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WIP: Managing and Assessing Students in Hybrid Software Project Classes

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Abstract

One of the authors teaches two courses focused on software engineering and game development. Each of these courses has in-person and asynchronous online students taught as a single course by the same instructor. Using active learning and authentic assessment techniques, the authors sought to improve the students' levels of engagement. The students in both courses learn to use agile software engineering practices to deliver incremental software prototypes. Students in both courses were given surveys measuring their sense of belonging, levels of intrinsic motivation, and belief in growth mindset. No significant differences were found between the online and in-person students from either course on these measures. The online and in-person students were surveyed at the conclusion of their courses to measure their perceived levels of engagement with course activities. No significant differences were found between the in-person students and online students in either course. We did find significant differences favoring the in-person students on the performance measures in the game design course, but not in the software engineering course.

Background

Many instructors are frustrated when trying to engage students in the subject matter they teach. Some students avoid reading the textbooks required for their classes and may not complete the homework assigned. The look of disengaged students can be observed in many courses across all STEAM disciplines on most college campuses. The authors have noticed higher levels of engagement when students participate in class activities rather than passively listening to lectures. These activities may include games, discussions, role-play, peer reviews, and group problem solving or design exercises. Since the return from the Covid lockdown engineering programs have been pressured by student demands to offer project courses completely or partially online. At the authors' institution asynchronous online student sections are often merged with an in-person section of the same course taught by the same instructor.

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 students attending the in-person section of the same class. This can be challenging for instructors teaching project courses which emphasize the use of active learning techniques and project-based learning. Activities developed for the face-to-face delivery of software engineering topics often need modification to accommodate online students. For example, an online student may need to complete a single person version of an activity completed by in-person groups or they may need to contribute asynchronously to the development of a group artifact online.

Students learning software engineering principles and practices may find it difficult to apply them in the development of complex software projects. Software engineering involves acquiring application domain knowledge to understand the client's needs. It is therefore important to do more than simply use a game as the term project in a software engineering course as some authors have suggested [1], [2], [3].

The authors believe that the capstone design course should not be the only opportunity for students to manage complex software development projects. This suggests the use of other courses in the curriculum such as a game design or artificial intelligence courses as a means of providing additional software engineering project experience. This paper describes the authors' approach to teaching two hybrid software project courses which make use of flipped classroom models that rely on active learning and the use of authentic assessment practices (e.g., reflective writing and peer assessment).

Active Learning

Engineering educators regard experiential learning as the best way to train the next generation of engineers [4]. It is reasonable to believe that the soft skills practiced in active learning classrooms can improve the capabilities software engineering students and better prepare them for their capstone projects [5]. 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" [6]. Prince defines active learning as any classroom activity that requires students to do something other than listen and take notes [7]. Active learning opportunities can complement or replace lectures to make class participation more interesting to students. Active learning using a flipped classroom approach can also foster developing an attitude of life-long learning among students [8].

Active learning helps students develop problem-solving, critical reasoning [9], and analytical skills, all of which are valuable tools that prepare students to make better decisions, become better students, and better employees [7]. Raju and Sankar undertook a study to develop teaching methodologies that could bring real-world issues into engineering classrooms [10]. 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 educational process [11], [12]. The group work that often accompanies active learning instruction helps students develop their soft skills [13]. Some instructors believe that the project activities inherent in real-world software development encourage students to improve their written and oral communication skills [14].

Day and Foley used class time exclusively for exercises by having their students prepare themselves through the study of materials provided online [15]. Research suggests that the success of flipped classroom approaches depends on the nature of the course being taught. The investment in time required for instructors to develop quality out-of-class materials and in-class active learning experiences can be substantial [16]. The instructor time commitment becomes greater if both in-person and online students are in the same course.

The investigators chose to make use of a flipped classroom approach for the project courses discussed in this paper. Students viewed short video lectures and completed any textbook readings before beginning the class activities.

Online Student Success

Why is there a perception that online students are not as successful as students taking the same class in-person? Glazier [17] discusses three possibilities: student characteristics, environmental factors, and instructor characteristics. Online classes can be challenging for students looking for an easy class. Some studies suggest that self-motivated independent learners may do better in online classes. Students with previous success taking online classes may have better study and time management skills. We surveyed the in-person and online students in our courses to determine if there were differences in their levels of motivation, sense of belonging, or growth mindset.

Environmental factors may impact online student success. Online students may be more likely to have work and family obligations that can disrupt their coursework. Many students take online classes hoping their flexibility in course delivery will help them deal with considerable time pressures in their life circumstances. Some of the causes of low success rates for online students can be mitigated by the instructor’s course design practices. The more frequently online students participate in class activities the more likely they are to complete the course. Instructors who engage online students and make them gain a sense of belonging to a learning community help these students succeed in their courses. Of course, online students need reasonable institutional support services (e.g., mentoring and redundant communication) to be successful [17].

Student Engagement

Student engagement refers to the degree of interest and attention shown in course activities. Student engagement can be a predictor for course completion and retention rates [18]. Active learning techniques such as think-pair-share exercises [19], pair programming [20], peer instruction [21], and flipped classrooms [22] have been demonstrated to increase student engagement [11]. Many of these interventions are used for introductory level instruction, primarily to address broadening participation in large classes [23].

