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Using Active Learning and Gamification to Teach Software Engineering in Game Design Courses

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Abstract

The authors teach two courses focused on software engineering and game development. They critically examined lecture heavy versions of these courses for opportunities to introduce active learning materials in both the face-to-face delivery and online delivery of the courses. Using active learning techniques, the authors sought to improve the students' levels of engagement while teaching how to design, implement, and test 2D and 3D video games. The students learn to use agile software engineering practices, most notably Scrum and Kanban, to deliver incremental game prototypes in each course whereas the focus of the second course is a term-long roleplay where students play the roles of developer-owners of a failing game company. In-person and online students were surveyed to measure their perceived levels of engagement with course activities. Using these assessments the authors demonstrate that it is possible to move an in-person active learning course to online delivery without significant loss of student satisfaction or perceptions of engagement with the course material. Ultimately, credit belongs to the active learning components of the classes and the levels of student interaction that accompany them for making this transition possible despite the environmental changes.

Background

Engineering instructors often rely on the traditional lecture model where they cover a topic, with or without a slideshow, to a classroom of students. Students often fail to engage with the material presented by lecture until an assessment activity is near. 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. This paper describes the authors' approach to revising two lecture heavy game design courses to make use of a flipped classroom model that relies on active learning, role-play, and gamification to present software engineering topics in game design courses.

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]. Adding game topics to already crowded software engineering courses, as some authors have advised [3], [4], requires sacrificing important software engineering topics. Focusing on one application area in the first software engineering class is not fair to students as not every software engineering student wants to become a game developer.

Game developers are beginning to understand that it is important to treat computer game design in the same way that software engineers approach projects involving large numbers of people and a significant investment of time [5]. Game developers can benefit from using evolutionary software process models to manage their development risks and reduce their project completion times. The process of determining the technical requirements for a game software product is like that used to specify any other type of software product. However, unlike most software products, games have an entertainment dimension. People play computer games because games are fun [6].

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 course as a means of providing additional software engineering experiences. This paper describes the authors' experiences revising and employing active learning materials to teach software engineering content in a sequence of two game design courses offered in both face-to-face and asynchronous online modalities during the past four years.

Active Learning

Engineering educators regard experiential learning as the best way to train the next generation of engineers [7]. 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 [8]. 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" [9]. Prince defines active learning as any classroom activity that requires students to do something other than listen and take notes [10]. 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 [11].

Active learning helps students develop problem-solving, critical reasoning [12], and analytical skills, all of which are valuable tools that prepare students to make better decisions, become better students, and better employees [10]. Raju and Sankar undertook a study to develop teaching methodologies that could bring real-world issues into engineering classrooms [13]. 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 [14], [15]. Active learning techniques help students to better understand the topics covered in the curriculum [16]. Active learning also helps students to be more excited about the study of engineering than traditional instruction [17]. The group work that often accompanies active learning instruction helps students develop their soft skills [18] and makes students more willing to meet with instructors outside of class [19]. 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 [30]. Some instructors believe that the project activities inherent in real-world software development encourage students to improve their written and oral communication skills [21].

Day and Foley used class time exclusively for exercises by having their students prepare themselves through the study of materials provided online [22]. Bishop and Verleger presented a comprehensive survey of flipped classroom exercise implementations [23]. Wu et al. effectively implemented class exercises as active learning tools in their flipped classroom approach [24]. Research suggests that the success of flipped classroom approaches depends on the nature of the course being taught. Courses requiring interactive, hands-on experiences may make learning content before engaging in course activities overwhelming for some students [25]. The investment in time required for instructors to develop quality out-of-class materials and in-class active learning experiences can be substantial [26].

Problem-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 [27]. While PBL was first incorporated into medical school curricula in 1969, it is currently used in a wide variety of courses [28]. 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 [29].

PBL has been used in senior level engineering courses with the same positive results [30], [31], [32]. 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 [33].

Student Engagement

Active learning techniques such as think-pair-share exercises [34], pair programming [35], peer instruction [36], and flipped classrooms [37] have been demonstrated to increase student engagement [11]. Many of these interventions are used on introductory level instruction, primarily to address broadening participation in large classes [38]. Admittedly, lack of access to technology to create and access the videos needed to flip a classroom can pose challenges to both students and teachers [26].

