



## Evaluation of Blended Learning Technologies in a Large Enrollment Case-based Systems Engineering Course

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## **Introduction**

Blended learning combines online and face-to-face instruction<sup>1</sup>. Instead of totally replacing the traditional face-to-face classroom experience, blended learning takes advantage of the convenience and flexibility of online activities outside of classroom in support of the classroom experience. In this study, we focus on evaluating the impact of several technology-enabled blended learning approaches on a sophomore systems engineering course with a large enrollment. The specific blended learning approaches utilized by the instructors for this study are<sup>2</sup>:

1. An online discussion board (Piazza)
2. An online peer review management system (Praise)
3. A video-capture technology that allowed students to submit oral briefings for cases and instructors to record and post videos (Panopto)

Throughout the class, several instruments were used to assess how the students were experiencing the introduction of these technologies that had not been used in prior course offerings. Data from these instruments are used in this paper to address the following questions:

1. Was student self-efficacy in demonstrating core course topics affected by the blended learning approaches?
2. Were student perceptions of feedback and grading affected by the blended learning approaches?
3. What were the student perceptions of the different blended learning approaches?

## **Literature Review**

To further the understanding of the impact of changes enabled by technologies utilized in the course studied here, the literature review focuses on the use of online discussion boards, peer review, and podcasting of lecture content.

### Online discussion

Previous studies have shown positive effects by the use of online discussion. Wu and Hiltz<sup>3</sup> conclude from their study that “online discussions do improve students’ perceived learning”. Compared to traditional didactic methods, there are several benefits that online discussion may bring:

- Provide convenience, place-independence, time-independence, and the potential for users to become part of a community<sup>4</sup>
- Provide learners with exceptional opportunities for self-expression and reflection<sup>5</sup>
- Enable learners to take an active role in the learning process<sup>6</sup>
- Encourage learners to contribute active, thoughtful, and equal participation<sup>7</sup>

The benefits are certainly not limited to those listed above. Furthermore, Althaus<sup>7</sup> argues that when online discussion is incorporated to supplement a traditional classroom as a form of blended learning, a superior learning environment is established, compared to the traditional classroom alone.

However, the benefits should not be taken for granted. According to Thomas<sup>8</sup>, “while online discussion forums promoted high levels of cognitive engagement and critical thinking, the virtual learning space of an online forum did not promote the coherent and interactive dialogue necessary for conversational modes of learning”. Levine<sup>5</sup> proposes 10 conditions as a guide for educators to support effective use of online discussions. Burkett, Leard, and Spector<sup>9</sup> also discuss the issues and trade-offs of online bulletin boards (BB) and argue that “Each aspect of BB use must be subjected to a cost-benefit analysis weighing the cost in instructor time against the gains in student understanding.”

### Peer Feedback

Falchikov<sup>10</sup>, who has contributed greatly to the topic of peer feedback, found evidence that peer feedback enhances student learning by actively engaging students in articulating their evolving understanding of courses. Falchikov<sup>11</sup> also concludes the main strength of peer feedback as the “enhancement of student learning by means of reflection, analysis, and diplomatic criticism”. Other benefits include the increased amount of more immediate feedback<sup>12</sup> and the potential of extending learning to a public domain<sup>13</sup>.

More recently, online peer review has become popular. DiGiovanni and Nagaswami<sup>14</sup> conducted a study on online peer review in two English-as-Second-Language classes and observed that “when our students were online, they remained on task and focused”. According to DiGiovanni and Nagaswami, other advantages, compared to face-to-face peer review, include closer monitoring of student interaction and independence on students’ memory to revise draft based on peer feedback. Effects are not only seen in writing classes; Tseng and Tsai<sup>15</sup>, in a study of a high school computer course, also conclude that “students significantly improved their projects as involving the peer assessment activities”.

However, in some cases, students may value instructor feedback more highly than peer feedback<sup>16</sup>. According to Hanrahan and Isaacs<sup>17</sup>, students perceive that they do not have enough expertise for peer feedback. In addition, students may also resist peer feedback with each other because they do not want to have power over each other<sup>13</sup>.

### Podcasting

Instructors of SYS 2001 video-recorded and distributed several lectures through Panopto. Students in SYS 2001 were also required to use Panopto to video-record some of their presentations as part of their assignments. Video recording is a form of podcasting. Many studies have been done on the effects of podcasting of lectures or lecture-related conversations by instructors. McGarr<sup>18</sup>, in his review of podcasting on higher education, summarized that “much that is written about podcasting refers to its ability to enhance convenience, flexibility and accessibility to learning”. Nathan and Chan<sup>19</sup> found in their study of talkback radio-style podcasting in a business subject that students in the study perceived

podcasting positively and were willing to assimilate this new mode of learning. In a study on both audio and video podcasts of lectures, Copley<sup>20</sup> revealed that students were enthusiastic for podcast recordings of lectures and further found that students mostly used those podcast recordings when preparing for assessments.