In software engineering courses, the use of real-world, community-based projects may be an effective way to engage students with meaningful problem solving while teaching them software engineering concepts [24]. Students often become more invested in their projects when they see that their products are more than simply paper designs. We made sure that the daily course activities help students practice skills they need to complete the larger team projects. We surveyed online and in-person students to see if there were differences in their perceived levels of engagement with the course materials.

Project-based Learning

Problem-based learning or project-based learning (PBL) has consistently demonstrated it can lead to positive learning outcomes such as self-directed learning habits, critical thinking skills, and deep disciplinary knowledge while engaging students in collaborative, authentic learning situations [25]. While PBL was first incorporated into medical school curricula in 1969, it is currently used in a wide variety of courses [26]. 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 [27].

PBL has been used in senior level engineering courses with the same positive results [28], [29], [30]. Although students in one 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 contrasted with students taught using a traditional lecture and project approach to the course who viewed completing a traditional course project more negatively [31]. Each of our project courses contains a significant group project that requires several weeks to complete.

Assessment Using Peers

Use of peer review, peer evaluation, and peer instruction can be helpful in engaging students with each other in hybrid (online or in-person) project courses. Peer review is the act of having classmates read what other students have created and responding to them in terms of its effectiveness. The reviewer finds the strengths and weaknesses of the draft deliverable and suggests strategies to improve the work product [17]. Having students peer review student presentations (either live or recorded) is one way to help keep them engaged with the course delivery. Peer reviews can be used to supply feedback on draft documents or project prototypes prior to their final submission for grading by the instructor.

Peer instruction engages students during class through activities that require each student to apply the core concepts being presented, and then to explain those concepts to other students. Ideally, a class taught using peer instruction can be divided into a series of short presentations followed by asking a related question which probes the understanding of the ideas just presented [32]. Online class members can deliver (or view) lessons uploaded as videos or use interactive zoom presentations.

Peer evaluation is a collaborative learning strategy that asks students to reflect on contributions made by colleagues on group work. Peer evaluation encourages students to critically examine the work of peers and reflect on the quality of the work. It often involves the use of a detailed rubric or checklist as a guide [17]. Peer evaluation is an important strategy to keep student team members honest about their contributions to team deliverables. Students on project teams in our courses evaluate the contributions made by each team member when submitting a milestone document or a software prototype.

Authentic Assessment

It is difficult to use traditional paper or digital tests in hybrid classes containing both in-person and online students. Authentic assessment is one way to assess students without relying on closed book tests. Use of authentic assessment involves having students solve real-world problems which have ambiguous answers. Real-world problems are often complex and require actionable solutions from students. Authentic assessment requires elevated levels of student engagement as students evaluate their own performance.

When devising an authentic assessment strategy. start with your course objectives and make sure that you have set clear measurable objectives in your syllabus. Decide what you want to evaluate and how you want to evaluate it. The trick is making sure the “how” matches the “what.” This means ensuring your instructional activities support your assessment techniques [33].

In classes that emphasize project-based learning, student activities involve group projects of all sizes and durations. In engineering, reports (both written and oral) and prototypes are the most common work products. It makes sense to have students develop progress report memos, lab reports, posters, and reflection pieces describing their lessons learned following textbook readings and learning activities [34]. These assessment activities should be short, frequent, and low stakes graded work products the students complete every few class periods.

Reflective Writing

Research on student learning shows many benefits to the use of reflective writing in clinical or professional experiences. This suggests its use as an authentic assessment technique. Students asked to reflect on their learning experiences are better able to retain and transfer their learning to new contexts. The act of reflecting requires retrieval, elaboration, and generation of information can make learning more durable for students [35].

Promoting reflective thinking is important to helping learners develop strategies to apply added information to unpredictable situations in real life. Knowledge is created through the transformation of experience. Reflective writing could be one method for promoting reflective thinking that allows learners to consider their experiences and transform them into knowledge that can be applied in new contexts. Reflective writing is an effective method for promoting metacognitive thinking. Reflective writing can be a useful tool for communication between students and mentors in experiential learning activities [36].

Reflection might be thought of as a cycle of thinking and doing. When learners engage in reflection their implicit knowledge is digested through active interpretation, questioning and exploration. In computer programming classes, novice programmers should focus less on the correctness of their solutions and more on developing their skills of reflecting on the process used to develop them. This can help students improve their abilities to solve new and unseen problems. As learners improve their reflection skills, they may become more effective lifelong learners [37].

Reflection provides opportunities for students to think about their performance, consider which strategies were effective, and contemplate how to improve their process. In work contexts, individuals who engage in reflection have lower error rates when learning new skills [38]. In asynchronous on-line courses, student reflective activities are important since students and instructors do not have opportunities for face to face communication. If gathered over a period time, student writings can guide instructors in refreshing course content. If reflections are collected over the course delivery, students can use them to monitor their own progress. In face to face classes, reflective writing can be used to initiate in-class discussions in small group activities [39]

In active learning, students working in small groups or by themselves, are required to summarize the lessons learned from each hands-on assignment. If students are assigned to read a textbook before coming to class, it may be helpful to have them summarize their reactions to the reading in writing. Writing critiques of student presentations in-class also encourages the development of critical thinking, which is a valuable life-long learning skill. It can be time consuming for instructors to grade large numbers of reflection documents, so this effort can be reduced by making use of peer evaluation strategies or allowing the submission of group reflection documents.

