Implementation and Assessment of a Blended Learning Environment as an Approach to Better Engage Students in a Large Systems Design Class

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Abstract

Blended learning refers to combining traditional face-to-face learning environments with online education tools and approaches. With the ubiquitous use of laptops by students and the proliferation of low and no cost tools to facilitate online education, opportunities for blended learning are more available now than ever before. Additionally, many universities are facing growing enrollments that push the limits on the scalability of classroom pedagogies. For example, providing students the opportunity to orally present technical work becomes challenging as the number of students per class grows to large numbers. Furthermore, decades of prior research in education have shown the effectiveness of formative feedback and an authentic, active, and collaborative environment in promoting student learning. It is in this context that the authors redesigned a class to take advantage of several blended learning approaches in an effort to provide a higher quality learning environment.

The purpose of this project is to implement and assess the impact of integrating blended learning approaches in a case study based systems design class that faces growing enrollment. The goals of integrating blended learning approaches into this class were to provide better formative feedback more quickly to students, to continue to integrate authentic work in the class through case studies, and to provide a more active and collaborative learning environment.

The blended experience for this class has several components, including

- Student teams recording presentations with video-capture software (instead of just turning in PowerPoint files for feedback).
- Peer review of aforementioned recorded presentations and other deliverables, utilizing an online peer-management system (called "PRAZE") to reduce the complexity of administering peer review for a large number of students
- In-class polls using Google Docs
- Discussion board forums for student questions, utilizing an online system called Piazza, and
- Video-capture of lectures covering several of the core topics, thereby allowing the instructors to spend class time on more engaging ways of helping students learn new topics (i.e., flipping the classroom)

The assessment plan for this project is multidimensional and focuses on the effectiveness of the blended approaches in promoting quick formative feedback, active learning approaches, and collaborative learning … all in an effort to improve student learning. To this end, evaluation will include an end-of-course survey aimed at collecting student perceptions of the different blended approaches, surveys of students related to self-efficacy and their perceptions of the feedback received on case studies, the matching of data on who watches online lectures to grades on specific assignments and questions, content analysis of course feedback as compared to prior years, and observations by instructors and teaching assistants. In this paper, the overall assessment approach is presented along with results from the end-of-course survey.

Introduction

Motivation: A traditional, face-to-face class facing challenges as enrollment increases

Enrollments were increasing. Some topics required several class days of content delivery from faculty with little interaction from students. Students felt that the grading of complex, open-ended assignments was not done fairly. Faculty struggled to give meaningful feedback to all students in a way that helped students learn.

In spite of these challenges, students and faculty viewed the class as being a "good" course. This paper is not about taking the worst class at university and turning it around. Instead, it is about a far more common topic: taking a "pretty darn good" class and striving to make it a "phenomenal" class. A phenomenal class where students are challenged and challenge themselves, where they learn process-oriented topics in a deep way and apply that knowledge beyond the final day of class, where learning is relevant because it is connected to other classes and the "real world," and where the entire community involved in the class collectively elevates their knowledge.

One can imagine a group of three to four students working closely with a faculty member and having such an experience… an apprenticeship-type model where continual failure and feedback leads to deep learning. Achieving these lofty aspirations with a larger number of students – 120 for the class discussed in this paper – is a different story. Ironic about this story is that online educational tools which allow students to receive an education "at a distance" – the same tools that allow students and faculty to engage in a class without ever meeting – were enlisted to create a more intimate, less-distanced learning environment for a face-to-face course facing enrollment pressures. Such an approach falls within a broad class of approaches called blended learning.