Despite the convenience and popularity of podcasting, studies also found some scenarios in which podcasting does not seem to be effective. While podcasting serves as an effective supplement to traditional face-to-face lectures<sup>19</sup>, it does not effectively substitute the more traditional learning methods<sup>21</sup>.

There are fewer studies on the effects of podcasts made by students. Frydenberg<sup>22</sup> noted that when students were challenged to create podcasts of lectures, they not only developed critical thinking skills, but also a comprehensive understanding of the lecture subject. In a similar study, Lee, McLaughlin, and Chan<sup>23</sup> suggest that “the collaborative development of audio learning objects enabling student conceptualizations of disciplinary content to be shared with peers is a powerful way of stimulating both individual and collective learning, as well as supporting social processes of perspective-taking and negotiation of meaning that underpin knowledge creation”. However, we were unable to find any research on the effects of students video-recording oral presentations.

## **Methods**

### *Site: An Introductory Course in Systems Engineering*

The SYS 2001 course is an introductory course required for all undergraduate students majoring in systems engineering at the University of Virginia. This course is taught in fall semester each year by two instructors who co-teach the two sections of the class. The enrollment has been increasing since 2004 and in 2012, 117 students were enrolled in this course.

The same faculty team has been teaching for the course for five years and few changes were made to the course from 2011 to 2012, except for the addition of technologies. SYS 2001 is a case-based course with the objectives to enable students to explain and apply systems thinking, communicate effectively, and work collaboratively. In addition to several individual assignments and three tests, four major cases are completed by student teams throughout the term. Table 1 below provides detailed learning objectives of the course:

**Table 1 Course learning objectives<sup>2</sup>**

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

With increasing enrollments and limited resources, the instructors identified several needs to minimize the impacts from increasing enrollments. Blended technologies were integrated into the course during fall 2012, with the following objectives:

- 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.

*Approach: Technology Enabled Changes to the Course*

SYS 2001 integrated technologies with the intention to improve the classroom experience for students in the face of increasing enrollments. The following technologies were introduced in the course in fall 2012 (timeline of the use of the technologies included in Figure 1):

**Piazza** is an online interface that helps manage Q&A in the form of online discussion. Students posted questions regarding cases, assignments, and tests online via Piazza and other students could view or answer the questions. Instructors of SYS 2001 also visited Piazza frequently to respond to students’ questions, post information relevant to the course, and/or initiate new course-related discussions.

**Panopto** is an all-in-one video platform that allows users to record, upload, and play videos online. The student teams were randomly assigned to two groups: one that submitted videos for Case 2 and the other submitted videos for Case 3. Instructors have also recorded three lectures using Panopto and distributed the videos on the website for students to review course materials.

**Praze** is a web-based system that manages and automates peer review. All students were required to individually give anonymous critiques on their peers' work and received feedback from others, before turning in Case 4 for grading. Peer review was also used for Case 3, but in this case all student submissions were posted on the course management site instead of using Praze and students gave and received feedback in teams.

The three blended learning tools used in this course are linked to the objectives in Table 2:

*Table 2 Technologies mapped to objectives<sup>2</sup>*

<b>Approach</b>	<b>Software</b>	<b>Improve formative feedback as enrollment increases</b>	<b>Maintain authenticity of case work as enrollment increases</b>	<b>Provide a more active, collaborative learning environment as enrollment increases</b>
<b>Student-recorded presentations</b>	Panopto	X	X	
<b>Online course content</b>	Panopto			X
<b>Online discussion board</b>	Piazza	X	X	X
<b>Interim peer review</b>	Praze and Content Management System	X	X	X

*Instruments: Assess Students' Perceptions*

Surveys were conducted in order to assess students' perceptions about their class experiences. The surveys focused on students' perceptions about their abilities to engage in systems thinking, the grades and feedback they received on their cases, and their general experiences with the course SYS 2001. Three major categories of surveys were used to assess students' perceptions (timeline of the use of the technologies included in Figure 1):

**Self-efficacy surveys** were modified based on an instrument measuring engineering

design self-efficacy by Carberry and Lee<sup>24</sup>. The surveys were believed to identify students' self-concepts to engineering design tasks<sup>24</sup>. Students were asked to rate on a scale of 0-100 their confidence, motivation, success, and anxiety in completing each of the 10 tasks which represent a systems approach.