Gamification

Gamified learning or the gamification of learning has been defined as the use of game design elements in non-game settings to increase motivation and attention on tasks [40], [41]. Using flipped course delivery (in the authors' experiences) may lead to issues with group-participation and motivation if students do not feel the need to work outside of class. Adding gamification elements to courses assessments can help mitigate this problem. A well-designed game can also motivate players to stay engaged by enhancing the value of the task or tasks being completed [42].

According to Gee [43], games can promote collaboration and skill building, if players are required to share knowledge and skills to be successful. Games that reward teamwork can have a positive impact on the development of prosocial skills [44]. Gee contends that well designed games are motivational specifically because of the different learning principles outlined previously [43]. Working to the limits of their abilities keeps players engaged as they continue to take on new challenges [45]. Gee refers to this process as a cycle of expertise, which requires players to constantly learn, act, revise and learn again to demonstrate proficiency and be successful in a game [46].

Gamification was used to allow students to select the project activities that matched their strengths and interests. We did not make use of badging or leader board in the software engineering course. We created a badging system in the game design course. We require all students to do some of the programming on software projects (they cannot just write documents or create game art).

Instructional Delivery

One of the authors teaches an undergraduate software engineering course CIS 375 and a course in game design CIS 487. These courses are offered in-person on campus and merged with an online section that allows enrolled students to complete the course requirements asynchronously online. We determined that a PBL (project-based learning) approach was well suited for the delivery of junior level software project courses. We use the class activities to motivate students to design software products and use software engineering techniques to solve real-world programming problems. The investigators included small group activities with the expectation that students would provide written or oral summaries (either live in-person or virtually using video) of the strategies used to complete their tasks and their lessons learned. Online students need to complete group work asynchronously. We require both groups of students to reflect on the lessons learned from design exercises either in writing or orally. We shifted to authentic assessment techniques to allow the use of more frequent, lower stakes graded activities in both courses.

Course Overview: CIS 375 Software Engineering 1

The junior level software engineering course, CIS 375 (Software Engineering 1), offered by the Computer and Information Science (CIS) department is organized as a fifteen week, four credit-hour course, meeting two days a week. The in-person meetings are recorded and made available for viewing after the class meetings end. Students in both sections had access to prerecorded video lectures. Students are allowed to enroll in the asynchronous section of CIS 375 and complete the course activities by themselves at home. For most online students, viewing the video lectures and reading the textbook were their primary sources of instruction. A week-by-week listing of the topics and activities appears in an earlier paper [47].

Prior to attending class meetings, the in-person students were expected to read the sections of the required course textbook [48] and view two 20-minute video lectures created as part of the weekly course module. The online students were expected to do the same. The activities in CIS 375 are often small group software design, project management, or problem-solving activities. Online students were asked to complete similar activities at home by themselves.

Course Overview: CIS 487 Computer Game Design I

The purpose of CIS 487 (Game Design and Implementation 1) is to introduce students to the technology, science, and art involved in the creation of computer games. The course meets once a week for three hours over a fifteen-week semester. This course uses small group activities to teach game design principles. A week-by-week listing of the topics and activities appears in an earlier paper [49].

The activities in CIS 487 are often small group game design or problem-solving activities. Online students were asked to complete similar activities at home by themselves. Students were asked to write reflections on the weekly activities. Students view Unity 2D and 3D game engine video tutorials outside of class. Both in-person and online students participate in peer review of work products produced by other students or teams. The creators of the works being reviewed classified the reviews as meaningful or not useful. All students participated in the peer evaluation of the final 2D and 3D game products. A gamification and badging system were introduced in the CIS 487 course [49].

Use of Teams in Hybrid Classes

Two big questions that need to be answered when assigning group project work in hybrid courses are: 1) how to involve online students in project work and 2) how to assess the contributions of individual team members to the final project deliverables. There are several factors that affect how these questions may be answered: 1) project origin, 2) appropriate team sizes, 3) team formation strategies, 4) progress tracking, 5) presentation of deliverables, and 6) some type of reflection opportunity.

We believe that allowing students to select their own projects and have some control over selecting the members of their team helps to give them a sense of ownership over their project. In some classes, students propose project ideas, and the class votes on which projects to develop. The winning proposal author manages the recruitment process to staff their project teams. For in-person classes the classroom can be organized like a job fair. This allows students to complete their project teams quickly. For hybrid classes, Google sheets and email need to be used to help students select projects and team members, especially since each team needs to contain both in-person and online students. To make this process work a little easier when online students are involved, the instructor might have students complete a Google sheet where each students lists their skills and project interests.

Our experiences suggest that for team projects lasting more than six weeks it is important to include regular checkpoints to ensure students are progressing in ways that will allow on time completion of their project. Students are asked to create a list containing the features and milestones needed to complete their project. Agile developers call this list the project backlog. Students are asked to share the updates to their backlog list every two weeks along with a Gannt chart showing tasks assigned to each team member as they work to reduce the size of the backlog each week. It is important to provide team members with ways to hold each other accountable if people fail to complete their assigned tasks. Peer review and peer evaluation may be helpful ways to hold team members accountable.

Peer reviews can be used to supply feedback on draft documents or project prototypes prior to their final submission for grading by the instructor. It has been our experience that students need to be taught how to provide feedback and that they will get better over time if rewarded for supplying meaningful feedback to content creators. We have occasionally had the document author’s (team or individual) send the names of their useful reviewers to the instructor. We typically award students two points for each useful review and one point for each ordinary review.