Ham and Myers introduced Process Oriented Guided Inquiry Learning (POGIL) into a computer organization course [39]. In software engineering courses, the use of real-world, community-based projects may be an effective way to engage students with a meaningful problem while

teaching them software engineering concepts [40]. Students often become more invested in their projects when they see that their products are more than simply a paper design.
An important aspect of software engineering education is the development of soft skills such as communication and project management. There are several examples of courses that make use of project work to help students enhance their soft skills simultaneously with their software development skills [41]. Decker and Simkins [42] introduced the use of an extended role play approach in a game development process class where the students were not assessed solely on the artifacts they produced, but the processes by which they created their artifacts. Their role-play activities emphasize industry best practices for both technical and soft skills (project management, communication, marketing, and interdisciplinary design).

Role-play

Simkins [43] defines role-play as simulating the real world in environments where consequences can be mitigated safely. Role-play allows students to get hands-on practice with engineering concepts and practice the soft skills that make for successful professional engineers: communication, problem-solving, and analytical skills. We believe this makes role-play a critical tool in the active learning engineering classroom. Numerous researchers have investigated the use of role-play in the software engineering classroom with success.

Moroz-Lapin [44] and Seland [45] used role-play in human computer interaction courses to engage students with the requirement engineering process to better understand system behavior from the users' point of view. Similarly, Zowghi and Parvani [46] also investigated requirements engineering using role-play to have their students understand the process of requirements gathering from both the client and developer perspective. Role-play was used by Börstler [47] to teach students object-oriented programming concepts with class-responsibility-collaborator cards. Vold and Yayilgan [48] achieved greater student engagement with role-play in an information technology course. Further, we draw inspiration from a study that used the Second Life online virtual world as a platform for students to role-play a fictional company for enterprise resource planning [49]. Other online role-play simulations focus on students taking the role of project managers with students receiving immediate feedback on their decisions [50], [51], [52].

The course redesign described in this paper builds upon the work of Maxim, Brunvand, and Decker [57], which used role-play in a redesigned game design course, CIS 488, at the University of Michigan – Dearborn. We re-used this work with some modifications in the revision of the second course in our two-course game design sequence. This course beginning in 2017 had the students role-play as developers of a failing game company with the goal of simulating concept to release creation of 3D computer games using Unreal Engine 4. The failing game company backstory used to motivate the role-play in our course is discussed further in Decker and Simkins [42]. Decker and Simkins provide the framework we used to build and adapt our role-play modules. These modules emphasize industry best practices for the technical game development work and soft skills development as well as the introduction of business and legal concerns that arise during the role-play [54].

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 [55], [56]. Using active-learning in the authors' experience 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 active learning can help mitigate this problem.

James Gee [57] has identified thirty-six learning principles that are present in good games. These learning principles provide the backbone for good game design and, in turn, can be used as guiding principles when designing a gamified learning environment. Good games provide players with information when they need it and within the context in which the information will be used [58]. Effective game design includes challenging players, so they are routinely working at the edge of their abilities and knowledge, also known as their zone of proximal development [59]. Having students, or players, operate within this optimal learning zone helps keep them engaged and encourages them to learn more to meet the demands of the next challenge.

According to Gee [58], 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 [60]. Gee contends that well designed games are motivational specifically because of the different learning principles outlined previously [58]. Working at the limits of their abilities keeps players engaged as they continue to take on new challenges [61]. 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 [57].

In addition to the motivational aspect of the cognitive element of games, Lee and Hammer [62] suggest that the social and emotional aspects of rewards and consequences earned in gaming environments contribute to motivation as well. However, there needs to be a balance between positive and negative outcomes to prevent discouraging or overwhelming the students [56]. A well-designed game can also motivate players to stay engaged by enhancing the value of the task or tasks being completed [63]. This is particularly beneficial with educational games focused on school related subjects that students might not otherwise choose to immerse themselves in. Toth and Kayler [64] created a role-playing game that made use of quests to motivate students' assignment completion.

