# Student Engagement in an Online Software Engineering Course

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**Abstract—Engineering instructors often rely on lectures as their primary mode of instruction even in project courses. In the lecture mode of instruction student engagement with the course material is often low or non-existent. Many engineering educators regard experiential learning as the best way to train the next generation of software engineers. For the past five years, one of the authors has taught a junior level software engineering course using active learning methods in a flipped classroom setting. During this past year, the COVID-19 lockdown prevented in-person delivery of this course. The challenge facing engineering faculty everywhere is figuring out how to include active learning experiences in online course delivery. This paper describes the authors' experiences introducing active learning methodologies into a junior level online software engineering course. The project team carefully considered the active learning course materials used in the in-person delivery of this course and adapted them to accommodate the idiosyncrasies of an online course delivery environment. Most importantly, a comparable online course delivery alternative needed to include zoom video class sessions containing live active learning exercises. The investigators compared the levels of student engagement between previous in-person offerings of the course with the online adaptation of the same course. Student engagement data was collected from each style of course delivery. In some cases, this data was supplemented by observational data and with Canvas course analytics. We found that students in both course settings were least engaged when listening to short lectures (either live or video recordings) and felt most engaged when involved in small group activities (either in person or in Zoom sessions with breakout rooms).**

***Keywords—online course delivery; active learning; student engagement***

## I. INTRODUCTION

Courses offered by the College of Engineering and Computer Science (CECS) rely heavily on lectures as the primary vehicle of instruction, even when the emphasis is on student project work. As a consequence of this delivery style, Computing students (Computer and Information Science (CIS), Data Science (DS), Software Engineering (SE), Cybersecurity and Information Assurance (CIA)), are often indifferent to the content delivered in this manner and lack engagement with the course material until the date of an assessment activity is near [1]. Not only does a passive learning environment such as this fail to garner the students' attention, but it also falls short in delivering opportunities for students to develop their soft skills.

The materials for this course were originally designed for an in-person, active learning environment, using a variation of the ADDIE (Analysis, Design, Development, Implementation, Evaluation) process model [2]. In previous in-person course offerings, the authors had observed higher levels of engagement when students participated in class activities involving games, discussions, group activities and peer reviews [1]. When COVID-19 restrictions forced the online delivery of all courses at our university last year, it was imperative to provide content beyond the use of recorded video lectures and develop an active learning approach for remote instruction. However, activities developed for in-person 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 in-person students. 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 [1, 3].

This paper describes the authors' experiences using active learning materials adapted for an online software engineering course. This course was offered to students taking it synchronously (via online Zoom meetings) in place of in-person class meetings. The authors wanted to provide opportunities for online students to develop soft skills on team projects by encouraging synchronous online students to participate in real-time reflection activities similar to those included in past in-person course offerings. The activities created for this project are grounded in the research literature on student engagement [1].

### A. *Active Learning*

Several engineering educators regard experiential learning as the best way to train the next generation of engineers [4]. Towards this end, it is reasonable to believe that the interaction practiced in active learning can improve software engineering education at the undergraduate level and better prepare students for the experiential learning that comes with their capstone projects.

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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" [5]. Prince defines active learning as any classroom activity that requires students to do something other than listen and take notes [6]. 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 [6]. Raju and Sankar undertook a study to develop teaching methodologies that could bring real-world issues into engineering classrooms [7]. 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 engagement in the process [8]. Active learning techniques help students to better understand the topics covered in the curriculum [9]. 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 [10]. 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 [11]. In our research projects students were encouraged to reflect on the lessons learned from the activities either in writing or orally during class postmortem discussions.

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 [12]. 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 [13]. Bishop and Verleger presented a comprehensive survey of flipped classroom exercise implementations [14]. Wu et.al. effectively implemented class exercises as active learning tools in their flipped classroom approach [15].

The active learning approach of problem-based learning (PBL) has 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 [16]. While PBL was first incorporated into medical school curricula in 1969, it is currently used in a wide variety of courses [17]. 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 skills [18].

PBL has also been used in senior level engineering courses with the same positive results [19-21]. 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 [22]. 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.

### B. *Student Engagement*

Active learning techniques such as Think-Pair-Share exercises [23], pair programming [24], peer instruction [25], and flipped classrooms [26] 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 [27].

