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WIP: Teaching a Knowledge Engineering Course Using Active Learning, Gamification, and Scaffolding

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WIP: Engaging Software Engineering Students in Synchronous and Asynchronous On-line Course Offerings

Abstract

Many engineering educators regard experiential learning as the most effective way to train future generations of engineers. The authors have noticed higher levels of engagement when students participate in class activities than when they are simply listening to lectures. These activities may include games, discussions, group activities, and peer reviews. Covid19 restrictions forced a shift to the online delivery of all courses at our university this year. Often, activities developed for face-to-face delivery of software engineering topics cannot be used without modification in the online delivery of either synchronous or asynchronous courses. This paper describes the authors' experiences using active learning materials in an online software engineering course. Students taking this course were allowed to take it either synchronously or asynchronously. The project team critically examined existing active learning materials used for face-to-face delivery of the course and adapted them for online course delivery. The authors monitored the levels of student engagement in each group and surveyed individual students to measure their perceived level of engagement with course activities. Our initial assessment data suggest that students attending synchronous class meetings were slightly more engaged with the course materials than those who did not. Students interacting with the active learning course materials, whether synchronously or asynchronously, felt more engaged with the course than they would have with a traditional online lecture course.

Background

Many courses offered by the College of Engineering and Computer Science (CECS) rely heavily on lectures as the primary vehicle of instruction. This is even true of courses that emphasize student project work. In the lecture mode of instruction, student engagement with the course material is often low or non-existent until the date of an assessment activity (assignment or exam) is near. Many computing students (Computer and Information Science (CIS), Data Science (DS), Software Engineering (SE), Cybersecurity and Information Assurance (CIA)), are turned off by this sterile delivery of material[1]. All too often, passive learning environments fail to deliver opportunities for students to develop their soft skills.

The authors observed higher levels of engagement when students participated in class activities involving games, discussions, group activities, and peer reviews than when they are simply listening to lectures[1]. Covid19 restrictions forced the online delivery of all courses at our university this year. The authors did not want to return to the use of lectures as the only content delivery method in online software project courses. Activities developed for face-to-face delivery of software engineering topics often require significant modification for use in the online delivery of course material. The authors felt it was desirable to create activities that engaged online students and allowed them to experience a level of active learning comparable to the experiences enjoyed by face-to-face students.

The materials created for this course were developed using a variation of the ADDIE (Analysis, Design, Development, Implementation, Evaluation) process model.[2] Using the ADDIE process model, the project team critically examined existing active learning materials used for face-to-face topic delivery and adapted them for online course delivery. When new materials were created, the team attempted to determine the best mix of case-study review, role-play and hands-on exercises. These materials involved working with software engineering techniques or tools, to facilitate coverage of the topics. Many of the activities implemented in the course have been used successfully with several groups of students and their evolution benefited from feedback provided by the students and faculty.

This paper describes the authors' experiences using active learning materials in an online software engineering course. This course was offered to students taking it either synchronously (via online Zoom meetings) or asynchronously (without Zoom class meetings). Soft skills are important for engineering professionals and the authors wanted to provide opportunities for online students to develop these skills on team projects by encouraging asynchronous online students to work with students enrolled in a synchronous online section. The activities created for this project are grounded in the research literature on student engagement.

Active Learning

Several engineering educators regard experiential learning as the best way to train the next generation of engineers[3]. This requires engineering programs to go beyond offering industry-based capstone courses and internships. It is our belief that introducing students to active learning opportunities can improve software engineering education at the undergraduate level as well. We believe this will also increase the pool of new professionals with practical engineering problem-solving skills.

Active learning is "embodied in a learning environment where the teachers and students are actively engaged with the content through discussions, problem-solving, critical thinking, debate and a host of other activities that promote interaction among learners, instructors and the material"[4]. Prince defines active learning as any classroom activity that requires students to do something other than listen and take notes[5]. Active learning opportunities can complement or replace lectures to make class delivery more interesting to the students.

Specifically, active learning helps students develop problem-solving, critical-reasoning, and analytical skills, all of which are valuable tools that prepare students to make better decisions, become better students and, ultimately, better employees[5]. Raju and Sankar undertook a study to develop teaching methodologies that could bring real-world issues into engineering classrooms[6]. The results of their research led to recommendations to engineering educators on the importance of developing interdisciplinary technical case studies that facilitate the communication of engineering innovations to students in the classroom.