**Grading surveys** were designed by the instructors to learn about students' perceptions about fairness of grading of cases and accuracy and usefulness of feedback provided by the instructors. The questions on the surveys were a mix of multiple choice and open-ended questions.

An **End-of-course survey** is conducted for every course taught at the University of Virginia and is completed by students in SYS 2001 every year. The instructors added seventeen new questions to the end-of-course survey pertaining to the use of technologies (Piazza, Panopto, Praze, etc.) in SYS 2001. Sixteen out of the seventeen questions were Likert questions and one was a short-answer question. The seventeen questions asked students about the ease of using the technologies, whether they would encourage continued use of those technologies, and whether they think the technologies used in the course were effective in general.

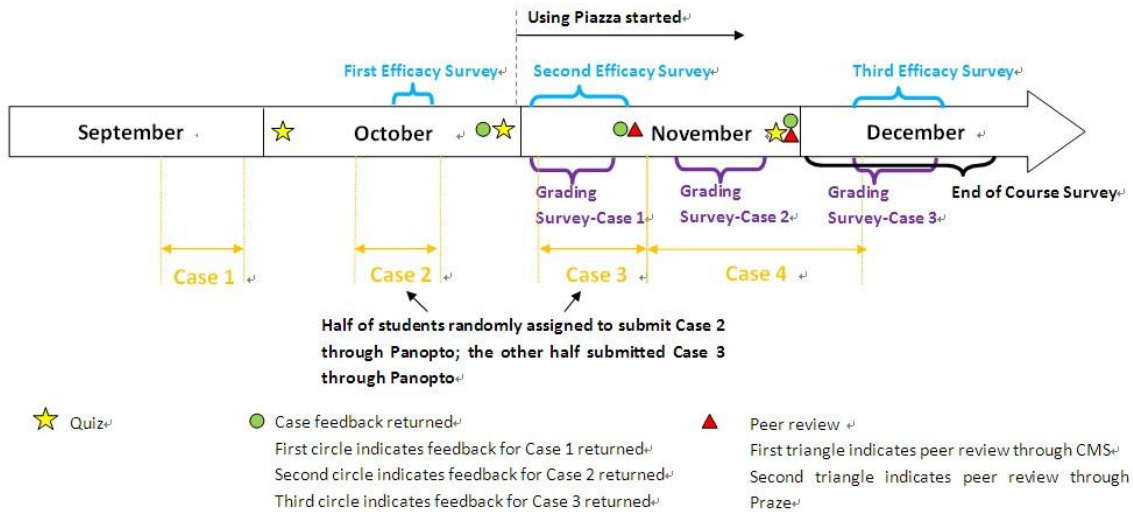
Table 3 summarizes the instruments and their corresponding measurement foci and contents.

***Table 3 Assessments of students' perceptions about the course experience***

<b>Instrument</b>	<b>Measurement focus</b>	<b>Contents</b>
<b>Self efficacy surveys</b>	Perceptions of self	Confidence, motivation, success, anxiety
<b>Grading surveys</b>	Perceptions of course experience	Fairness of grades, accuracy of feedback, and expectations of grades
<b>End of course evaluations</b>	Perceptions of course experience	Usefulness and ease of use of blended learning tools

Figure 1 summarizes the activities throughout the semester in a timeline. Piazza was introduced roughly halfway into the semester; Panopto was used by half of the class for Case 2 and by the other half for Case 3; Praze was only used for the peer review for Case 4 towards the end of November. The self-efficacy surveys were spread out through the semester. However, they were not completed exactly after feedback for each case was returned, due to other class activities. Meanwhile, the grading surveys were completed soon after case feedback was returned to students.





**Figure 1** Timeline for activities throughout the semester

**Results**

Perceptions about self efficacy

Students evaluated their confidence, motivation, success, and anxiety in performing ten systems design tasks by completing self-efficacy surveys. The students were asked to rate each dimension on a scale of 0-100. Table 4 shows the scale of each of the four areas.