Ham and Myers brought Process Oriented Guided Inquiry Learning (POGIL) into a computer organization course [28]. 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 [29]. Students often become more invested in their projects 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 [30]. Decker and Simkins [31] 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 our course redesign.

## II. Course Structure

### A. Course Structure

Our junior-level software engineering course, CIS 375 (Software Engineering 1), is organized as a 14 week, four credit-hour course. This is a required course taken by all computing majors(CIS, SE, CIA, DS) in the CIS department. Pre-COVID-19, this course was typically offered using a synchronous, in-person format with the live lectures being recorded for streaming on-demand by students taking the same course asynchronously. Typically, one or two students drop this class after the first two weeks each time it is offered.

One of the authors taught an in-person (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 with 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. [3]. The topics covered in this course are listed in Table I.

TABLE I. 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 |
| Project management, 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 |

### B. Course Delivery

Due to COVID-19 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 had access to prerecorded video lectures. Students in the in-person sections viewed live delivery of the short lectures.

For both groups of students, 20% of their total course grade was allocated to participation in the weekly activities, 20% to graded reading reflections, and 60% to the completion of five team project assignments. 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 in-person students were expected to read the textbook sections, but viewed the lectures in class. Table II lists the course modules adapted from the in-person modules to be completed by online students.

TABLE II. CIS 375 Course Activities

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

### C. Course Activities

Breakout rooms are a feature of Zoom video conferencing that allow the attendees to be split up into smaller groups, either by random assignment or into pre-defined groups. Prior to the first Zoom class meeting, the authors had several discussions concerning the best approach for handling what would have been in-class activities during in-person instruction. We felt it important to develop an effective workflow for moving students in and out of breakout rooms. Concerns included the size of activity groups for breakout room and whether or not breakout rooms should be preassigned or randomly generated. Another concern was how groups would share documents among breakout rooms (a feature that Zoom lacked in Fall 2020) when activities required interaction between groups.

The paper airplane activity is one of the early in-person class activities designed to help students understand the unforgiving nature of the Waterfall model. The students are asked to form groups and execute a design for a paper airplane. They are asked to successfully fly and land the plane on a desktop. If the first attempt does not meet the acceptance criteria, they must begin again from scratch with a full redesign. The spontaneity of in-person meetings made the exercise fun and enlightening for students. However, under COVID restrictions, the students could not be in the same physical space when it came time to design their airplane and test it. Using a Zoom meeting created a layer of distance that did not allow for the tactile interaction that the students would have had as they passed a paper airplane model around in their worktable in an in-person class session. Previously, the exercise required only a sketch of the proposed design. However, for the online activity, the exercise was modified to include step by step instructions explaining the procedure to fold the paper airplane. The intention was to get the students to think past the less-than-optimal webcam image, and explicitly describe the construction of an object that they could no longer pass back and forth.

The Process Improvement Game [33] is a card game that helps students to understand the Agile Software Development Process Model by having the player, playing the role of Scrum Master, attempt to schedule the completion of a software project, on time, under budget, and with an acceptable number of defects. Each round is a four-week sprint and various play options affect the cost, number of defects, and time to complete user stories. The students can download the game or play via a web interface. There was not time to learn the rules of the game while in the breakout rooms, so the students were asked to familiarize themselves with the game's flow prior to the Zoom class meeting. To facilitate their introduction to the game, the authors created a short demo video to explain the rules and flow for each turn in the game. This would allow the students to enter the breakout rooms prepared to start the game. In addition to playing the first level of the game as a group, the students were asked to share their play strategies when they returned to the main Zoom class meeting.

For the in-person class, the CRC modeling exercise had students form groups of four and create a set of CRC (Class-Responsibility-Collaborator) cards from a set of ATM system user stories. The students were instructed to look for nouns to identify candidate classes and verbs to determine the candidate methods. The cards were then dealt to the group members with the dealer/reader reading from a use case selection. When a member recognized a class name from a card in their possession, a physical token (pen) was passed to that person and that person read the responsibilities from the card. The group then decided whether a responsibility matched the requirement. Once again, for the Zoom breakout session, time and logistic issues dictated some altering of the exercise. There was no virtualization of the card set which could be shared amongst group members in the breakout rooms so the CRC cards (with candidate class names), were provided prior to the start of class. That way, each student could print out or display their own copy of the cards for the activity. The activity included some short answer reflections for the groups to respond to once they returned to the main session.