Active learning helps students learn by increasing their involvement in the process[7]. Active learning techniques help students to better understand the topics covered in the curriculum[8]. Active learning helps students to be more excited about the study of engineering than traditional instruction[1]. The group work that often accompanies active learning instruction helps students develop their soft skills and makes students more willing to meet with instructors outside of class[9]. Krause writes that engagement does not guarantee learning is taking place, but learning can be enhanced if it provides students with opportunities to reflect on their learning activities[10]. In our project, students were encouraged to reflect on the lessons learned from the activities either in writing or in a class postmortem discussion.

There is consensus among members of our department's professional advisory board that professional practice invariably requires strong verbal and written communication skills. To develop their oral communications skills, students need opportunities to present their work as well as observe their peers doing the same. Some instructors believe that the project activities inherent in real-world software development encourage students to improve their written and oral communication skills[11]. To this end, the investigators included small group online activities with the expectation that students would provide written or oral summaries (either live online or using video) of the strategies used to complete their tasks and their lessons learned.

Day and Foley used class time exclusively for exercises, by having their students prepare themselves through the study of materials provided online[12]. Bishop and Verleger presented a comprehensive survey of the research on different ways of using class exercises using a technique that is often referred to as the "flipped" classroom[13]. Wu et.al. effectively implemented class exercises as active learning tools in their flipped classroom approach[14].

The active learning approach of problem-based learning (PBL) has been consistently demonstrated to lead to positive learning outcomes such as self-directed learning habits, problem-solving skills, and deep disciplinary knowledge while engaging students in collaborative, authentic learning situations[15]. While PBL was first incorporated into medical school curricula in 1969, it is currently used in a wide variety of courses[16]. For instance, within the field of engineering, Warnock and Mohammadi-Aragh investigated the impact of PBL on student learning in a biomedical materials course and found that students made significant improvements in their problem-solving, communication and teamwork skill[17].

PBL has also been used in senior level engineering courses with the same positive results[18, 19, 20]. Although students in a PBL software engineering course reported that the projects were more time intensive than a typical course project, they were receptive to the approach since they thought it was related to the professional environment and provided them with opportunities to relate theory and practice. This was in contrast to students taught using a traditional lecture and project approach to the course who viewed completing a traditional course project more negatively[21]. Given all of the positive evidence, it was determined that a PBL pedagogical approach was well suited for a junior level software engineering project course.

Student Engagement

Active learning techniques such as Think-Pair-Share exercises[22], pair programming[23], peer instruction[24], and flipped classrooms[25] have been demonstrated to increase student engagement.

Many of these interventions are used at the introductory level, primarily to address broadening participation in large classes[26].

Ham and Myers brought Process Oriented Guided Inquiry Learning (POGIL) into a computer organization course[27]. In software engineering courses, the use of real-world, community-based, projects may be a good way to engage students with a meaningful problem while teaching them software engineering concepts[28]. Students often become more invested in their project when they see that their products are more than simply a paper design. In our course redesign, we used the class activities to motivate students to design software products and use software engineering techniques to solve a real-world programming problem.

An important aspect of software engineering education is the development of soft skills such as communication and project management. There are a number of examples of courses that make use of project work to help students enhance their soft skills simultaneously with their software development skills[29]. Decker and Simkins[30] introduced the use of an extended role play approach in a game development processes class where the students were not assessed solely on the artifacts they produced, but rather the processes by which they created the artifacts. Their role-play activities emphasize industry best practices for both technical and soft skills (project management, communication, marketing, and interdisciplinary design). We included some roleplay activities in the course redesign.

The authors felt it was desirable to create activities that engaged asynchronous online students and allowed them to experience a level of active learning comparable to the experiences enjoyed by the synchronous online students. The objective of our study was to see if students enrolled in the synchronous online section of a software engineering course were more engaged than students enrolled in the online asynchronous section of the same course. A flipped classroom style course delivery was used to provide synchronous students with opportunities to spend time applying software engineering practices in Zoom breakout meetings. Asynchronous students completed the course materials on their own after viewing video lectures. Both groups of students answered online survey questions about their perceptions of the effectiveness of the course activities and their personal levels of engagement with the course materials. Their levels of engagement were monitored during the semester.