Peer evaluation is an important strategy to keep student team members honest about their contributions to team deliverables. It can be a simple system like having each student team member upload a document with anonymous ratings (0 = nothing and 5 = great) for each team member. Students can be asked to rate their own level of participation and their teammates. It might be good to supply a list of each team member's contributions to the team deliverable. The participation scores can be averaged for each person. Team members with low participation scores can be given reduced grades on the team project. For projects which include the delivery of a running software product I have the team meet and complete a set of timecards that document tasks completed by each team member and the time spent on each.

Oral presentations of work products (both group and individual) are frequent in our in-person classes. Online students need to submit videos of their presentations. To ensure that they get meaningful feedback on their presentations class members are assigned the task of providing peer feedback on other students' submissions.

Gamification can be used as a means of promoting rewards for completing tasks. Students can be rewarded for compliance to software process steps and for taking the initiative to improve their "soft skills." On diverse teams it is important to recognize the contributions of each team member. Allowing students to negotiate the nature of their activities (artist, author, designer, tester, programmer) and knowing the rewards up front often goes a long way to ensuring that all students are engaged for the entire semester [40].

In asynchronous on-line courses, student reflective activities are important since students and instructors do not have opportunities for face to face communication. If gathered over a period time, the student answers can guide instructors in refreshing course content. If reflections are collected over the course delivery, students can use them to monitor their own progress. In face to face classes, reflective writing can be used to initiate in-class discussions in small group activities.

Reflective writing can take many forms: lab notebooks, project change logs, minute papers, or project postmortems. We might simply ask our students to answer three questions when they reflect on their work after completing a project milestone (document or prototype): What went right? What went wrong? What lessons learned or process improvements are suggested? Students need to be told that reflection involves more than simply reporting what happened. The lessons learned type questions attempt encourage students to think critically about what they experienced.

Assessment

The authors created three research questions to compare the students taking CIS 375 or CIS 487 under the in-person face-to-face (FF) delivery of active learning materials to students taking the same courses under asynchronous online (AO) delivery.

RQ1: Do students choosing a particular delivery mode (in-person or online) of CIS 375 or CIS 487 differ in the characteristics: intrinsic motivation, sense of belonging, growth mindset?

RQ2: Does the delivery mode (in-person or online) affect student performance in taking either CIS 375 or CIS 487?

RQ3: Does the delivery mode (in-person or online) affect student performance in taking either CIS 375 or CIS 487?

RQ1 focuses on differences in student characteristics on entering the course. RQ2 examines differences in student performance based on course analytics. RQ3 examines differences in student perceptions of engagement at the end of the course.

Each of the course assignments was evaluated using Canvas rubrics designed by the instructor for each type of submission. Currently, these rubrics contain two to ten criteria, each scored from 0 to 5. Table 1 shows the rubric used to evaluate the active learning assignments. Specialized rubrics were created for the team project assignments.

Table 1: Activity Question Rubric

Topic	**Rating and Feedback** **(0 = Missing, 4 = Satisfactory, 5 = Exceeds Specification)**
Quality of Answers	
Completeness of Write-up	

No statistical comparison of student performance on the individual assignments was made between students in the in-person section and the asynchronous online sections of either CIS 375 or CIS 487 in Fall 2023. However, informal comparisons of student data from the two modes of classes delivered by the instructor in Fall 2023, suggest that students attending the in-person class meetings produced work which received higher scores using similar grading rubrics.

RQ1: Do students choosing a particular delivery mode (in-person or online) of CIS 375 or CIS 487 differ in the characteristics: intrinsic motivation, sense of belonging, growth mindset?

To answer this question, the authors surveyed the students at the beginning of each course using three scales: intrinsic motivation [50], belonging [51], and growth mindset [52]. These scales were used to create the 19 statement questionnaire shown in Table 2. Student indicated the level of agreement by selecting a response from a Likert scale with 5 points (strongly disagree to strongly agree) Genter, et. al. [53].

The Intrinsic Motivation Inventory [50] is an instrument that assesses participants' intrinsic motivation based on six subscale scores related to performing an activity: Interest/

Enjoyment, Perceived Competence, Effort/Importance, Pressure/Tension, Perceived Choice, and Value/Usefulness. These are reflected in Table 2 statements 1 through 12. Mann-Whitney U tests revealed no significant differences between FF and AO students in either CIS 375 or CIS 487.

Table 2: Questionnaire

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. I think this class is going to be boring.					
2. I think class is going to be enjoyable.					
3. I think that I am going to be pretty good at this class.					
4. This is a class that I cannot do very well in.					
5. I plan to put a lot of effort into this class.					
6. It is important to me to do well in this class.					
7. I am anxious about this class.					
8. I feel very relaxed about this class.					
9. I feel like it is not my own choice to do this class					
10. I feel like I am taking this class because I have to.					
11. I believe this class could be of some value to me.					
12. I believe doing this class is important.					
13. My teachers see me as a computer scientist.					
14. My friends/classmates see me as a computer scientist					
15. My family sees me as a computer scientist.					
16. I see myself as a computer scientist.					
17. You can learn new things, but you can’t really change your basic math ability					
18. Your math ability is something that you can’t change very much.”					
19. You have a certain amount of math ability, and you can’t really do much to change it					

The sense of belonging to a person's college major is a feeling of membership and acceptance. [51]. Students respond to survey statements 13 to 16. Mann-Whitney U tests revealed no significant differences between FF and AO students in either CIS 375 or CIS 487.

