenges to planning and implementing a course across multiple institutions?
   ii. How should the course and/or approach be modified for Fall 2009 based on findings from the pilot offering?

Assessment Methodology

The study employed a mixed-method design using both qualitative and quantitative methods to address the research questions. Students provided feedback on the course format and online modules through feedback surveys, focus group interviews, and through beginning- and end-of-course surveys. Student performance relative to conceptual understanding and systems thinking ability was measured course assessments and a pre/post course block diagramming exercise.

Module Feedback Survey

After completing each online module, students rated aspects of module quality including pacing, organization, graphics, and overall quality and responded to a series of questions regarding accessibility and clarity of content and objectives. Open-ended items allowed students to comment on aspects of the module they particularly liked, those they found confusing, and suggestions for module improvement.

Student Focus Group Interviews

The external evaluator for the project (Haden) conducted focus group interviews with students at the midpoint of the semester. Interview questions centered on a) class format, b) coherence of assignments, c) in-depth feedback on module format, quality and accessibility, and d) overall course related feedback. A total of nine students participated across two interviews, each lasting 40 minutes.

Student Surveys

Students completed a brief survey at the beginning and end of the semester. The initial survey measured students' level of experience with web-based and hybrid courses, attitudes toward online and hybrid class format. The final survey examined whether student expectations for the course had been met and offered a final opportunity to provide course feedback.

Course Assessments

In the pilot offering, students were assessed using a mixture of homework assignments, quizzes, two exams during the semester, and class participation. Homework sets were created by the module developer. In place of a final examination, teams of two or three students were given a final presentation assignment. The assignment was somewhat unique in that the teams were required to create a video of their presentation, giving them a chance to create multimedia content. The presentations were viewed by all students in the final class meetings. The presentations were required to address some aspect of wireless sensor networks. The teams submitted topic proposals which were reviewed and approved by the instructor. Presentation topics included the role of spread spectrum and an intelligent parking application of WSNs.

Findings

Student Feedback on Course Format

Students indicated that what they most liked about the inverted classroom format was the flexibility it allowed them in accessing course content. They appreciated that they could watch the modules on their own time and could proceed at their own pace through the material. This allowed them to repeat parts of the videos that they initially found confusing, something they are unable to do in a face-to-face lecture experience. Having the material in a video format helped students when reviewing for course exams by allowing them to go back to specific clips while studying to revisit key concepts and diagrams and examples.

While students liked the flexibility of working through the modules on their own time, they struggled with not having immediate access to the instructor for questions and clarification of concepts while viewing the modules. The opportunity to ask questions came after viewing the modules during face-to-face time in class. For some students, this presented a problem when they came to a point in a module where they needed clarification before moving on to the next slide. As one student stated, "*You don't have access to the professors for immediate feedback. [In class] a professor can adjust the speed of delivery to student learning*." Another student commented that he "*felt nervous about asking questions*" because with longer modules there was so much to remember for the in-class discussion component. For this course, in-class time was spent clarifying content from the modules and providing opportunities to apply the content to examples, but a mechanism for having key questions answered while viewing would have helped in understanding the content along the way. A web-based course discussion forum or message board was a suggested way to address this issue.

Student feedback also indicated that developing a laboratory component to the course would increase conceptual understanding. Many students talked of wanting "*to work with their hands*", and to have the opportunity to actually see some of the systems discussed in the modules. Several suggested breaking larger modules into segments with class time between segments to explore the concepts through projects or hands-on activities.

Student Feedback on Online Modules

Individual module feedback offered a means of both gauging the success of the inverted class format, and providing feedback to inform future revisions of the modules. Student observations and focus group interviews clarified the aspects of modules that made them better at building conceptual understanding. Because the modules were viewed independently from in-class time, it was essential that they presented material in a clear and organized format. Students rated the overall organization across all modules highly (M=4.01 on a 5-point scale). Module format—the mix of graphics, film clips, voiceovers—was also rated highly (M=3.94). Students gave slightly higher ratings of quality to modules presented in the Flash Player format versus the QuickTime format (M=4.08 and 3.79, respectively). Modules in the Flash Player format contained embedded quiz questions that students completed at key points while working through the slides. Students commented that the embedded quizzes made it easier to identify the key concepts in the modules, and gave them a means of checking their understanding before moving on. This was especially helpful since they did not have a means for checking their understanding with the instructor while working through the content. Students identified other key features in module quality, including clear introductory slides outlining the module learning objectives, and concluding slides summarizing key concepts. Organizing module instruction in this manner helped students not only identify the learning objectives for each module, but also helped them check their own understanding at the end of the module.

The format of the modules—progressing through the slides while the instructor wrote and diagrammed as if on a blackboard—particularly appealed to students. Several commented that it gave the modules a more "*interactive*" feel than if they had been presented as completed PowerPoint slides. Modules engaged student interest by presenting material in this more dynamic format. Presenting examples that involved commonly understood and well known systems (such as a car engine) were particularly effective in increasing understanding, as were modules that presented real-world examples of the use of wireless sensor technology.

Student Interest and Engagement

Students offered mixed views of whether the course met their expectations. During interviews, several commented that the class piqued their interest in wireless technology. One student commented: "*I think this class is very reality-based*. *It's applicable to industry and what we would do in the field*." However, this student and many others commented that coming into the course they expected a broader scope of course content including more on wireless communication rather than only wireless sensor networks.