Course Description

A junior level software engineering course, CIS 375 (Software Engineering 1), offered by the Computer and Information Science (CIS) department is organized as a 14 week, four credit-hour course. This is a required course taken by all computing majors in the CIS department which includes: Computer Science (CIS), Software Engineering (SE), Data Science (DS), and Cybersecurity and Information Assurance (CIA). Pre-Covid19, this course was typically offered using a synchronous, face-to-face format with the live lectures being recorded for streaming on-demand by students taking the same course asynchronously. The ABET student outcomes for CIS 375 appear in Table 1.

Table 1: CIS 375 ABET Student Outcomes and Course Outcomes

ABET Outcomes addressed in this course:

- Outcome 1 – Ability to analyze complex computing problems and apply principles of computing and other relevant disciplines to identify solutions.
- Outcome 2 – Ability to apply engineering design to produce solutions that meet specific needs with respect to public health, safety, and welfare keeping into consideration, global, cultural, social, environmental, and economic factors.
- Outcome 3 – Ability to communicate effectively with a range of audiences.
- Outcome 4 – Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, with consideration for the impact of engineering solutions in global, economic, environmental, and societal contexts.
- Outcome 5 - Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
- Outcome 7 - Acquire and apply new knowledge as needed, using appropriate learning strategies.

Course outcomes:

1. The student will be able to create a risk table for a software development project and risk information sheets for each critical or catastrophic risk.
2. The student will be able to create and execute a test plan for a software system, including test case creation, based on the specified requirements.
3. The student will be able to implement a software system that meets the needs of an external customer and that involves the creation of a significant user interface and help system.
4. The student will be able to make use of appropriate software engineering tools in the development of a software product.
5. The student will be able to manage the completion of a software project for an external customer.
6. The student will be able to participate in several peer design walkthroughs, including the presentation and critiquing of each other’s designs during class time.
7. The student will be able to participate on a multi-disciplinary design team to design and implement a software project.
8. The student will be able to write a complete design document for a software system.
9. The student will be able to write a management plan for a software project that involves time and resource estimates, personnel scheduling detail, and determine of its production costs.

One of the authors taught a face-to-face version of CIS 375 using a flipped classroom model for the past 5 years. This class covers the full software development lifecycle with an emphasis on agile software engineering practices and most of the weekly contact hours being devoted to engaged/experiential learning. The students also work on a team-based term project outside of the regular class meeting times. A detailed description of the class content and activities appears in Maxim, et al.[31] The topics covered in this course are listed in Table 2.

Table 2: CIS 375 Course Topics

Topic	Hours
Software design process, life-cycle models	4
Software requirements analysis	4
Software analysis and design modeling	4
Reviews and Inspections	4
Software project management and process metrics, cost estimation	2
Software project scheduling	2
Software risk management	2
Software design	2
Software architecture design	2
Software change and configuration management	2
User interface modeling and analysis, component design	4
Software quality assurance and usability	4
Software testing strategies and methods	6
Security inspections	2
Software design implementation	6
Team presentations and peer reviews	6

Course Delivery

Due to Covid19 restrictions, the offering of CIS 375 was restricted to online-only course delivery during Fall 2020. A synchronous section of this course was taught using a flipped classroom model and included a two-hour weekly Zoom meeting which made use of breakout rooms for small group problem solving and design activities. The Zoom meetings were not recorded and were not available for viewing after the class meetings ended. Students in both sections had access to prerecorded video lectures. Students enrolled in the asynchronous section of this course completed the course activities by themselves at home. For most asynchronous students, viewing the video lectures and reading the textbook were their primary sources of instruction.

For both groups of students, 20% of their total course grade was allocated to write-ups of the weekly activities, 20% to graded reading reflections, and 60% to the completion of five team project assignments. Each project team was composed of a mix of synchronous and asynchronous students. Students were not required to do all activity write-ups or all textbook chapter reflections. They were only required to complete 16 of 18 reading reflections and 20 of 22 activity write-ups. This allowed them the ability to spend more time on some tasks and less time on others. It also gave students a means of making up lost points by doing more than the minimum number of tasks assigned.

Prior to attending the weekly Zoom meeting, the synchronous students were expected to read the sections of the required course textbook[32] and view two 20-minute video lectures created as part of the weekly course module. The asynchronous students were expected to do the same. Table 3 lists the course modules completed by all students.