The Growth Mindset Scale [52] assesses student's mindset by asking students to react statements 17 to 19 using a point from the Likert scale. Mann-Whitney U tests revealed no significant differences between FF and AO students in either CIS 375 or CIS 487.

The authors conclude that differences in motivation, belonging, or mindset may not be the primary reason for choosing an in-person or online section of a course. Other researchers have suggested other factors (e.g., flexible scheduling of class activities) may be more important,

RQ2: Does the delivery mode (in-person or online) affect student performance in taking either CIS 375 or CIS 487?

To answer this question, the authors looked at data analytics (number of late and missing assignments) collected by the Canvas management system for the two instructional delivery modes (FF and AO) for each course as shown in Table 3 and Table 4.

Table 3: Canvas Data - Based on CIS 375 Section Enrollment

	Fall 2023 In-person - FF (N = 35)	**Fall 2023 Online - AO (N = 12)**
Average Overall Course Grade	97.1%	96.9%
Average Number of Late Assignments Per Student	2.34	3.83
Average Number of Missing Lab Assignments Per Student	0.86	1.41

In Table 3 for CIS 375, students in the in-class instruction sections (FF) had slightly better overall grades (97.1% vs. 96.9% respectively) than students in the asynchronous online section of the course. The in-person students had a slightly lower average number of missing (0.86 vs. 1.41) and late assignments (2.34 vs. 3.83) than their peers in the asynchronous sections. Yet, one-tail Student t-tests comparing the FF and OA students revealed that there were no significant differences between these groups at the 95% confidence level for any of these metrics.

In Table 4, students in the in-person section (FF) of CIS 487 performed remarkably better overall than students in the online section (AO) with an average overall grade of 95.6% vs. 82.2%, respectively. Students in the in-person section (FF) also had far fewer missing (0.39 vs. 1.06) and late assignments (0.19 vs. 0.69) on average than online students (AO). The average course average grade. number of missing assignments per student, and number late assignments per student were found to be statistically different at the 95% confidence level using a one tail Student t-test.

Table 4: Canvas Data - Based on CIS 487 Section Enrollment

	Fall 2023 In-person - FF (N = 31)	**Fall 2023 Online - AO (N = 16)**
Average Overall Course Grade	91.6%	82.2%
Average Number of Late Assignments Per Student	0.39	1.06
Average Number of Missing Assignments Per Student	0.19	0.69

We attribute the statistical difference of missing assignments to student engagement with the course as student feedback revealed that the online students tended to feel disconnected from their in-person peers who used class time to make team decisions and work on assignments together which provided motivation for work on the material. The differences in course grades may be the result of three students receiving unusually low grades on the team project because they failed to contribute to the team 3D prototypes,

In both CIS 375 and CIS 487 the student sections (FF and AO) worked independently of each other with the students in-person completing the class assignments in-class or at least discussing them heavily before submission together while the online students worked independently and submitted their work without much or any interaction with their peers. We noted that this impacted student perceptions of their engagement with the course material, particularly for CIS 487. The term projects in both CIS 375 and CIS 487 were completed by teams made of mixtures of in-person and online students.

Course Surveys

We surveyed the students during the final weeks of each semester, to gather the students' perceptions of their levels of engagement with the class, active learning, and gamification. Both surveys CIS 375 and CIS 487 emphasized active learning and personal engagement.

RQ3: Do does course delivery mode (FF or AO) affect student perceptions of engagement as reported on final surveys taken in CIS 375 or CIS 487?

The students in all sections were asked a series of online questions designed by the authors to elicit candid responses. Students rated each statement on their perceptions of active learning and their engagement in the survey. The survey was conducted separately from the regular student course evaluations and was completed before the final course grade postings.

The Mann-Whitney U test was used to compare in-person student responses (FF = in-person Face-to-Face) to online student responses (AO = Asynchronous Online) on the student surveys in each course. The CIS 375 survey data are summarized in Table 5. No question showed significant statistical differences between the FF and AO student responses at the 95% confidence level.

Table 5: CIS 375 Final Survey Student Perceptions of Engagement for Fall 2023 FF (N = 33) vs. AO (N = 11)

Survey Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Course
1. **There were opportunities for me to actively engage in learning**	0 0	1 (3%) 0	2 (6%) 2 (18%)	8 (24%) 3 (27%)	22 (75%) 6 (54%)	FF AO
2. **Course activities were useful way to learn**	0 0	0 0	7 (21%) 3 (27%)	8 (24%) 3 (27%)	18 (54%) 5 (45%)	FF AO
3. **Course activities let me apply what I learned**	0 0	1 (3%) 1 (9%)	4 (12%) 1 (33%)	8 (24%) 3 (27%)	20 (60%) 6 (54%)	FF AO
4. **Course is an example of active learning**	0 0	0 1 (9%)	3 (9%) 2 (18%)	10 (30%) 2 (18%)	20 (60%) 6 (54%)	FF AO
5. I Felt more engaged during the activities than during video lectures	0 0	0 1 (9%)	3 (9%) 3 (27%)	3 (9%) 3 (27%)	22 (66%) 4 (37%)	FF AO

The distribution of response to each question for CIS 487 is seen in Table 6. We performed a statistical analysis of the responses using the Mann-Whitney U Test. No question showed statistical differences between the responses at the 95% confidence level.