**Table 4** Scales of self efficacy surveys

Rating	Confidence	Motivation	Success	Anxiety
0	cannot do at all	not motivated	cannot expect success at all	not anxious at all
50	moderately can do	moderately motivated	moderately expect success	moderately anxious
100	highly certain can do	highly motivated	highly certain of success	highly anxious

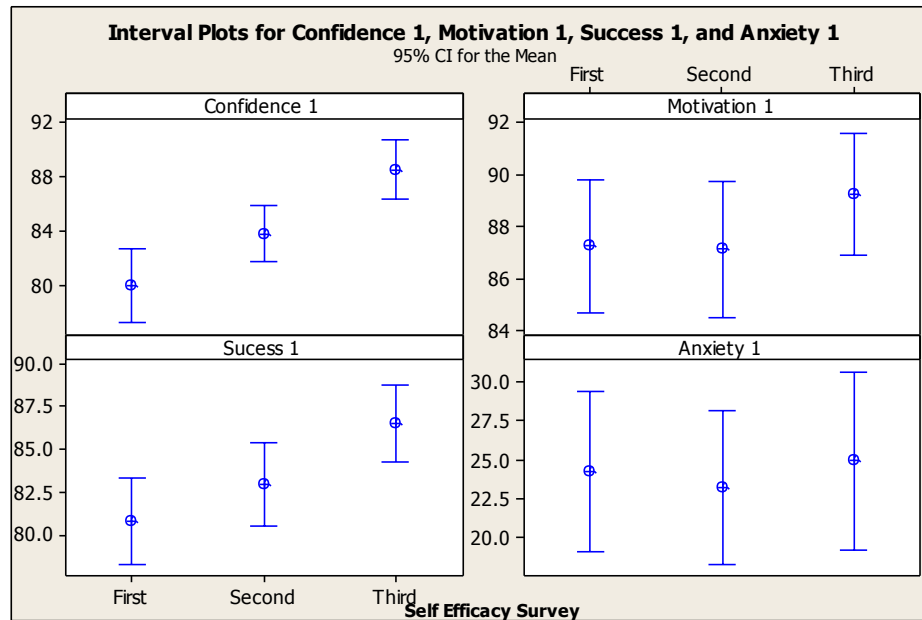
For analysis purposes, the ratings on the ten systems design tasks for each aspect were divided into the rating of the first design task and the average of the rest nine tasks, as shown in Table 5. This arrangement divides the responses into ratings on the overall process and ratings on the individual steps, as done in the study by Carberry and Lee.

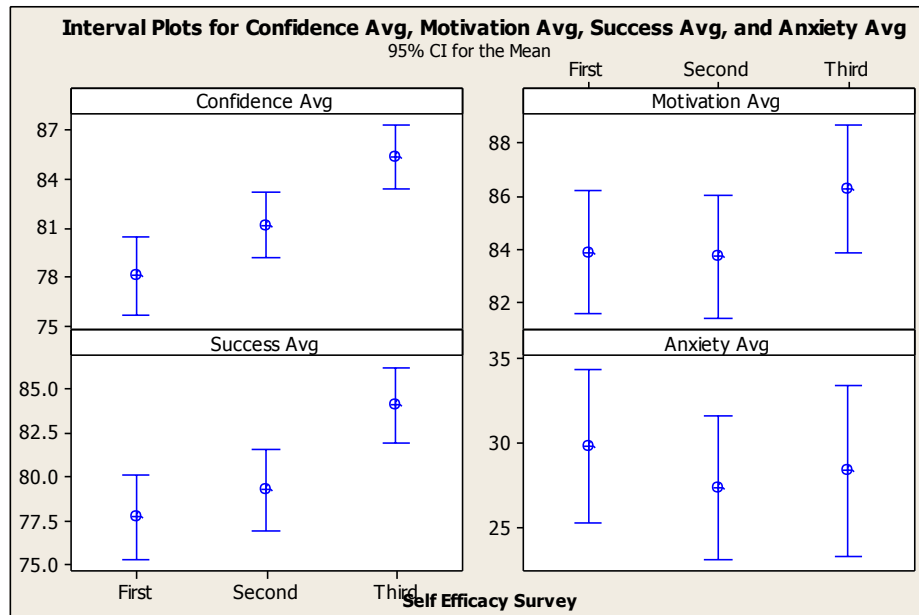
**Table 5 Ratings for the questions**

Question	Confidence	Motivation	Success	Anxiety
Question 1	Confidence 1	Motivation 1	Success 1	Anxiety 1
Average rating of Questions 2-10	Confidence Avg	Motivation Avg	Success Avg	Anxiety Avg

- Throughout the semester, significantly higher ratings in confidence and success**

Throughout the semester, three self-efficacy surveys were conducted. In the areas of confidence and success (Confidence 1, Confidence Avg, Success 1, and Success Avg), students' ratings rose significantly higher on the third survey from the first survey (t values ranging from -6.43 to -4.37, p values less than 0.001). For motivation and anxiety (Motivation 1, Motivation Avg, Anxiety 1, and Anxiety Avg), students' ratings did not change significantly from the first to the third survey (t statistics ranging from -1.84 to 0.54, p values ranging from 0.068 to 0.817). The 95% interval plots in Figure 2 summarize the mean ratings given on the self-efficacy surveys throughout the semester.