Instructional Delivery

The University of Michigan – Dearborn offers a two-course undergraduate sequence, CIS 487 and CIS 488, in game design. These courses are offered in-person on campus and paired with an online section that allows enrolled students to complete the course requirements asynchronously. Prior to 2017 instruction was delivered (either live or recorded video) to students in this class via a three-hour power point lecture. We call this approach lecture heavy (LH). Little in-class interaction between students was observed in this in-person course lecture style course delivery. Our experience observing students throughout the two-semester sequence was that most students spent their class time viewing their laptops than the course lecture material [17]. These classes typically had 5 or 6 major assignments (milestone documents or prototype demonstrations) and 1 or 2 presentations. Students in these classes participated in formal technical reviews of their documents and evaluated game projects through informal playtesting. We wanted to change the structure of these courses to better engage the students with the software engineering content covered in these courses. We describe our experiences in altering these courses to include active-learning, gamification, and role-play.

We determined that a PBL pedagogical approach was well suited for the delivery junior level software project courses. In our course redesign, we used the class activities to motivate students to design game 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. We encouraged students to reflect on the lessons learned from game design exercises either in writing or orally for in-person classes. We shifted to authentic assessment techniques and introduced the use of more frequent, lower stakes graded activities in both courses.

Gamification was introduced in our revised courses as a means of promoting rewards for completing tasks. Students can be rewarded for compliance with software process steps and for taking the initiative to improve their “soft skills” through team communication, planning, and problem solving. In this way, the authors hoped to resolve some of the discrepancies in personal efforts that are often present in student project work. We designed numerous tasks covering the gamut of game design and process engineering and assigned point values for their successful completion. Students were allowed to negotiate their own tasks within their team while also being encouraged to work on a variety of different tasks in to earn points towards their final course grade. It is our experience that allowing students to negotiate the nature of their efforts and rewards up front often goes a long way to ensuring that all students are engaged for the entire semester.

Course Overview: CIS 487 Computer Game Design I

The purpose of CIS 487 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. Before the Fall 2017 semester, this course split time between lectures on game design principles and Unity 2D and 3D game engine video tutorials. The revisions to this course focused primarily on introducing the active learning of game design as an alternative to a lecture heavy focus for presenting course content. Table 1 shows a week-by-week listing of the topics for the course.

The activities in CIS 487 were 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. Both in-person students 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 revised CIS 487 course.

Table 1. The Weekly Topics and Activities for CIS 487

Week	Software Engineering Topic	Activities
1	Game Design Evaluation Intellectual Property	Bartok Rule Changes Exercise Copyright Card Game
2	Game Storylines in Design Puzzle Design Process	Storyline Exercise Shocking Puzzle Design
3	Game Quality Review	Peer Review of Game Review
4	Game and Balance Storyboarding Feasibility Prototypes	Analysis of 3 Dot Game Paper Prototype – Test Feasibility of New First Person Shooter Game Design
5	Design Documents Brainstorming and Pitches Tradeoff Analysis	Ideation and One Page Creation Create Game Pitch for One Page Game Analyze Impact of Adding or Removing Features Using Paper Prototypes
6	Formal Technical Reviews Playtesting	Peer Review 2D Pitch Document Playtest 2D Game Feasibility Prototype
7	User Experience Design Agile Development	Revise User Interface Design Process Improvement Game (PIG) Contest
8	UX Sound Design UX Level Design	Create Skit Using 2D Games Sounds Only Create Outline for New 2D Game level
9	2D Game Testing	Peer Review 2D Game Beta Prototype
10	Game AI Design Game AI Testing	Design New Finite State Game AI for 2D Game Test Game AI Using Paper Prototype and Roleplay
11	Game Design Documents Formal Technical Reviews	Peer Review 3D Game Concept Presentations
12	Playtesting and Testing	Create Testing Script for 2D Game External Testers use Script to Test 2D Game
13	Playtesting	Playtesting of 3D Alpha Prototypes
14	Marketing	Marketing Exercise for 3D Game
15	Quality Assessment	Peer Assessment of 3D Beta Prototypes

In the revised CIS 487, in-person students watched video lectures before coming to class. Each weekly class was taught using a flipped classroom approach and the class period was split into three principal components. The first component was a 30 to 45 minute interactive presentation on the game design material for the week. The second component consisted of 60-80 minutes of small group work where students completed hands-on activities to engage them more deeply with the course material. Finally, the third component was a 30-minute tutorial video on a particular Unity engine topic related to the game design content for the week.