Table 3: CIS 375 Course Modules

Topic	**Activity**
Course Introduction	• Zoom ice breaking activity. • Group chapter reflection
Process Models	• Waterfall process - paper airplane construction activity • Process improvement video game • Scrum trigger video - group viewing with discussion
Requirements Engineering	• Requirements video - group viewing with discussion. • Requirements ambiguity exercise
Requirements Modeling 1	• CRC modeling exercise • User story and use case exercises
Requirement Modeling 2	• UML modeling exercise • SRS document review exercise
Reviews and Inspections	• Formal code inspection review – roleplay • Inspection video - group viewing with discussion
Cost and Time Estimation	• Project cost estimation exercise • Software requirements document with peer review
Project Scheduling and Risk Management	• Project scheduling exercise • Project risk management exercise
Software Architecture and Configuration Management	• Architecture tradeoff analysis exercise • Version control system assessment exercise
User Experience Design 1	• Web page usability assessment exercise • Project planning document peer reviews
User Experience Design 2	• Roleplay web user interface design • Roleplay use of personas in usability assessment
Software Quality	• Defect life cycle exercise • Software design document peer review
Testing – part 1	• Creating test cases from requirements • Test plan analysis and critique exercise
Testing – part 2	• Cost effective testing activity. • Web page accessibility exercise
Security Engineering	• Security inspection video - group view with discussion • Test plan peer review
Term Project Delivery	• Tiny Tool Video Demonstrations

The lecture slides and class handouts were available to students in both sections on Canvas (the campus course management system). If students had any questions on the module materials, they were encouraged to email or meet the instructor online during his office hours. Most students read the text material and completed their reflections prior to completing the module activities.

The team project assignments were completed outside of class and included writing a software requirements specification document and creating a project management plan for developing a pizzeria touch screen point of sale system. The term project involved the design, implementation, and testing of a web-based software engineering tool (Tiny Tool). The students were given 7 weeks to complete the term project and instructed to manage their team using an agile scrum framework.

Assessment

Each of the course assignments was evaluated by Canvas rubrics designed by the instructor for each type of submission. Currently, these rubrics contain two to ten criteria, each scored from 1 to 5. Table 4 shows the rubric used to evaluate textbook reading reflections. Table 5 shows the rubric used to evaluate the active learning assignments that called for students to conduct experiments. Specialized rubrics were created for the team project assignments.

Table 4: CIS 375 Reading Reflection Rubric

Topic	Feedback	Rating
What did you find interesting about the reading? Why?		0-4
What parts of this chapter do you feel would be challenging in a professional environment? Why?		0-2
Did your perception of the chapter material change after you read it? What did you view differently?		0-2
What do you consider the key take away from this chapter? Why?		0-2

Table 5: CIS 375 Activity Question Rubric

Topic	Rating and Feedback (0=missing, 4=satisfactory, 5=exceeds specification)
Quality of Answers	
Completeness of Write-up	

No statistical comparisons were made between the performance of students in the synchronous and asynchronous sections of CIS 375. However, informal comparisons of student data from the two delivery modes of CIS 375 delivered by the instructor, suggest that students attending the synchronous zoom meetings produced work which seemed to receive higher scores using similar grading rubrics.

Table 6 contains a brief summary of some student analytic data generated by the Canvas course management system. Student t-tests were performed on the mean scores for each group. The only significant difference ($p < 0.05$) was for the average number of missing lab exercises. In terms of student engagement, comparing the average course grades assigned to synchronous and asynchronous students may be less telling than the average number of late assignments and number missing assignments. This may be because the synchronous students get started on the activities in class that most asynchronous students complete on their own. Even in cases where the synchronous students were not able to complete the activities during their breakout sessions, they had the opportunity to start fleshing out the main points of the activity with a group. The average number of missing assignments was greater for the asynchronous students.