Literature Review

Blended Learning: Using online tools to support and enhance face-to-face learning

Blended learning refers to combining traditional face-to-face learning environments with online education tools and approaches[1]. Blended learning approaches vary widely – as do the different ways that these approaches are categorized in the literature. Bersin includes asynchronous and synchronous fully online classes, instructor-led face-to-face classes with online content, on-the-job training that is combined with online materials, and simulations/on-line labs[1]. Alonso simplifies this into the three categories of synchronous, asynchronous, and traditional classroom[2]. Alonso also highlights key ingredients of a blended learning class, including that the course is dynamic, collaborative, and personalized[2]. In converting a face-to-face traditional class to a blended class, three models have been identified: the supplemental model (where online content supplements face-to-face meetings), the replacement model (where the number of in-class meetings is reduced), and the emporium model (where all in-class meetings are eliminated)[3]. The supplemental model was used in the work presented in this paper.

With the ubiquitous use of laptops by students and the proliferation of low and no cost tools to facilitate online education, opportunities for the supplemental blended learning model are more available now than ever before. Additionally, many universities are facing growing enrollments that push the limits on the scalability of classroom pedagogies. For example, providing students

the opportunity to orally present technical work becomes challenging as the number of students per class grows to large numbers. Furthermore, decades of prior research in education have shown the effectiveness of formative feedback and an authentic, active, and collaborative environment in promoting student learning (for several different summaries, see "Future of Engineering Education" articles by Felder et al.[4, 5], *How People Learn*[6], or *How Learning Works*[7]). It is in this context that the authors redesigned a class to take advantage of several blended learning approaches in an effort to provide a higher quality learning environment; a learning environment where the sacrifices made as enrollments increase are minimized.

Project Focus

Objective: Implement research-based practices such as peer evaluation and an active, collaborative learning environment in a high-enrollment class using a blended approach.

The purpose of this project is to implement and assess the impact of integrating blended learning approaches in a case study based systems design class that faces growing enrollment. The goals of integrating blended learning approaches into this class were to

1) provide better formative feedback more quickly to students,
2) continue to integrate authentic work in the class through case studies, and
3) provide a more active, collaborative learning environment.

In short, the authors were trying to move the class closer to their vision for a "phenomenal" class described earlier.

Focus: This paper focuses on the implementation of blended learning approaches, the overall evaluation framework, and preliminary results.

The primary focus of this paper is to describe the blended-learning approaches implemented in a particular class, describe the overall evaluation framework being used to assess the impact of the approaches, and present preliminary, high-level results from the evaluation. The preliminary results are aimed at answering two questions. First, how did the blended-learning course compare to the same course in prior years? Second, which of the blended learning approaches used were most preferred by students and why?

The Setting

An introductory systems engineering class

We introduced the blended learning approaches in a sophomore "methodology" class in Fall 2012. As used here, the word "methodology" means that the primary learning objective centers on how to approach an ill-defined problem. Some analytical tools and approaches are covered in the class, but the primary focus is on the overall methodology. One could think of this as a sophomore "design class," but the focus is admittedly more strategic and more upstream than most design classes (cases typically ask students to offer recommendations as to "what should we design" as opposed to asking students to offer a design). The specific high-level learning objectives of the course are shown in Table 1.

Table 1 Course Learning Objectives

Through working on case studies from real world systems engineering practice and a team-based course project, students should be able to:

1. Explain and effectively apply systemic thinking within a systematic approach to open-ended problems, including
    - *formulating a problem and develop a clear statement of needs*
    - *identifying solutions to a problem*
    - *evaluating and select solutions to a problem*
    - *explaining and applying iteration as needed both within steps and through an entire process*
2. articulate their personal view of systems engineering methodology based on their experiences with applying systemic thinking within a systematic approach in a variety of contexts
3. explain and apply basic systems modeling and analytical tools, including introductions to
    - *decision trees, decision making with multiple objectives, group/team decision making, engineering economic analysis, performing sensitivity analysis*
4. communicate effectively with clients/stakeholders, including
    - *interacting with stakeholders to formulate a problem, creating and deliver effective "client" presentations, writing effective technical documents for clients*
5. work collaboratively on complex systems problems involving technology and multiple stakeholders

The major assignments in the class were four cases. With each case, teams of students were given information on an open-ended situation where a decision-maker needed a recommendation as to what action to take. Student teams prepared briefings for the decision-makers as their final deliverable. Student teams had between one and three weeks to complete the cases. As an example, one case focused on teams recommending which set of bridges should be prioritized for funding given an uncertain total budget and data on 126 bridges that had been identified as candidates for funding. Other assignments included three quizzes and five individual homeworks.