**Figure 2** Interval plots for self efficacy ratings

- **Self efficacy ratings do not change significantly when intensity of Piazza usage varies**

The results from the self efficacy surveys were further analyzed by comparing ratings given by students with different intensity levels of Piazza usage. Students’ usage of Piazza was evaluated according to the number of views on Piazza during the semester (from Piazza account information) and was categorized in the following way:

**Table 6** Students’ usage of piazza

Number of views for the semester	Intensity level	Number of students with this level
0-15	Low	38
16-30	Medium	32
>30	High	47

Students started using Piazza for online discussion after completing the first self efficacy survey and when students completed the third survey they had used Piazza for around one and a half months. Therefore, a one-way analysis-of-variance (ANOVA) test was performed with Piazza intensity as the independent variable and the difference of average ratings between the third and first surveys for confidence, motivation, success, and anxiety as the dependent variable. ANOVA test results, with F statistics ranging from 0.02 to 1.36 and p-values ranging from 0.261 to 0.976, indicate that with different intensity levels of Piazza usage, students’ ratings for self-efficacy in the four areas do not vary significantly.

- **Self efficacy ratings do not change significantly when submission method varies**

To analyze any direct influence caused by submission type of cases on students' ratings on self efficacy surveys, the ratings from the second and third self-efficacy surveys were compared. Half of the students (randomly assigned) used Panopto for submitting Case 2 while the other half used Panopto for Case 3 (please refer to the timeline in Figure 1). Repeated measures ANOVA tests for the four areas were done with submission type as the within subject effect and subject as the between subjects effect. This resulted in p-values ranging from 0.119 to 0.627, suggesting that there is no significant relationship between self-efficacy ratings and submission method.

### *Perceptions about grading and feedback*

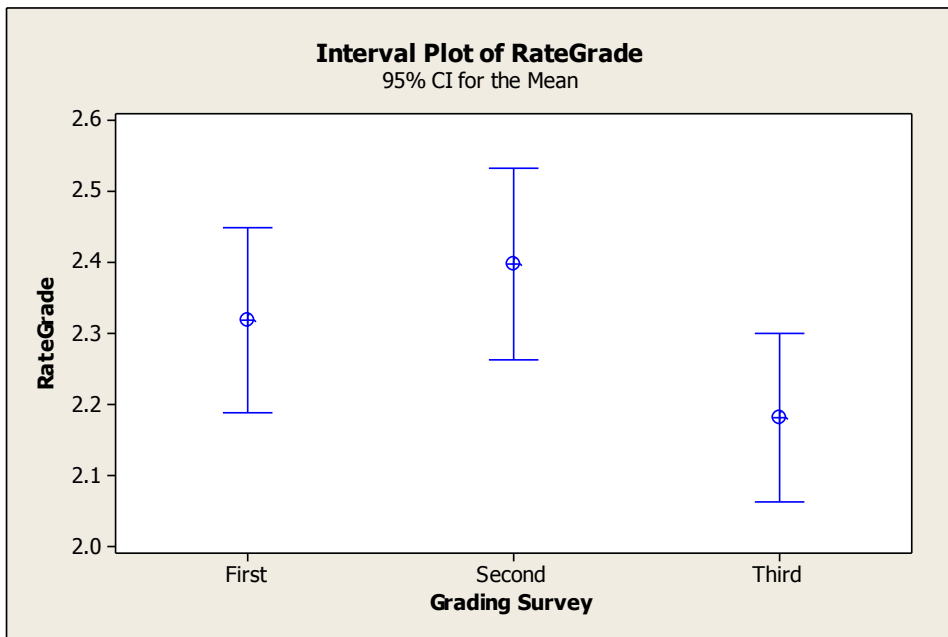
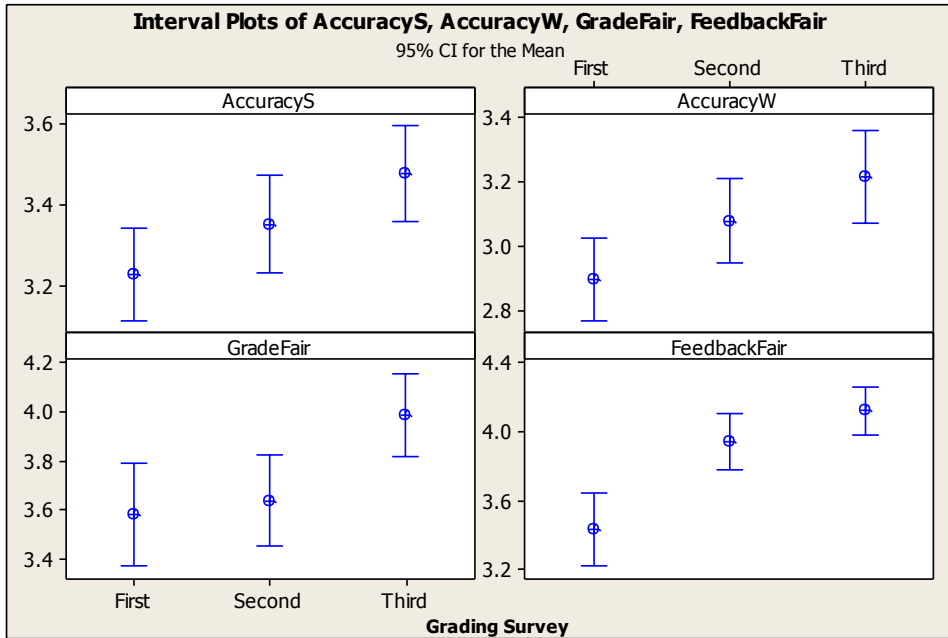
Students' perceptions about grading and feedback on their submitted case presentations were reflected from the ratings given by students on the grading surveys. The questions from the survey are shown in Figure 3.