The Roleplay Web User Interface Design Activity required each group to create a table of requirements for a two-page website then trade the requirements with a partner team in another breakout room. Each team would then sketch a model of a web page user interface (UI) using the design from the requirements created by their partner team. The problem that needed to be solved was how to exchange design documents and the UI sketches quickly and gracefully between partnered rooms. Breakout rooms are controlled by the meeting host and (at the time of this research), did not allow intercommunication between rooms, only with the host. This problem had been anticipated but initially, presented no good solutions. Although we decided that assigned breakout rooms would be used, a predetermined contact for each room could not be determined in advance because there was no guarantee that a particular student would be in attendance. A mailbox type feature for breakout rooms would have been ideal but did not exist. The solution was to have the meeting host, manually move a student from one breakout room into a partner room and have them exchange or share their documents using their preferred collaboration tool (Google doc, email, text, etc.).

In the early planning stages, we thought it might be important to assign class-activity breakout rooms using the same team personnel that would be together for the term project. This was not only because the students may prefer the comfort factor, but also because it would give the teams more time to practice soft skills together. After a couple of sessions in which we were successful in assigning the breakout rooms in this manner, we had requests from the students to return to the previous mode of using randomly assigned rooms. Although some activities require an assigned room, the random room assignments can be made automatically during Zoom sessions.

## III. Evaluation

Comparing the data for the Fall 2019 in-person students with that of the Fall 2020 online students, the team looked at three primary reports which are automatically generated by the course management system, Canvas. We also looked at student evaluations of the course and surveyed the students' perceived levels of engagement.

## A. Course Analytics

Table III contains a summary of some relevant course analytics. The average course grade in both sections (Fall 2019 and Fall 2020) was almost 95%. A mastery-learning philosophy guided the evaluation activities in both offerings of the course. Most students completed their work in small groups. Students were allowed to submit their individual work for re-grading after correcting the deficiencies identified in the original assignment turn-in.

Student t-tests were performed on the mean scores for each group. The only significant difference found ($p < 0.05$) was for number of missing lab assignments, which favored the in-person class students. While most students were diligent when it came to project related assignments, students were more likely to miss turning in a reading reflection. Students in the online section missed more reflections than the in-person students and on average, were twice as likely to miss an assignment of any type. The average number of late assignments was similar for the two groups. Reading reflections represent a solitary study activity that should be unaffected by course delivery method. The student was to read the assigned textbook chapter and then answer a set of short questions asking the student to reflect on their understanding of the chapter material. Yet, if this data were a partial indicator of overall class engagement, it might indicate that the in-person class students were slightly more engaged than the online students.

TABLE III. CIS 375 COURSE ANALYTICS

| | 2019 In-Person (N=40) | 2020 Online (N=41) |
|---|---|---|
| **Average Course Grade** | 94.9% | 94.8% |
| **Average Number of Late Assignments per Student** | 6.9 | 6.1 |
| **Average Number of Missing Group Assignments per Student** | 1.7 | 3.1 |
| **Average Number of Mssing Reflectionss per Student** | 1.4 | 1.7 |
| **Avergae Number of Missing lab Assignments per Student** | 0.3 | 1.3 |

Student comments suggest the in-person students felt more peer pressure to complete the readings prior to participating in the next small group activity or class discussion. Students in the online section may have felt they could hide behind a Zoom profile image without being called out by their peers. The number of missing group assignments may indicate slightly lower levels of engagement in the online section. For group assignments individuals were subject to peer evaluation of their participation on the group product. This made it easy to identify team members who failed to contribute.

## B. Course Evaluations

Students on our campus are asked to complete a standard course evaluation at the end of the semester, which is conducted anonymously online and prior to the posting of final grades. Table IV shows the mean scores for the Fall 2019 in-person section vs the Fall 2020 online section. In general, the course evaluations ask the student to rate the course on expectations, understanding of subject matter, workload compared to other courses, helpfulness of lab activities, and overall rating of the course. The course evaluations do offer students an opportunity to identify strengths and/or areas of improvement by asking a few short answer questions. Participation in the course evaluations is voluntary and has dropped during the COVID-19 lockdown.