Course Overview: CIS 488 Computer Game Design II

The CIS 488 course contains a semester-long role-play in which the students function as the employees of a struggling game company. In the lecture heavy version of the course the role-play served as back story to provide context for graded assignments. Gamification and badging were introduced with the game company role-play in the lecture version of this course. There was some peer review of student work products, but no peer evaluation. The only reflection opportunities took the form of prototype postmortems. The student teams delivered three incremental game prototypes during the semester. The decision was made to continue and enhance the term long role-play activities in revised CIS 488. Table 2 shows a week-by-week listing of the topics for the course.

The revised CIS 488 makes greater use of gamification and active-learning elements than its predecessor (CIS 487). CIS 488 meets one day a week for 3 hours over a fifteen-week semester. The activities in the revised CIS 488 were often small group game design studio activities or solving problems that might arise in the business of game development. Online students completed modified activities at home by themselves. Student teams consisted of both in-person and online students. Students were asked to write reflections on the weekly activities, sometimes required in-person and online team members to exchange information outside of class time. Both in-person students and online students participate in online peer reviews of works produced by other students or teams. All students participate in the peer evaluation of the final game 3D game products. Peer instruction was introduced in the revised CIS 488, with on-line students creating videos of the content they needed to present.

During the first class period students were introduced to the back story of the role-play and how it would affect the conduct of the course. In previous offerings of this course much of the class time was spent observing instructor lectures on Unreal4 programming techniques. In the revised course, class time was spent in game design studio role-play activities. Classes often began with an all hands meeting to introduce the day’s role-playing activities. Students were expected to use video tutorials outside of class to learn to use the Unreal4 Blueprint system and level editor.

The fictitious company created for the role-play had a tradition of using a green light system for continuing or stopping development of game products. The first task was for each company developer to do a quick market research review and create a pitch for an innovative game product. Five pitches were selected by class vote for development and the pitch authors were allowed to recruit 4 or 5 team members to join their projects during the third class period. Each team was asked to provide a representative to a committee whose charter was to write a company-wide software process standards document based on the scrum framework. A contest was held within the company to create a new name and logo. The developers selected their favorite logo and Imagination Studio was launched.

Table 2. A listing of the weekly topics and activities for CIS 488

Week	Software Engineering Topic	Activities
1	Role-play Introduction	
2	3D Game Pitch Presentation	Peer Green Light Vote Team Formation
3	Software Process Definition	Teams Refine Game Concepts as One Pages Develop Agile Company Process Model
4	Business Plan Creation	Process Model Presentation and Approval One Page Review
5	Formal Technical Reviews	Peer Review of Draft Design Document
6	Elevator Pitches IP Ownership	Creation and Review of Game Elevator Pitch Game Theme Ownership Dispute Activity
7	Contracts and Scope Creep	Two Pitch Swaps Contract Dispute Activity Lens Presentations
8	Playtesting	Peer Review of Alpha Game Prototypes
9	Retrospective Game AI Design	Greenlight Vote on Alpha Prototypes Alpha Retrospective and Beta Planning Lens Presentations
10	Security	Game Espionage Activity Lens Presentations
11	Formal Technical Review Playtesting	Peer Review of Final Game Design Document Playtesting of Beta Game Prototype
12	Software Evolution	Create an Outline for a Game Sequel Taking Game Asset Reuse into Consideration Lens Presentations
13	Game Packaging Marketing	Create the Script for the Team Game Project Lens Presentations
14	Marketing Presentations	Peer Review of Game Marketing Video
15	Quality Assessment	Peer Assessment of Gold Release Candidates

Each team's first task was to create a game design document and a business plan for their game. To assist them in this task two local game company owners were recruited to act in the role of business consultants who shared their experiences with creating a company and bringing their first games to market. The second team deliverable was a game alpha prototype which included one complete logic path, and a draft user manual. This delivery signaled the end of the first sprint in the scrum framework. These games were evaluated for quality of game play. The company then looked at the productivity of each team. The team leads were asked to make an oral presentation to confirm that they had sufficient resources to complete their game products on time (the end of the semester was designated as the end of the fiscal year). All developers discussed the future of the game products and decided (without the instructor's influence) to cancel one of the projects. The developers from the canceled project were reassigned to existing development teams.