From this we conclude that the AO modality was at least no worse than the FF modality for student perceptions of engagement in either course. Of significance was that only in CIS 487 only 12 of the online students completed the survey which could be skewing the results to only those students that were engaged in the online section of the course.

Table 6: CIS 487 Final Survey Student Perceptions of Engagement for Fall 2023 FF (N = 19) vs. AO (N = 12)

Survey Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Course
1. There were opportunities for me to actively engage in learning	0	0	1 (5%)	3 (16%)	15 (79%)	FF
	0	0	0	2 (17%)	10 (83%)	AO
2. Course activities were useful way to learn	0	2 (11%)	0	5 (26%)	12 (63%)	FF
	0	0	0	7 (58%)	5 (42%)	AO
3. Course activities let me apply what I learned	0	1 (5%)	0	6 (32%)	12 (63%)	FF
	0	0	0	7 (58%)	5 (42%)	AO
4. Course is an example of active learning	0	0	1 (5%)	5 (26%)	13 (68%)	FF
	0	0	1 (8%)	2 (17%)	9 (75%)	AO
5. I Felt more engaged during the activities than during video lectures	0	0	0	5 (26%)	14 (74%)	FF
	0	0	3 (25%)	3 (25%)	6 (50%)	AO

Threats to Validity

We recognize that one of the limitations of this study was that we did not have a control group. We acknowledge that the instructor teaching all the course offerings may account for the lack of significant differences on the evaluation measures in CIS 375. Three students of the 16 AO students in CIS 487 stopped turning in any work during the last 4 weeks of the semester. This may be the reason for the significant differences between the evaluation measures for the FF and AO students in CIS 487. Two of these three students did not participate in the final survey either in CIS 487.

The pairing of an asynchronous, distance learning section with a face-to-face section of the same course did not guarantee students experienced the same educational experience, The live class sessions were captured, verbatim, for later viewing by the asynchronous students. This allowed AO students the opportunity to witness the live lecture and class activities as a virtual classroom observer. It is not clear how often AO students viewed the lecture capture videos. AO students were not allowed to attend FF sessions in 2023. It is possible the asynchronous students experienced more uncertainty when attempting to complete the activities alone.

One area of uncertainty when measuring the student responses is the unknown amount of interaction between students in the two sections in the same course. Students in the CIS department know each other from other classes that they have taken together. A few students took both CIS 375 and CIS 487 in Fall 2023. Even though a student registered in the asynchronous online section was not allowed to attend any in-person class meetings, it is quite possible that a friend from an in-person course section may have shared their course experiences with them giving them additional insight into group activities completed in the classroom.

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 for in-person students. We could not include direct observation of students in the A0 sections, the average number of late and missing assignments is the best we could do.

Conclusions and Future Direction

In this paper we demonstrated that it is possible to offer software project courses to online students without significant loss of student satisfaction or perceptions of engagement. We take this as evidence that it is possible to manage a hybrid software project course and keep most online students engaged. We credit the active learning components of the classes and the levels of student interaction that accompany them for making this possible.

The active learning components of the course, the hybrid project teams, and peer evaluation work also should be credited with the success of the project work. We encourage instructors to develop authentic assessment practices and modify them as needed to manage their hybrid course deliveries to achieve higher levels of student satisfaction and engagement.

It may be important to continue developing ways in which asynchronous students are encouraged to be a part of more experiences with face-to-face students outside formal class meetings. We will continue to search for additional formative assessment techniques that will help to catch slackers earlier. The current plan is to make use of the revised modules in Fall 2024 offerings of CIS 375 and CIS 487 which will be offered as hybrid (FF and AO) courses. We are continuing to develop tools to provide scaffolding assistance for student activities for both FF and AO students.

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Bibliography

[1] K. Becker, "Teaching with games: the minesweeper and asteroids experience," *Journal of Computing Sciences in Colleges* 17 2 (December 2001), 23-33.

[2] R. Jones, Design and implementation of a computer games: a capstone course for undergraduate computer science education. In *Proceedings of 31st SIGCSE Technical Symposium* (Austin, TX, March 2000), ACM Press, New York, NY, 2000, 260-264.

[3] G. Pleva, "Game programming and the myth of child's play," *Journal of Computing Sciences in Colleges* 20 2 (December 2004), 125-136.

[4] L. Samavedham, and K. Ragupathi, "Facilitating 21st century skills in engineering students," *The Journal of Engineering Education*, Vol. XXVI No. 1, 2012, pp.38-49.

[5] B.R. Maxim, S. Acharya, S. Brunvand, and M. Kessentini, "WIP: Introducing active learning in a software engineering course," *Proceedings of the 2017 Annual Meeting of the American Society for Engineering Education*, Columbus, OH, June 2017, pp.1-12.

[6] Promoting Active Learning https://utah.instructure.com/courses/148446/pages/active-learning, [Accessed February 25, 2016].

[7] M. Prince, "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education*, Vol. 93, 2004, pp. 223-231.

[8] S. Luster-Teasley, S.C. Hargrove-Leak, and C. Waters, "NSF TUES: Transforming undergraduate environmental engineering laboratories for sustainable engineering using the case studies in the sciences instructional method" *Proceedings of the 2014 Annual Meeting of the American Society for Engineering Education, Indianapolis, IN, June 2014*, 10.18260/1-2–22873.