**Table 7 Questions rated on the grading survey (\*names used for statistical analysis)**

<p>1. Have you looked at both the grade and the feedback (you should have received an excel file with the feedback and the overall grade for your case submission).</p> <p>Yes</p> <p>No</p> <p>2. How accurate do you feel the feedback you received is?</p> <p>The areas identified as strengths (AccuracyS*):</p> <p>1- Completely off/wrong</p> <p>2- More off-base than on target-although a little bit of it was accurate</p> <p>3- Generally on target</p> <p>4- Completely on target</p> <p>The areas identified as weaknesses (AccuracyW*):</p> <p>1- Completely off/wrong</p> <p>2- More off-base than on target-although a little bit of it was accurate</p> <p>3- Generally on target</p> <p>4- Completely on target</p> <p>3. How would you rate your grade on this assignment (RateGrade*):</p> <p>1- Higher than expected</p> <p>2- About as expected</p> <p>3- Lower than expected</p> <p>4. Please rate the following:</p> <p>I think my grade (not the feedback) is fair (GradeFair*):</p> <p>1- Strongly disagree</p> <p>2- Disagree</p> <p>3- Neither disagree or agree</p> <p>4- Agree</p> <p>5- Strongly agree</p> <p>I think my feedback (not the grade) is fair (FeedbackFair*):</p> <p>1- Strongly disagree</p> <p>2- Disagree</p> <p>3- Neither disagree or agree</p> <p>4- Agree</p> <p>5- Strongly agree</p>
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- **Throughout the semester, students felt that the feedback they received was more accurate and grade was more fair**

Compared to the first grading survey, students' gave significantly higher ratings on the third survey on the accuracy (AccuracyS and AccuracyW) and the fairness of feedback and grades (FeedbackFair and GradeFair) (t values ranging from -4.68 to -3.28 and p values smaller than 0.001). Meanwhile, students did not rate their expectations about grades significantly different between the first and third surveys (t=1.62, p=0.109). Figure 4 shows the interval plots of students' responses on all three surveys during the semester.



*Figure 3 Interval plots of students' ratings on grading surveys*

- **Students' perceptions about grades did not change significantly when intensity of Piazza usage varied**

Students just started using Piazza when they completed the first grading survey and when they were completing the third grading survey, they had used Piazza for more than one month. The difference between ratings on the first and third surveys was thus compared with students' usage of Piazza to determine whether using Piazza has impacted students' perceptions about grading. According to one-way ANOVA analysis (independent variable: Piazza usage level; dependent variable: change in rating between first and third survey), none of the questions on

the grading survey received significantly different rating between the first and third survey (F statistic ranging from 0.25 to 3.02 and p-value ranging from 0.054 to 0.777).