TABLE IV. SELECTED COURSE EVALUATION QUESTIONS IN-PERSON VS ONLINE

| 1 = strongly disagree<br>5 = strongly agree | 2019 In-Person (N=24/40) | 2020 Online (N=18/41) |
|---|---|---|
| **Course met my expectations** | 4.75 | 4.61 |
| **Course objectives were clear** | 4.79 | 4.65 |
| **Typical workload compared to other courses** | 4.71 | 4.11 |
| **Course advanced my understanding of subject** | 4.83 | 4.67 |
| **Lab activities increaed my understanding of lecture topics** | 4.83 | 4.50 |
| **I knew what was expected of me** | 4.83 | 4.39 |
| **Overall course rating** | 4.75 | 4.56 |

The evaluations for the online delivery showed a slightly lower mean scores for all responses. The only significant difference found ($p < 0.05$) using the Mann-Whitney U test was for the workload where students were asked if the course had a typical workload compared to other courses. Unfortunately, the written comments did not reveal if this perception was due to the feeling that this course involved more work or less work. In terms of assignments and projects, the actual course workload was not altered for the online delivery of this course, The online students were required to turn in their group activity write-ups for grading. The in-person students made oral presentations of their group activities and were credited based on their observed class participation. In Fall 2020, The entire campus was forced into moving courses online. So, whatever comparison the students made may have been affected by other classes with a more dramatic change in workload.

The online section also showed a decline in agreement with the statement “I knew what was expected of me in this course”. There was a slightly lower mean score for the online students compared with the in-person section from the previous year. The results revealed that the students were still largely in agreement with the positive statements in the evaluation. It is within reason, that any negative connotation might be attributable to the general awkwardness of an interactive online class. There were comments in the online course evaluation acknowledging this yet realizing the necessity of the online format. While online students have the means to speak and ask questions, interactions do not have the same natural flow as a live conversation and certainly there is little visual feedback for the instructor. Although Zoom claims to provide full-duplex audio, other noise cancelling features make it difficult to be fully realized unless all participants are using earbuds. With the network latency, often two or more people attempting to speak at the same time causes clumsy breaks in conversations and often leads to a tentativeness amongst the students. It may make students feel that they cannot interject a quick comment or question.

Without prompting, both the in-person and online students, showed a strong preference for the activities and projects, as opposed to taking exams. They 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.

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 assessment approach. 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.

### C. Engagement Survey

We surveyed the students at both mid-term and end of term in Fall 2018 (in-person) and Fall 2020 (online) courses in order to check student perceptions of their classroom engagement. The most recent survey data collected for in-person students was collected during Fall 2018. The results for the midterm surveys appear in Table V. The Mann-Whitney U tests did not find any significant differences between the two groups of students on the midterm surveys.

Looking at end term survey results in Table VI, despite the limitations of Zoom video conferencing, online students (Fall 2020) had a slightly stronger preference for active learning than students in-person (Fall 2018) agreeing that they had more opportunities to engage in active learning (82% vs. 94%), felt more actively engaged in learning (71% vs. 90%), were more engaged during activities than lectures (69% vs. 92%), and more strongly preferred use of activities to lecture (69% vs. 82%). This stronger preference may be attributable to student exhaustion with pure lecture content through Zoom from their other courses in 2020. The opportunities to actively engage with the material and participate in their learning may have therefore stood out more strongly to students than when classes were in-person. Yet, it is clear that students at the very least did not feel that online-only instruction hindered their ability to be actively engaged as compared to in-person instruction in the course.

Only one significant difference between the two groups of students ($p < 0.05$) was found on one of the end term survey questions using the Mann-Whitney U tests. This difference favored the online students who felt more engaged on during class activities than during lectures. It should be noted the in-person students viewed interactive, live lectures and the online class viewed video recordings of similar lectures, Most students in both semesters indicated their satisfaction and preference for active learning course delivery based on their responses.