Most students felt that providing a hands-on project based aspect to the course would greatly increase their engagement in the content. Several students signed up for the course not realizing that it was an inverted format and had expected the course to be a more traditional lecture format with laboratory experiences embedded throughout the semester. Many felt that the hybrid nature of the class would have worked better if hands-on opportunities were provided during class time.

Student enthusiasm during the pilot was strongly positive overall. Most students were very positive about the inverted classroom format, where they could watch the lecture videos at their own convenience, followed by free-wheeling Q&A/discussions in the classroom. The in-class discussions often led to the (usually unplanned) introduction of new concepts or applications, engendering a spontaneity that the students seemed to find engaging.

Assessment of Systems Thinking

Perhaps our greatest challenge thus far has been the design of effective measures of the systems thinking ability of students. In the pilot, we had the students draw block diagrams of a mobile phone, both as an initial assessment and at the end of the course (where we returned their initial responses). A common difference between the initial and final responses was additional detail in the RF front-end; this could have been because there was a strong emphasis placed on both systems- and RF-level block-diagram representations in the in-class sessions. On a less-positive note, the responses did not clearly identify (i) the natural hierarchy of the design of these systems, nor the dependencies within and between hierarchical layers, (ii) how functionality is allocated to different types of hardware and software. We are working on a more appropriate assessment tool within the structure of a formal concept inventory for the next offering of the course.

Lessons Learned

At the conclusion of the Fall 2008 pilot, the initial module developers (Flikkema, Frolik and Weller) met with the external evaluator (Haden) to discuss lessons learned in regards to the multi-university collaboration in developing the course. The following are some of their key findings.

- Working from multiple institutions presents challenges. Each faculty partner has different thinking about how the course should be structured, what content to include, etc. because of differences in local cultures and curricula at each institution. This has implications for the portability of the course, but is also viewed as an asset in that a variety of perspectives were represented in its development.
- Planning and implementation benefitted from the project partners having known each other for many years. Comfort level with one another was key to successful planning and fostering a shared vision for the course and overall project.
- Due to scheduling constraints, the modules for the pilot were developed by the different faculty in parallel. Working on modules at the same time made it more difficult to make sure one module flowed well with the next. A better strategy would have been to develop the first module, all review together, then move on to developing the second, and so on. In addition, having modules ready prior to the start of semester would have enabled third-party testing (e.g., by graduate students) to identify any outstanding issues.
- Creating the videos was very time consuming. Faculty first needed to establish a comfort level with the recording technology and with simply being recorded. To avoid stumbling over words, scripts were often written which had the effect of eliminating any spontaneity in delivery. For a 20-minute video clip the time invested in terms of identifying content, developing materials, and recording videos was at least 3 hours.
- Assessment of the primary project objective (i.e., developing systems thinking in students) needs to be improved. More or better tools are needed to know not only if students understand the course material but whether they can leverage this knowledge in other scenarios involving complex engineered systems.
- Students desired a means to ask questions while viewing the online content. To address this, we will investigate a way for students to blog or discuss course content, share ideas and ask questions while watching the content. As the course will be offered at multiple institutions beginning in Fall 2009, we will utilize, for example, Google Groups for this purpose. Such a written record of student questions, misconceptions and concepts in need of clarification will ease the documentation of improvements needed to the curriculum.
- Each module was developed by an individual faculty member and the result comes across as a typical lecture. A more engaging approach which will be explored is to have more than one faculty member discussing the content in a module, resulting in more of a conversation about the material. This will also bring to the attention of the students that topics can be seen by different views even amongst those with similar training.
- For the pilot, faculty at UVM and USF developed modules but had no interaction with students taking the course. This proved challenging: the lack of student reaction made it difficult to understand areas of improvement. While feedback forms helped assess what to revamp for Fall 2009, this feedback often was too late for improving the pilot. Similar issues were faced with creating homework and exam questions – the remote faculty could not tell how the students were reacting and whether the instructor piloting the class had all the needed information to address student questions.
- Inadequacy of computer and web interaction tools that worked across institutions presented challenges for PI communication. In the first year Skype was used, however problems with audio fidelity and reliability motivates interest in a more robust and flexible web conferencing solution (e.g., WebEx).

- Computer-aided design tools available to students differ across universities. However, in order to develop and integrate hands-on laboratory assignments a common platform, preferably free to students and not restricted to use only in computer laboratories, is needed. Ideally, for broad dissemination of the course material, such access should be part of a standard package provided by the software vendor so that special arrangements are not needed.

Conclusion

In this paper we have presented assessment results for a pilot implementation online curriculum designed to improve systems thinking in electrical engineering students. The course utilizes wireless sensor networks as a motivating technology for this purpose and was developed by faculty members at multiple universities. Assessment results identified areas for improvement both in the online modules and the course overall. Evaluation of the impact of the pilot on preparing students for their Capstone course is also underway. Revisions to the course are ongoing, and it will be offered in Fall 2009 at NAU, USF and UVM. UH will serve as an early adopter of the course modules and as an additional assessment point in Fall 2010.

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Reference

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