- **Perceived accuracy of feedback about strengths was significantly changed when submission type varied while perceptions about all other aspects of grading remained the same.**

Panopto was used to enable students to submit their case presentations by recording videos, with the intention to improve formative feedback through evaluating a video, not just a powerpoint file. For the second and the third cases, half of the class submitted PowerPoint slides only and the rest submitted videos of their case presentations. Thus, the ratings of the second and third grading surveys were analyzed with repeated measures ANOVA tests to discover any impact on students' perceptions about the feedback they received. Students who submitted through Panopto gave significantly higher ratings on the question "How accurate do you feel the feedback you received is—Areas identified as strengths." (F=4.28, P=0.042) For all other questions on the grading survey, students did not give significantly different ratings when they had different submission methods (F statistic ranging from 0.28 to 1.67 and p value ranging from 0.200 to 0.596).

#### Perceptions about the general class experience

Sixteen Likert questions on the end-of-course survey specifically regarding the usage of technologies in this course were evaluated by Bailey and Smith (2013). The mean and standard deviation of the ratings were reported and observations were made. In general, students gave higher ratings on encouraging the future use of Piazza than Praze and Panopto. Students also thought Piazza was easier to use than Praze and Praze was easier to use than Panopto. When asked to compare SYS 2001 to other courses, students agreed the most with the statement that "Compared to other courses, this course used technology to allow more face-to-face interaction with the instructor(s) and other students." 97% students agreed or strongly agreed that they received more feedback in SYS 2001 than other courses and 67% agreed or strongly agreed that the structure of the course and the technologies used helped students explore course material in more meaningful ways.

Qualitative comments provided by the students were analyzed in this study to learn further about students' perceptions about the technologies used. The question "comment on how the course structure and activities, including the use of technology, affected your learning" was asked in order to collect such feedback about technologies used and the changes enabled.

- **No negative comment about Piazza and the online discussion activity was made.**

Thirty-three students wrote positive comments related to the use of Piazza and none gave negative comments. The students' perceptions about Piazza and online discussion were that they were helpful. Online discussion, enabled by Piazza, allowed students to view questions asked by other students, which often provided lots of helpful information to all the students. As one student noted, "Especially piazza was very useful as we could ask questions any time

any day and get immediate answers to them.” Online discussion also allowed more interaction among students and instructors anytime and anywhere. Some students also mentioned that Piazza was a good substitute for office hours. Concerning ease of use, no student mentioned any difficulty with using Piazza and one student mentioned that “Piazza benefits both (professors and students) and has a great user interface.”

- **Students perceived peer review to be helpful but had split views about Praze.**

All twenty-two comments made about peer review were positive. Students perceived peer review as helpful in that it provided valuable criticism and helped the understanding of reviewers. However, students seemed to have split views about Praze as the platform for online peer review. Two students wrote that Praze was effective in organizing peer feedback and was simple to use. Two students commented that Praze was excessive and did not have an effective interface.

- **Students had more positive perceptions about videos of lectures than about videos of case presentations. Panopto was perceived as difficult to use by some students.**

There were twenty-four comments about video-recorded lectures using Panopto and twenty-two of them were positive. Students noted that recording lectures freed up some in-class time for more interaction and discussion. Most of the positive comments also mentioned that the lecture videos were a good resource for review before exams. Convenience and flexibility were also mentioned about the video recordings of lectures. The negative comments about video-recorded lectures mentioned that it was hard to pay attention when watching the videos and thus was not as effective as regular in-class lectures.

On the other hand, fewer positive comments and more negative comments were made about video-recorded case presentations using Panopto. There were sixteen comments in total and only seven of them were positive. Some students liked making videos of case presentations because they felt they were giving an actual presentation to clients and the videos were a great way for the instructors to evaluate presentations. For students who did not like recording case presentations, they mentioned that recorded presentations were not live and thus were not a real experience. Some students also felt that using Panopto to record case presentations was more a waste of time than a learning tool.

Regarding the ease of use of Panopto, nine students out of forty students who commented on Panopto mentioned that they did not like Panopto as an implementation. A number of students noted that it was frustrating to use Panopto because it took a long time to make and upload videos, which seemed to them unnecessary because they did not perceive much learning gained from the process.

## **Discussion**

From the results presented in the previous section of the paper, the following themes were summarized:



Theme 1: Students' perceptions about some aspects of self efficacy and accuracy of feedback improved throughout semester, while other perceptions did not change significantly.

As the semester proceeded, technologies were gradually introduced to SYS 2001. As shown in the Results section, with the introduction of new activities, students gave significantly higher ratings in some aspects (confidence and success) of self efficacy later in the semester than earlier. Students also gave higher ratings on accuracy of feedback on later surveys than earlier ones. This suggests that the introduction of new technologies and new activities may have positively impacted students' perceptions about themselves and their course experience. However, without comparing to the same course offered in previous semesters when technologies were not used, this is not conclusive.