TABLE V. MIDTERM SURVEY STUDENT PERCEPTIONS OF ENGAGEMENT FALL 2018 IN-PERSON VS FALL 2020 ONLINE

**I = In-person (N=43) O = Online (N=41)**
**SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree**

| Survey Statement | | SD | D | N | A | SA |
|---|---|---|---|---|---|---|
| **There were opportunities for me to actively engage in learning** | I | 0 | 1 2% | 4 9% | 16 34% | 22 51% |
| | O | 0 | 0 | 4 10% | 14 34% | 23 56% |
| **Course activities were useful way to learn** | I | 1 2% | 1 2% | 7 16% | 18 42% | 16 37% |
| | O | 1 2% | 1 2% | 4 10% | 21 51% | 14 34% |
| **Course activites let me apply what I learned** | I | 0 | 0 | 7 16% | 15 35% | 21 49% |
| | O | 0 | 0 | 5 12% | 19 46% | 17 41% |
| **Course is an example of active learning** | I | 0 | 1 2% | 5 12% | 12 30% | 25 58% |
| | O | 1 2% | 1 2% | 4 10% | 17 41% | 18 44% |
| **I was actively engaged in my learning** | I | 0 | 2 5% | 6 14% | 16 37% | 19 44% |
| | O | 0 | 2 5% | 4 10% | 15 37% | 20 49% |
| **I applied the course material to real world sittations** | I | 1 2% | 7 16% | 4 9% | 17 40% | 14 34% |
| | O | 0 | 1 2% | 12 29% | 14 34% | 14 34% |
| **I felt more engaged during activites than lecture** | I | 0 | 2 5% | 7 16% | 11 26% | 23 53% |
| | O | 0 | 0 | 1 2% | 18 44% | 22 54% |
| **I prefer use of activitieis and discussion to lecture only content** | I | 0 | 3 7% | 5 12% | 12 28% | 23 53% |
| | O | 0 | 1 2% | 6 15% | 15 37% | 19 46% |

As part of the engagement surveys students had the opportunity to write short answers to several questions. The comments from the Fall 2020 students were in agreement with the comments from Fall 2018. Students overwhelmingly stated that the class activities were the most engaging part of the course. One student's comment which is representative of the majority of responses was that "I felt most engaged during the projects [class activities]. They gave me an opportunity to really apply what we were learning in class and understand the reason I am learning the topics in the first place." Further, another student stated "Honestly, the projects [class activities] really tied everything together for me." Additionally, when students were asked which teaching methods worked best, they overwhelmingly mentioned in the words of one student that

"The Zoom meetings and group work worked well!" However, not all students shared this sentiment as when asked about the greatest challenges when learning in an online format some students commonly pointed out that they felt hindered by the breakout sessions through Zoom. As summarized by one student who felt "lost with the zoom group activities. It was like me, and my group were missing some piece of knowledge every time and having to fumble through them". A known problem with zoom breakout sessions is the difficulty in communicating with room participants once they enter their room. This clearly resulted in some students not receiving needed clarifications to complete the breakout activities. However, we may need to better instruct students on how to seek assistance while in Zoom breakout rooms.

When asked if the lab activities increased the students' understanding of course topics a few online students expressed some concerns. At least one student indicated in their written response to this question that there was sometimes confusion on entering the breakout room for a group activity. The student did go on to clarify that the confusion was usually cleared up by returning to the main Zoom class session for discussion with the instructor. This does demonstrate the relative awkwardness of toggling between breakout rooms and the main session in the Zoom classroom. There is a feature for students to request assistance while in a room. However, if there are two or more breakout rooms needing the instructor's help, the waiting party has no way to know that the instructor is assisting students in another room. During the Fall 2020 Zoom classes, there was always at least one team member monitoring the main session. The need provide help to students in multiple rooms was observed several times during the semester.

### *D. Implications*

We believe that some of our findings can be applied to other engineering project courses. Looking at the course analytics, course evaluations, and engagement survey data we found two common themes.

The first was that there were few statistical differences between the in-person course data and the online course data. We interpret this as a sign that the course successfully transitioned from an in-person format with live activities and group-based discussions to an online format run through Zoom with the group activities and discussion occurring remotely through video chat. The one significant difference was between the course evaluations workload statement. This difference is likely attributable to the extra work of writing up the group activity reports in the online version of the class. In the in-person version of the class students simply presented their group's work to the rest of the class. In support of this observation, students were just as satisfied with the course instruction, objectives, and lab assignments as they were with the in-person course offering. Additionally, the data shows that students in both groups felt there were opportunities to actively engage and that course activities were a useful way to learn and apply what they had learned.