Class enrollment of 117 was divided into two sections of 68 and 49. The same team of two faculty taught each section. Active learning approaches were utilized heavily during class, with students working together during class frequently. Faculty created rubrics for each case and used them in grading the cases. A single faculty member graded Case 1 and 2 (each faculty member graded one) while both faculty graded Case 3 and 4 together. The two teaching assistants graded quizzes and homework.

Methods

Subjects: 117 students, mainly from one major, all required to take the course

Of the 117 students, 99 were required to take this course for their major (systems engineering). The remaining 18 students were required to take this course as part of an interdisciplinary program. The specific major breakdown, along with the gender breakdown, is shown in Table 2.

Table 2 Major and Gender of Students in Sample

	Section 1	Section 2	Total
Computer Engineering	2	3	5
Electrical Engineering	1	3	4
Mechanical Engineering	9	--	9
Systems Engineering	56	43	99
Female	18	17	35
Male	50	32	82
Total	**68**	**49**	**117**

Approach: five online tools were used to reach the three objectives of increasing formative feedback, maintaining authenticity, and improving active, collaborative learning environment

Five blended learning tools were implemented in the course in an effort to reach the three objectives cited in the Introduction. The file tools and their relationship to the three objectives are shown in Table 3.

Table 3 Blended Learning Tools Mapped to Objectives

Approach	Software	Improve formative feedback as enrollment increases	Maintain authenticity of case work as enrollment increases	Provide a more active, collaborative learning environment as enrollment increases
Student-recorded presentations	Panopto[8]	X	X	
Online course content	Panopto			X
In-class polls	Google Docs	X		X
Online discussion board	Piazza[9]	X	X	X
Interim peer review	PRAZE[10] and Sakai-based CMS	X	X	X

Panopto is screen-capture software that was used for faculty to record lecture content and for students to record their final briefings for some case studies. The university at which the course was taught subscribes to Panopto. All other tools used are free. Polls were created in Google Docs for several class periods and students responded to questions using either laptops or smartphones; this is pedagogically similar to using "clickers" but without any additional hardware or software to purchase. Piazza is an online discussion board created specifically to support interactions between students and faculty in higher education.

Peer reviews were administered using two tools. First, a course management system used by the university was used to "manually" support peer review; students submitted files, instructors posted these submissions for all students to access, students reviewed work of their peers assigned to them and posted their review back on the course management system. PRAZE was the other tool used for peer review. Specifically designed to support peer review, students uploaded work to PRAZE and then were automatically assigned and given access to work from their peers to review. Reviews of their own work were accessible through the PRAZE interface.

Overall research design: A suite of assessment instruments to evaluate several facets of the student learning experience.

Several instruments were used to assess the impact of the blended learning approaches on student self-efficacy, learning, and overall student perceptions. These instruments are shown in Table 4.