Theme 2: Piazza usage and submission type do not seem to affect students' perceptions about self efficacy and grading significantly

According to the statistical tests, when students had different intensity of online discussion through Piazza, they had similar perceptions about self-efficacy and the fairness of grades. Similarly, the submission through Panopto or PowerPoint did not significantly change how students perceived their self-efficacy or how they felt about the grades in general, although students did have significantly different perceptions about the accuracy of feedback in areas of strengths when submission type varied. Considering that only one question out of the five analyzed had significantly different ratings, it is concluded that students' perceptions about grading in general did not change when the submission method differed.

Theme 3: Students valued easy-to-use blended learning technologies that increased feedback and interaction.

Students preferred online discussion to online peer review and the video capturing technology. Students perceived that Piazza was easy to use and it increased access to timely feedback from the instructors. While students valued the increased feedback from peer review itself, online peer review was less preferred because Piazza was hard to use. Making video-recorded presentations and viewing video-recorded lectures were valued the least because students did not gain as much educational value and Panopto was the hardest to use compared to Piazza and Piazza. However, such preferences could result from the specific designs of the technologies utilized or the different functions enabled by the different technologies. In other words, for example, students may prefer to use Piazza for online discussion because Piazza as a technology is easy to use, or because online discussion as a function has more value to the students.

Previous studies about online discussion boards suggest both advantages and disadvantages. While Wu and Hiltz conclude in their study that online discussion improves students' perceived learning, this study does not suggest any direct relationship between usage of online discussion and students' perceptions. Such difference could be caused by the

different student sample, measurements, and experimental design utilized in this study.

As for online video capturing, this study majorly focused on the impacts of students using the video capturing technology, Panopto, to turn in case presentation. No other research was found on evaluating students' perceptions about students recording videos.

Previous studies have shown effectiveness of online peer review. While not much<sup>14</sup> quantitative analysis was done to evaluate students' perceptions about online peer review, students' qualitative responses on the course evaluations did also suggest that students perceived peer review to be useful. The challenges of peer review mentioned by Hyland & Hyland, Hanrahan & Isaacs, and Liu & Carless did not stand out in this study.

### **Limitations**

- **Self selection**

For the evaluation of impact of Piazza usage on students' ratings on self-efficacy surveys, the independent variable was Piazza usage with three levels of intensity. Students self-selected themselves into the three levels of Piazza usage. With self selection, there might be some systematic differences among the three levels of students, in addition to difference in Piazza usage. Therefore, the impact of Piazza usage on self-efficacy surveys was confounded by the uncontrolled systematic differences due to self-selection. With respect to students' submission of cases, random assignment was made and therefore threat from self-selection was controlled in this case.

- **Lack of control group**

When the instructors introduced Piazza and peer review to the class, for the purpose of fairness, all the students started using the technology and participating in peer review at the same time. Thus, no control group was available for this activity. Therefore, the potential effect of peer review on students' perceptions could be hardly singled out. However, the use of repeated measures design for submission type of cases (submitting through PowerPoint or Panopto) did mitigate this concern for comparisons based on submission types. Also, without data from previous semesters when technologies were not used, students' improvements on self-efficacy surveys could not be attributed to the use of technologies.

- **Testing**

The same surveys were given out multiple times to measure students' perceptions about self efficacy and grading of cases. Testing effect poses a threat because students' responses may be affected by the fact that they completed the same surveys several times.

### **Closure**

This study analyzed students' feedback and assessments on self-efficacy surveys, grading surveys, and course evaluations to evaluate the effectiveness of blended learning tools—an online discussion board, an online peer review system, and an online video capturing technology. Results show that throughout the whole process, students' perceptions have significantly changed. They became more confident and perceived more success in

performing systems design tasks. Students also indicated that the feedback they received later on during the process was more accurate. However, no direct relationship between usage of technologies and change of students' perceptions was found according to the statistical analyses in the study. This lack of evidence could be due to the limitations (self selection, lack of control group, and testing) of the study. This study also analyzed students' preferences of the three blended learning tools through students' comments. While the preferences for the designs of technologies and the functions of technologies are hard to separate, the online discussion board was most preferred, the online peer review system ranked the second, and the online video capturing technology was the least valued. Based on the content of student comments, we conclude that the students preferred blended learning technologies that increased timely feedback and interaction (with faculty and with fellow students) while also being intuitive and quick to learn.

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