The second was that students were just as engaged in the online course as they were in the in-person class. This is pointed to by the engagement survey data for the two courses. This is important because video chat is often seen as an impersonal medium better suited to a lecture driven instruction. This work shows from student survey results and comments that an online course can successfully engage students at least as well as an in-person class designed around active learning.

We recognize that one of the limitations of this study was that we did not have a control group. We also acknowledge that the instructor teaching all CIS 375 course offerings may also account for the lack of significant differences one the evaluation measures. It is also possible that the use of Zoom does not reduce student levels engagement for students taking engineering project courses.

TABLE VI. END TERM SURVEY STUDENT PERCEPTIONS OF ENGAGEMENT FALL 2018 IN-PERSON VS FALL 2020 ONLINE

**I = In-person (N=35) O = Online (N=39)**
**SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree**

| **Survey Statement** | | **SD** | **D** | **N** | **A** | **SA** |
|---|---|---|---|---|---|---|
| **There were opportunities for me to actively engage in learning** | I | 3<br>9% | 0 | 3<br>9% | 11<br>31% | 18<br>51% |
| | O | 1<br>3% | 0 | 11<br>31% | 15<br>38% | 22<br>56% |
| **Course activities were useful way to learn** | I | 3<br>9% | 2<br>6% | 2<br>6% | 17<br>49% | 11<br>31% |
| | O | 1<br>3% | 1<br>3% | 6<br>15% | 2<br>51% | 11<br>28% |
| **Course activites let me apply what I learned** | I | 3<br>9% | 2<br>6% | 3<br>9% | 14<br>40% | 13<br>37% |
| | O | 1<br>3% | 4<br>10% | 3<br>8% | 19<br>49% | 12<br>31% |
| **Course is an example of active learning** | I | 3<br>9% | 1<br>2% | 3<br>9% | 13<br>37% | 14<br>40% |
| | O | 1<br>3% | 1<br>3% | 3<br>8% | 13<br>33% | 21<br>54% |
| **I was actively engaged in my learning** | I | 3<br>9% | 2<br>6% | 5<br>14% | 13<br>37% | 12<br>34% |
| | O | 1<br>3% | 0 | 3<br>8% | 14<br>36% | 21<br>54% |
| **I applied the course material to real world sittations** | I | 3<br>9% | 3<br>9% | 6<br>17% | 12<br>34% | 11<br>31% |
| | O | 1<br>3% | 2<br>5% | 6<br>15% | 12<br>31% | 18<br>46% |
| **I felt more engaged during activites than lecture** | I | 4<br>11% | *2*<br>*6%* | 5<br>14% | 10<br>29% | 14<br>40% |
| | O | 1<br>3% | 1<br>3% | 1<br>3% | 16<br>41% | 20<br>51% |
| **I prefer use of activitieis and discussion to lecture only content** | I | 3<br>9% | 3<br>9% | 5<br>14% | 9<br>26% | 15<br>43% |
| | O | 1<br>3% | 1<br>8% | 3<br>8% | 12<br>31% | 20<br>51% |

## IV. CONCLUSIONS AND FUTURE WORK

During the last year, a majority of institutions across the world were required to switch to online formats. This switch to using video conferencing often required major adjustments to course design and left many students simply watching online lecture videos and taking exams. We demonstrated that it is possible to move an in-person active learning software engineering course online. We believe that an engineering project course can be run completely online without observing significant differences in student levels of engagement between the course formats. We take this as evidence that it is possible to design an online course that can be as engaging as an in-person counterpart. We credit the active learning components of the class and the levels of student interaction that accompany them for making it possible. We encourage other instructors to adopt active learning practices in their online courses in order to achieve levels of student satisfaction and engagement on-par with their in-person instruction.

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 online students are encouraged to be a part of some sort of group experience, even if it is not during a formal online class meeting. Informal study or discussion groups that meet online, with flexible meeting times, might be a way to increase their 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.

The current plan is to make use of the revised modules in the Fall 2021 offering of CIS 375 which may again be fully online due in response to the COVID-19 pandemic. If we are allowed to deliver this course using in-person activities, we anticipate having to create socially distanced versions of the class activities. 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 in-person 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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