Table 6: Canvas Data - Based on Section Enrollment

	Synchronous (N=41)	Asynchronous (N=20)
Average Overall Course Grade	94.8%	92.8%
Average Number of Late Assignments Per Student	6.0	7.0
Average Number of Missing Assignments Per Student	3.1	6.0
Average Number of Missing Reflections Per Student	1.7	2.4
Average Number of Missing Lab Exercises Per Student	1.3	3.4

There were two primary categories that comprised the majority of missing assignments. The reading reflections and the homework exercises. Students in both sections would have the same experience with the reading reflections in that each student was to read the assigned textbook chapter and then write a brief summary by answering a set of questions with short answer type responses. No student interaction was to take place for the reflections. The homework assignments may or may not have included student interaction, depending on the section in which the student was enrolled. Synchronous students had an opportunity to attend the live Zoom class session and work through some or all of the homework exercises with other students. They may not have finished the entire exercise during the Zoom session but at the very least, these synchronous students had the opportunity to discuss the exercise material in their respective breakout rooms and then again in the main Zoom session. The asynchronous students were to complete the homework exercises at home but were allowed to work with other asynchronous students for some activities as long as their answers to open-ended questions demonstrated original work. Some asynchronous students did find their way to the Zoom sessions despite the fact that the meeting link was only broadcast to students in the synchronous section. The asynchronous students (on the average) were missing twice as many small group homework exercises as the synchronous students. Since all students were allowed to skip two reading reflections and two homework writeups the number of missing assignments for the synchronous students is not surprising.

Course Surveys

We surveyed the students during the midterm and final weeks of the semester, to gather the students' own perceptions of their level of engagement with the class and active learning. The students in both sections were asked a series of questions designed by the authors, to elicit candid responses. The survey was conducted separately from the regular student course evaluations and was completed before the final course grade postings. Table 7 compares student responses on the midterm survey (S = Synchronous, N=41/41 and A = Asynchronous N=19/20). The only significant difference ($p < 0.01$) found using the Mann-Whitney U test was for the statement "I felt more engaged during activities than lectures". Table 8 compares student responses on the final survey (S = Synchronous, N=39/41 and A = Asynchronous N=20/20). The only significant difference ($p < 0.05$) found using the Mann-Whitney U test was for the statement "I prefer the use of activities and discussion rather than lecture only content".

The students were asked specifically, "With which activities or parts of the course have you felt most engaged?" This was a question posed to each student in both the midterm and again in the final surveys. Although students were registered for either the synchronous or asynchronous sections, some synchronous students did not attend all of the video class sessions and some asynchronous students found their way to the Zoom video sessions despite the fact that the meeting invitations were not shared with them. This information is presented for context when interpreting the responses to the aforementioned question and response tables.

In the midterm survey responses for the synchronous section, 100% of the students mentioned group projects and/or class breakout room activities, as the most engaging parts of the course. The responses for the final survey continued this same trend with the exception of two students that indicated the readings and reflections were more engaging. The final survey also indicated that approximately 85% of the synchronous students claimed to have attended at least 50% of the video class meetings.

For the asynchronous students, the midterm survey showed an even split of seven each between group projects and distance learning exercises as being the most engaging part of the course. The remaining three students stated that the reading reflections were most engaging. It should be noted here that the distance learning exercises were the same activities that students worked on as a group in the video class breakout rooms. By the time the final survey was taken, projects and group activities were cited as the most engaging parts of the course for all except two students. This may suggest that several asynchronous students were attending video class sessions. Possibly, these were students working on the distance learning exercises by themselves earlier in the semester, that later sought out the video class breakout rooms. The responses from both sections and surveys seem to indicate a preference by students to be involved in the active learning exercises and projects.

At the midway point in the semester, the two sections were in close agreement with at least four statements of the survey. Greater than 80% of students from both sections either agreed or strongly agreed with the statements that course activities were a useful way to learn; an example of active learning; and engaging for the student. However, the synchronous students were far more in the affirmative with the statement “I felt more engaged during activities than during lecture”. 98% of the synchronous students agreed or strongly agreed with this statement but only 72% of the asynchronous students felt the same. There was a similar gap between sections when asked if they preferred activities/discussion over lecture content with 85% of synchronous students agreeing or strongly agreeing while only 63% of the asynchronous students agreed.