Table 4 Assessment Instruments

Instrument		Timing	Purpose	Analysis Approach
End-of-Course Survey	Likert questions about blended learning approaches	Once, at end of course	To assess student perceptions of the different blending learning tools and approaches used, e.g., which tools are more preferred	Descriptive statistics
	Open-ended questions about blended learning approaches		To gain deeper insight into student perceptions of the different blending learning tools and approaches used, e.g., why are certain tools more preferred	Content analysis
	Likert questions about the course in general		To compare overall student perceptions of the course with prior offerings of the course	Descriptive statistics and hypothesis tests compared to prior years' data
	Open-ended questions about the course in general		To gain deeper insight into overall student perceptions of the course as compared with prior offerings of the course	Content analysis, compared to prior years' data
Self-efficacy surveys		Three times: after Case 1, Case 2, and Case 3	To study overall change of self-efficacy throughout term and impacts of peer review and of submitting briefing as video versus as static PowerPoint	Hypothesis tests, 2^2 full factorial
Case feedback and grading surveys		Three times: shortly after feedback and grades for the first three cases were returned	To evaluate student perceptions related to fairness and usefulness of case feedback and case grading	Descriptive statistics and hypothesis tests of Likert data, content analysis of open-ended comments
Grades on quiz questions related to who watched online course content		For Quiz 1 and Quiz 3 (no online course content was available for Quiz 2)	To evaluate relationship between watching online course content with knowledge of course material.	Hypothesis tests and regression
Instructor observations		Interview conducted after completion of course	To gain insight into the instructors' experience with using the blended learning tools	Content analysis of interviews

Questions about the blended learning approaches and the use of technology in the course were included in the end-of-course survey. Analysis on these questions is a post-test only, no control group quasi-experimental design. Questions specifically about each blended learning approach could not be asked prior to the course; hence the post-test only design.

In addition, a standard set of questions on the end-of-course survey is used to compare the blended learning version of the course with the same course in prior years. Changes are made to the course each year, so such comparisons are not perfect. That said, the same faculty team has been teaching the course for five years and the course changes (other than the addition of the blended learning approaches) made between Fall 2011 and Fall 2012 were minor. Analysis of course evaluation data across multiple years of the course is a pre-test, post-test, no control group quasi-experimental design, with the pre- and post-test groups being independent, self-selected populations. A control group was not used due to 1) the instructors' perception that providing different experiences in the same term could be unfair (e.g., some students get peer review, others do not), 2) logistical challenges of running a control group (e.g., if some students did do a peer review while others did not, then due dates for assignments would not align for all students), and 3) the lack of convincing evidence that the Fall 2012 group of students would have different experiences from students from prior years if a control group were run. Self-selected populations are unavoidable as this is a required course for any student who takes it.

The self efficacy instrument was modeled after an instrument developed by Carberry, et al.,[7] to assess design self-efficacy. The only changes were to the names of the specific tasks about which self-efficacy was being measured. The self-efficacy survey was administered after Case 1 as a baseline. With Case 2 and 3, two factors were varied factorially with self-efficacy change as the primary dependent variable. The two factors were whether interim peer feedback was given and how students submitted cases (as either static PowerPoint presentations or screen-captured video recordings). Peer feedback was given for Case 3 but not for Case 2. Student teams were randomly assigned to submit the screen capture video recording for either Case 2 or 3.

The only other note to make about Table 4 is that Panopto, the video capture software used, records which students watch specific videos at which times and for how long. This data will be the basis for linking the watching of videos outside of class to grades on specific quiz questions related to the content covered in the videos. A limitation of this analysis is that which students watch the videos online is not randomly assigned.

In this paper, the only results presented are the quantitative data from the end-of-course evaluations.

Results

Results from the end-of-course survey questions related to the blended learning technologies are shown in Table 5, Table 6, and Table 7. All questions range from "strongly disagree" (1) to "strongly agree" (5), with the middle rating named "neutral."

Table 5 Blended Learning Technology Questions from End-of-Course Survey: Encouraging Future Use