[9] V., Jungic, H. Kaur, J. Mulholland, and C. Xin, "On flipping the classroom in large first-year calculus courses," *International Journal of Mathematical Education in Science and Technology*, 46(4), 1–8, 2015.

[10] P.K. Raju, and C.C. Sanker, "Teaching real-world issues through case studies," *Journal of Engineering Education*. Vol. 88 No 4 pp501-508, 2018.

[11] K.M. Nickels, "Do's and don'ts of introducing active learning techniques," *Proceedings of the 2000 Annual Meeting of the American Society for Engineering Education*, St. Louis, Missouri, June 2000.

[12] J.P. Lavelle, M.T. Stimpson, and E.D. Brill, "Flipped out engineering economy: Converting a traditional class to an inverted model," In A. Krishnamurthy & W. K. V. Chan (Eds.), *Proceedings of the 2013 Industrial Systems Engineering Research Conference* pp. 397–407

[13] K. Yelamarthi, S. Member, and E. Drake, "A flipped first-year digital circuits course for engineering and technology students," *IEEE Transactions on Education*, 58(3), 179–186, 2015.

[14] M. Ardis, S. Chenoweth, and F. Young, "The 'Soft' Topics in Software Engineering Education," *Proceedings of 38th Annual Frontiers in Education Conference (Vol. 1, Oct 2008)*, IEEE Press, Saratoga Springs, NY, 2008, pp. F3H1-F3H6.

[15] J.A. Day and J.D. Foley, "Evaluating a Web Lecture Intervention in a Human-Computer Interaction Course," *IEEE Transactions on Education* 49(4):420-431, 2006.

[16] G.R. Morrison, S.M Ross, J.E. Kemp, and H. Kalman, Designing *effective instruction*. John Wiley & Sons, 2010.

[17] The Center for Advancing Teaching & Learning (CATL) at the University of Wisconsin-La Crosse, "Peer Evaluation and Peer Review" https://www.uwlax.edu/catl/guides/teaching-improvement-guide/how-can-i-improve/peer-evaluation/ [Accessed May 23, 2023].

[18] P.C. Schlechty, *Engaging Students: The Next Level of Working on Work*, Wiley and Sons, 2011.

[19] R. Kothiyal, Majumdar, S. Murthy, and S. Iyer, "Effect of think-pair-share in a large CS1 class: 83% sustained engagement," *Proceedings of the ninth annual international ACM conference on international computing education research (ICER '13)*. ACM, New York, NY, USA, 2013, pp. 137-144.

[20] M. Nagappan; L. Williams, M. Ferzli, E. Wiebe, K. Yang, C. Miller, and S. Balik, "Improving the CS1 experience with pair programming," *Proceedings of the 34th SIGCSE technical symposium on Computer science education (SIGCSE '03). ACM, New York, NY, USA, 2003*, pp. 359-362.

[21] L. Porter, D. Bouvier, Q. Cutts, S. Grissom, C. Lee, R. McCartney, D. Zingaro, and B. Simon, "A multi-institutional study of peer instruction in introductory computing," *Proceedings of the 47th ACM Technical Symposium on Computing Science Education (SIGCSE '16). ACM, New York, NY, USA*, 2016, pp. 358-363.

[22] T. Greer, Q. Hao, M. Jing, and B. Barnes, "On the effects of active learning environments in computing education," *Proceedings of the 50th ACM Technical Symposium on Computer Science Education (SIGCSE '19), February 27-March 2, 2019, Minneapolis, MN, USA. ACM, New York, NY, USA*, 6 pages.

[23] B. Hoffman, R. Morelli, and J. Rosato, "Student engagement is key to broadening participation in CS," *Proceedings of the 50th ACM Technical Symposium on Computer Science Education (SIGCSE '19), February 27-March 2, 2019, Minneapolis, MN, USA. ACM, New York, NY, USA*, 7 pages.

[24] J.A. Stone and E. Madigan, "Experiences with community-based projects for computing majors," *Journal of Computer. Science in the Colleges*, Vol. 26, No.6, June 2011, pp.64-70.

[25] J. Savery and T. Duffy, "Problem-based learning: An instructional model and its constructivist framework," *Educational Technology*, Vol. 35, No. 5, 1995, pp.31-38.