Table 7: Student Perceptions on Midterm Survey

Survey Statement	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***	
Course activities were a useful way to learn	1 (2%) 1 (5%)	1 (2%) 2 (10%)	4 (10%) 0	21 (51%) 9 (48%)	14 (35%) 7 (37%)	S A
Course activities let me apply what I learned	0 0	0 1 (6%)	5 (12%) 2 (10%)	19 (46%) 8 (42%)	17 (42%) 8 (42%)	S A
Course is an example of active learning	1 (2%) 0	1 (2%) 1 (5%)	4 (10%) 2 (11%)	17 (41%) 8 (42%)	18 (45%) 8 (42%)	S A
I was actively engaged in my learning	0 0	2 (5%) 1 (5%)	4 (10%) 2 (11%)	15 (37%) 8 (42%)	20 (48) 8 (42%)	S A
I applied the course material to real world situations	0 0	1 (2%) 1 (4%)	12 (30%) 6 (32%)	14 (34%) 6 (32%)	14 (34%) 6 (32%)	S A
I felt more engaged during activities than during lecture	0 0	0 0	1 (2%) 5 (26%)	18 (44%) 9 (46%)	22 (54%) 5 (26%)	S A
I prefer the use of activities and discussion rather than lecture only content	0 1 (5%)	1 (2%) 3 (16%)	6 (15%) 3 (16%)	15 (37%) 5 (26%)	19 (46%) 7 (37%)	S A
I feel that doing activities on my own would be just as beneficial as working on them with a group in class	10 (24%) 4 (21%)	9 (22%) 3 (16%)	8 (20%) 4 (21%)	6 (15%) 7 (37%)	8 (19%) 1 (5%)	S A

By the time of the final survey, the synchronous section was slightly less convinced that the activities were a useful way to learn but still greater than 80% agreed with the statement. However, the asynchronous students were significantly less positive about the “usefulness” of the activities with only 60% in agreement. By the end of the semester, 90% of the synchronous students agreed that they were actively engaged but only 75% of the asynchronous students felt the same. The data suggest that the synchronous students maintained their enthusiasm for activities and active learning as the semester progressed whereas a notable amount of asynchronous students' responses fell to a neutral or disagreement state.

Table 8: Student Perceptions on Final Survey

Survey Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Course activities were a useful way to learn	1 (2%) 0	1 (2%) 4 (20%)	6 (15%) 4 (20%)	20 (52%) 5 (25%)	11 (29%) 7 (35%)	S A
Course activities let me apply what I learned	1 (2%) 0	4 (10%) 1 (5%)	3 (8%) 6 (30%)	19 (49%) 5 (25%)	12 (31%) 8 (40%)	S A
Course is an example of active learning	1 (2%) 0	1 (2%) 1 (5%)	3 (8%) 5 (25%)	13 (34%) 4 (20%)	21 (54%) 10 (50%)	S A
I was actively engaged in my learning	1 (2%) 1 (5%)	0 3 (15%)	3 (8%) 1 (5%)	14 (36%) 6 (30%)	21 (54%) 9 (45%)	S A
I applied the course material to real world situations	1 (2%) 1 (5%)	2 (5%) 3 (15%)	6 (16%) 4 (20%)	12 (31%) 2 (10%)	18 (46%) 10 (50%)	S A
I felt more engaged during activities than during lecture	1 (2%) 0	1 (2%) 1 (5%)	1 (2%) 1 (5%)	16 (42%) 8 (40%)	20 (52%) 10 (50%)	S A
I prefer the use of activities and discussion rather than lecture only content	1 (2%) 1 (5%)	3 (8%) 6 (30%)	3 (8%) 3 (15%)	12 (31%) 4 (20%)	20 (51%) 6 (30%)	S A
I feel that doing activities on my own would be just as beneficial as working on them with a group in class	4 (10%) 2 (10%)	10 (26%) 5 (25%)	8 (20%) 2 (10%)	12 (31%) 5 (25%)	5 (13%) 6 (30%)	S A

Course Evaluations

Students on our campus are requested to complete a standard set of course evaluations at the end of the semester. The evaluation form is completed online and anonymously, prior to receiving their final course grades. Table 9 shows the mean scores for the synchronous vs asynchronous sections. The only significant difference ($p < 0.05$) found using the Mann-Whitney U test was for the statement "The course met my expectations". Completion of these course evaluation forms is voluntary and student participation on our campus has dropped during the Covid19 lockdown. The most revealing indicators of overall course effectiveness was the large gap between the opinions of synchronous and asynchronous students. This suggests a synchronous environment is preferred for delivery of online active learning.

In general, the course evaluations ask the student to rate the course on expectations; understanding of subject matter; helpfulness of course materials; and overall rating of the course and instructor. Unlike the midterm and final active learning surveys administered as part of this research, the course evaluations do not ask students any specific questions related to the style of course delivery. The course evaluations do offer students an opportunity to identify strengths and/or areas of improvement in the form of a short answer.