		Section 1 n=68	Section 2 n=49	Total n=117
I'd encourage the continued use of in-class polls using Google Doc Forms.	Avg	4.15	4.35	4.23
	St Dev.	0.71	0.56	0.65
I'd encourage the continued use of PRAZE to manage peer reviews.	Avg	3.87	3.82	3.85
	St Dev.	0.90	0.83	0.87
I'd encourage the continued use of Panopto for students to record presentations for cases	Avg	3.40	3.47	3.43
	St Dev.	0.87	0.98	0.91
I'd encourage the continued use of Panopto for faculty to record lectures with class time being used for more interactive feedback.	Avg	3.84	3.98	3.90
	St Dev.	1.03	0.88	0.97
I'd encourage the continued use of Piazza for managing questions from students and answers from instructors (and peers).	Avg	4.35	4.50	4.41
	St Dev.	0.73	0.65	0.70
I'd encourage the continued use of peer review mid-way through cases (instead of just turning in a final case presentation without any interim peer review).	Avg	4.41	4.45	4.43
	St Dev.	0.60	0.77	0.67

Notable in Table 5 is that Google Docs (in-class poll tool) and Piazza (online discussion tool) are preferred moreso than Panopto (screen capture tool) or PRAZE (peer review tool). Furthermore, peer review itself, independent of the software tool used to implement it, is popular with 91% of students agreeing or strongly agreeing with the statement "I'd encourage the continued use of peer review mid-way through cases," resulting in an average score of 4.43.

Table 6 Blended Learning Technology Questions from End-of-Course Survey: Ease of Use

		Section 1 n=68	Section 2 n=49	Total n=117
PRAZE was easy to use.	Avg	3.85	3.67	3.78
	St Dev.	0.76	0.92	0.83
Panopto was easy to use for recording presentations.	Avg	3.22	3.20	3.21
	St Dev.	0.90	1.00	0.94
Piazza was easy to use.	Avg	4.24	4.33	4.28
	St Dev.	0.70	0.69	0.70

In Table 6, Piazza (online discussion tool) is the most favored of the three tools surveyed in terms of ease of use. Students had the most difficulty with Panopto (screen capture).

Table 7 Blended Learning Technology Questions from End-of-Course Survey: Compared to Other Classes

		Section 1 n=68	Section 2 n=49	Total n=117
Compared to other courses, this course helped me explore course material in more meaningful ways because of its structure and the technologies used.	Avg	3.74	3.83	3.78
	St Dev.	0.94	0.91	0.92
Compared to my experiences in other courses, in this course I received more frequent feedback from the instructor(s) and peers, and/or had more opportunities to critique my own work.	Avg	4.32	4.43	4.37
	St Dev.	0.53	0.54	0.53
Compared to other courses, this course used technology to allow more face-to-face interaction with the instructor(s) and other students.	Avg	4.55	4.65	4.59
	St Dev.	0.56	0.48	0.53

Of the three questions where students were asked to compare this class to others, students felt most strongly (average score of 4.59) that the course provided more face-to-face interaction (98% agreed or strongly agreed). Additionally, 97% agreed or strongly agreed (average score of 4.37) that they received more feedback from instructors and peers and/or had more opportunities to critique their own work. Only 67% agreed or strongly agreed (average score of 3.78) that the course helped them explore material in more meaningful ways due to the course structure and the technologies used.

Table 8 Common Questions from End-of-Course Evaluation

	2008 n=89	2009 n=91	2010 n=97	2011 n=101	2012 n=117
The instructor used methods other than/in addition to traditional lectures (for example, active learning, in-class problems, collaborative learning, in-class discussion) effectively in this course.	not asked prior to 2011			4.36	4.53
The homework assignments helped me learn the subject matter.	4.16	4.06	4.09	4.21	4.49
The course material was well organized and developed.	4.09	3.81	4.36	4.18	4.39
The grading policy was fair.	3.52	3.42	3.65	3.54	3.69
The instructor responded adequately to in-class questions.	4.31	4.09	4.43	4.24	4.22
The instructor effectively used technology in support of the learning goals for this course.	not asked prior to 2011			4.35	4.45
I learned a great deal in this course.	4.13	4.00	4.23	4.40	4.58
Overall, this was a worthwhile course.	4.24	3.88	4.20	4.43	4.59
The course's goals and requirements were defined and adhered to by the instructor.	4.06	3.99	4.18	4.34	4.49
The instructor was approachable and made himself/herself available to students outside the classroom.	4.17	3.90	4.28	4.07	4.11
Overall, the instructor was an effective teacher.	4.28	3.97	4.47	4.34	4.54

Data from Table 8 shows a mixed picture. The 2012 blended learning course was particularly successful with using non-lecture methods, providing useful homework, and promoting learning and a sense that the course was "worthwhile." Students' view of the grading policy, on the other hand, was in line with their views in prior years, as was their view of how well the instructor responded to in-class questions and made himself available and approachable.