[26] A. Silva, .A. Bispo, D. Rodriguez, and F. Vasquez, "Problem-based learning: A proposal for structuring PBL and its implications for learning among students in an undergraduate management degree program", *Revista de Gestão*, Vol. 25, No. 2, 2018, pp. 160-177.
[27] J.N. Warnock and M.J. Mohammadi-Aragh, “Case study: use of problem-based learning to develop students' technical and professional skills,” *European Journal of Engineering Education*, Vol. 41, No, 2, 2016, pp.142-153,
[28] J. Dunlap, “Problem-based learning and self-efficacy: How a capstone course prepares students for a profession,” *Education Technology Research and Development* Vol. 53, No.1, 2005, pp. 65–83.
[29] R. Urbanic, “Developing design and management skills for senior industrial engineering students,” *Journal of Learning Design*, Vol. 4, No. 3, 2011, pp. 35–49.
[30] K. Gavin, “Case study of a project-based learning course in civil engineering design,” *European Journal of Engineering Education* Vol., 36, No. 6, 2011, pp. 547–558.
[31] M. Souza, et. al. “Students perception on the use of project-based learning in software engineering education,” *SBES 2019: Proceedings of the XXXIII Brazilian Symposium on Software Engineering*, 2019, pp. 537–546.
[32] C. Crouch & E. Mazur “Peer instruction: Ten years of experience and results.” American journal of physics, 69(9), 2001, pp. 970-977.
[33] “Measuring Student Learning,” Center for Teaching Innovation, Cornell University, https://teaching.cornell.edu/teaching-resources/assessment-evaluation/measuring-student-learning [Accessed July 21, 2023].
[34] “Alternative to Traditional Testing”, Center for Teaching & Learning, University of California Berkley, https://teaching.berkeley.edu/resources/course-design-guide/design-effective-assessments/alternatives-traditional-testing [Accessed July 21, 2023].
[35] Writing Across the Curriculum, “”Using Reflective Writing to Deepen Student Learning”, *The WAC Clearinghouse*, University of Minnesota, https://wac.umn.edu/tww-program/teaching-resources/using-reflective-writing (accessed September 3, 2023)
[36] C. Kingkaew, T. Theeramunkong, T. Supnithi, P. Chatpreecha, K. Morita, K. Tanaka, ans M. Ikeda. “A Learning Environment to Promote Awareness of the Experiential Learning Processes with Reflective Writing Support.” *Education Sciences*. 2023; 13(1):64. https://doi.org/10.3390/educsci13010064 (accessed September 4, 2023)
[37] Villareale, J., F. Biemer, C., Seif El-Nasr, M., & Zhu, J. “Reflection in game-based learning: A survey of programming games.” In *Proceedings of the 15th International Conference on the Foundations of Digital Games*, 2020, pp. 1-9.
[38] V. Clinton, “Reflections versus Extended Quizzes: Which is Better for Student Learning and Self-Regulation?” Journal of the Scholarship of Teaching and Learning, 18(1), 2018, pp. 1-10. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/22508 (accessed September 3, 2023)
[39] N. Ragonis and O. Hazzan, “Reflection Pre-learning in Computer Science Courses,” *Communications of the ACM BLOG@ACM*, January 2022. https://cacm.acm.org/blogs/blog-cacm/258361-reflection-pre-learning-in-computer-science-courses/fulltext, (accessed September 4, 2023).
[40] J. Domínguez Saenz-de-Navarrete, L. de-Marcos, L. Fernández-Sanz, C.A, Pagés, and J.J. Martínez-Herráiz, “Gamifying learning experiences: Practical implications and \outcomes,” *Computers & Education*, 380–392
[41] J. Simões, R.D. Redondo, and A.F, Vilas, “A social gamification framework for a K-6 learning platform,” *Computers in Human Behavior*, 29, 2012, pp. 345–353.
[42] Y.T.C. Yang, “Building virtual cities, inspiring intelligent citizens: Digital games for developing students’ problem solving and learning motivation.” *Computers and Education*, 59(2), 2012, pp. 365–377.
[43] J.P. Gee, “What Video Games Have to Teach Us About Learning and Literacy,” *Computers in Entertainment*, 1(1), October 2003, pp.1-4.
[44] I. Granic, A. Lobel, and R. Engels, “The benefits of playing video games,” *American Psychologist*, 69(1), 2014, pp. 66–78.
[45] M. Ott and M. Tavella, “A contribution to the understanding of what makes young students genuinely engaged in computer-based learning tasks,” *Procedia - Social and Behavioral Sciences*, 1(1), 2009, pp. 184–188.
[46] J.P. Gee, *What Video Games Have to Teach Us About Learning and Literacy*. Second Edition. St. Martin’s Press, 2014.
[47] B. R. Maxim; T. Limbaugh; and J. J. Yackley, “Socially Distant Active Learning and Student Engagement in Software Engineering Courses,” *Proceedings of the 2022 Annual Meeting of the American Society for Engineering Education*, Minneapolis, MN, June 2022, pp. 1-22.
[48] R.S. Pressman and B. R, Maxim, *Software Engineering: A Practitioner’s Approach*, McGraw-Hill, 2020.
[49] B. R. Maxim, and J. J. Yackley, “Using Active Learning and Gamification to Teach Software Engineering Courses in Game Design Courses.” *Proceedings of the 2023 Annual Meeting of the American Society for Engineering Education*,” Baltimore, MD, June 2023, pp. 1-21.
[50] E.L. Deci and R.M. Ryan. 2012. Self-determination theory. In *Handbook of theories of social psychology*, P.A.M. van Lange, A.W. Kruglanski, and E.T. Higgins (Eds.). Sage Publications Ltd., 416–436.
[51] J. Mahadeo, Z. Hazari, and G. Potvin. “Developing a computing identity framework.” *ACM transaction on Computing Education* 20, 1 (March 2020), pp. 1–14.
[52] C.S. Dweck. *Mindset: The new psychology of success*. New York: Random House, 2006.
[53] Y. Gertner, J. Alvarez, and B. Cosman, “Identifying Student Profiles Related to Success in Discrete Math CS Courses.” *Proceedings of the 2023 Annual Meeting of the American Society for Engineering Education*,” Baltimore, MD, June 2023, pp. 1-7.