Without specific prompting regarding active learning or style of delivery, the student comments on the course evaluations indicated that the students preferred the activities to taking exams and that the students felt that the activities and project-based learning approach not only prepared them better for their senior design class but also prepared them better for their careers. Even though some students indicated they were not fond of the reading reflections, some admitted that the reflections were a good way to ensure that students actually read the textbook. One comment acknowledged that the reflections made them read but suggested improving the method somehow.

Table 9: Selected Course Assessment Questions Synchronous vs Asynchronous

CIS 375 **1 = *strongly disagree*, 5 = *strongly agree***	**Synchronous** **N = 18/41**	**Asynchronous** **N = 14/20**
Course met my expectations	4.6	3.9
Course objectives were clear	4.6	4.3
Course advanced understanding of subject	4.7	4.5
Course never repeats other course material	4.5	4.4
Overall course rating	4.6	4.0

Overwhelmingly, the projects are the biggest strength cited by students in the course evaluations. Their comments reinforce the positive effect of projects on practical learning as well as the development of team oriented, problem solving skills. Several students also indicated that replacing exams with projects provided a more meaningful learning experience and knowledge that would be otherwise difficult to assess with a traditional assessments approach.

Threats to Validity

It is important to note a significant difference between the delivery of the asynchronous course material, pre and post Covid19 restrictions. In recent years, this university implemented a policy which required the pairing of an asynchronous, distance learning section with a face-to-face section of the same course. The live delivery of the face-to-face course instruction was recorded as a video. The asynchronous students were expected to view this video after the fact. This was true for most CIS courses. In this scenario, the distance learning (asynchronous) student was able to view not only the lecture, but the entire class interaction, including the ability to eavesdrop on the in-class activities and discussions. This provided an advantage to the pre-Covid asynchronous section in that they could view the live lecture as if they were there and even getting some insight into the in-class activities. This is in contrast to the post-Covid asynchronous sections that were only viewing pre-recorded lectures with no way to observe a live classroom audience interacting during in-class activities. Even if Zoom class meetings were recorded, there was no facility to record the activities and exercises conducted in the breakout rooms. Although the general trend of preference towards active learning seems to have remained intact, the current situation may leave the asynchronous student feeling slightly more uncertain when attempting to complete the activity exercises alone.

One area of uncertainty when measuring the student responses is the unknown amount of interaction between students in the two sections. Many students in the CIS department know each other from other classes that they have taken together. Even though a student is registered in the asynchronous section and has not attended any online class meetings, it is quite possible that a friend from the synchronous section may have shared their course experiences with them giving the asynchronous student additional insight into group activities from the classroom. In other words, the asynchronous student is not really isolated from knowledge learned in the group activities.

Student engagement can only be measured indirectly in online courses using surveys and course analytics. In previous studies, direct observation of student behavior was used to provide insight into their levels of engagement. It is difficult to observe student behavior during a synchronous Zoom meeting without violating student privacy in their home spaces. Even if students turn on their web cameras, often, less than half the class can be displayed as thumb nails on the instructor's display. Trying to measure student engagement using chat comments or interaction with shared google documents is a possible alternative but also lacks the immediate visual feedback an instructor experiences with a real-time view of a student's face.

Conclusions and Future Direction

We were encouraged by the enthusiasm that students exhibited while working with the active learning modules in the synchronous class meetings and look forward to continuing to develop this course content. It may be important to develop ways in which asynchronous students are encouraged to be a part of some sort of face-to-face experience, even if it is not during a formal online class meeting. Informal study or discussion groups that could meet online, with flexible meeting times, might be a way to increase engagement with activities. Experiences from the Fall 2020 course delivery of CIS 375 are being used to revise the next offering of this course and the corresponding active learning materials. We will continue to search for activities which better match the course topics.

The current plan is to make use of the revised modules in the Fall 2021 offering of CIS 375 which may to be fully online due to decisions to maintain social distancing in all classes in response to the Covid19 pandemic. We are continuing to develop software tools to provide scaffolding assistance for student experiments. It may also be desirable to add some course elements to reward students for coming to class with the assigned readings completed when face-to-face classes return in the future. Tailoring writing prompts to specific chapter subjects might help improve the student experience when doing the reading reflection assignments. We also hope to follow these students and see how successful they are in their Senior Design courses over the next year.

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