Discussion

The high-level objective of using technology in a blended learning environment for this course was to provide a more personal, meaningful learning experience for all students even as enrollment increases. Three sub-objectives outlined earlier in this paper support the high-level objective: to improve formative feedback, to maintain authenticity of case studies, and to provide a more active, collaborative learning environment. The preliminary data presented in this paper provide early insights into all three of the sub-objectives

Students perceive that they receive more feedback from peers and faculty and they value this feedback.

With 97% of students agreeing or strongly agreeing that they receive feedback more frequently in this course compared to others and 91% would encourage or strongly encourage the continued use of peer feedback mid-way through cases, it is clear that students know that they are getting more feedback and that they think we should continue the primary approach for formative

feedback in the class, peer review. The students are less strongly in support of the particular software tool we used to administer peer review, PRAZE.

Student recording of case study briefings was not widely viewed as enhancing authenticity of cases.

The only change aimed at impacting the authenticity of the case study assignments was to require students to submit recorded briefings instead of static PowerPoint slides. Students were not overwhelmingly convinced that this was a good idea. One clue as to why is that the ease of use rating for Panopto, the screen capture software used, is low (less than 45% agreed or strongly agreed that Panopto was easy to use to record presentations). Investigation of the qualitative end-of-course survey data is necessary to determine if the difficulty of using Panopto is the main or only reason for why students did not like submitting video recordings. Furthermore, evaluation of the self-efficacy data is necessary to assess the use of video recordings on a measure other than student preferences.

Students view increased interaction associated with an active learning environment favorably.

From the use of Google Polls in class to the use of Piazza to increase active interaction among students and with faculty outside of class, students are clear in their preference for tools that promote more interaction. In another question, results indicate that students felt that such tools were used more in this course than in others. Furthermore, students' views of Panopto as a platform to view recorded videos such that class can be used for more interactive feedback are more favorable than their views of Panopto overall. In sum, students valued the use of technology tools to facilitate interaction and effective, free tools currently exist to do this. This adds to the prior literature on blended learning which highlights the role of blended learning in promoting increased collaboration among students and between students and faculty[2].

Closure

In an age when massive open online courses (MOOC) and the technology supporting them are pushing distance education to new arenas and to the front pages of newspapers, blended learning provides a framework within which to utilize the same technologies to increase interaction among students and faculty in face-to-face, not distance, courses. Perhaps the sole distinctive feature of a face-to-face course, when compared to a MOOC, is the personal attention that each student can receive. As enrollment in face-to-face courses increases, this distinctive feature is eroded if traditional teaching methods are used in such courses. Blended learning offers an opportunity to maintain or improve the personal attention that a student receives, be it through feedback to students from instructors, interaction between students, or interaction between students and faculty.

Preliminary results from this study, in which several blended learning technologies were applied to a methodology-oriented sophomore course in systems engineering, indicate that students felt that they learned more and that the course was more worthwhile than four prior offerings of the course. In end-of-course survey questions, students also cite that the technologies used enhanced face-to-face interaction with faculty and other students and that they received more feedback from faculty and peers and/or had more opportunity to reflect on and evaluate their own work.

All of this occurred in a class that has grown from roughly 90 students to nearly 120 students. While the results presented here are preliminary – they show promising leads that will be explored in more detail as the full evaluation plan is executed.

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