The third team deliverable was a beta prototype which needed to accommodate a requirement change. This change required the addition of a significant game artificial intelligence (AI) element to their evolving design. This deliverable also included the creation of the final game design document and test plan. The final team deliverable was the gold release prototype and a marketing presentation that included a video piece to promote their game product. Company developers scored each game (other than their own) using a rubric provided by the instructor. The average of these scores was used as the grade for the gold prototype.

Throughout the semester, the students participated in several role-play scenarios such as dealing with a security breach suggesting development of similar games by a competing company. One element of this class that was hard to fit into the role-play framework was the assignment where each developer uses their own game to illustrate game design features from Schell's book on game design lenses [65]. In this assignment, each student selects a group of three related lenses and creates a 20 minute presentation discussing how these lenses illustrate qualities from their game or not. This is sold as continuing education or inspiration for undertaking perfective maintenance activities to the company developers.

Assessment

Each of the revised course assignments was evaluated by Canvas rubrics designed by the instructor for each type of submission. Currently, these rubrics contain two to ten criteria, each scored from 1 to 5. Table 3 shows the rubric used to evaluate the active learning assignments. Specialized rubrics were created for the team project assignments.

Table 3: Activity Question Rubric

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

No statistical comparisons of performance on the in-class assignments were made between students in the in-person section and the asynchronous online sections of either CIS 487 during Fall 2021 or CIS 488 in Winter 2022. However, informal comparisons of student data from the two modes of classes delivered by the instructor in Fall 2021 and Winter 2022, suggest that students attending the in-person class meetings produced work which seemed to receive higher scores using similar grading rubrics. There were no comparable graded assignments in the lecture version of the courses, so no comparisons were possible.

The authors created four research questions to compare the levels of engagement by students taking CIS 487 under in-person face-to-face (FF) active learning as compared to the engagement of students taking CIS 487 under asynchronous online (AO) active learning and by student taking CIS 488 under in-person face-to-face (FF) active learning as compared to the engagement of students taking CIS 488 under asynchronous online (AO) active learning. The graded assignments in the lecture heavy (LH) version of each course were far fewer in number and no statistical comparisons were attempted. The date is presented for two allow comparison with the active learning courses.

RQ1: Does the delivery mode (in-person or online) affect student performance in taking either CIS 487 or CIS 488?

To answer this question, the authors looked at data analytics (number of late and missing assignments) collected by the Canvas management system for the three versions (LH, FF, and AO) of each course as shown in Table 4 and Table 5.

In Table 4 for CIS 487, students in the in-class instruction sections (LH and FF) had slightly better overall grades (91.2% and 91.8% vs. 89.6% respectively) than students in the asynchronous online section of the course. However, the in-person students had slightly higher rates of average number of missing (0.4 and 0.6 vs. 0.2) and late assignments (4.3 and 0.3 vs. 0.1) than their peers in the asynchronous sections. Yet, 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 metrics in Table 4.

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

	Fall 2016 Lecture - LH (N=24)	**Fall 2021 In-person - FF (N = 23)**	**Fall 2021 Online - AO (N = 19)**
Average Overall Course Grade	91.2%	91.8%	89.6%
Average Number of Late Assignments Per Student	0.4	0.3	0.1
Average Number of Missing Assignments Per Student	0.1	0.6	0.2

Although in Table 5, students in the in-person section (FF) of CIS 488 performed remarkably better overall than students in the online section (AO) with an average overall grade of 95.1% vs. 88.8% respectively. There was no significant difference detected between populations with the Student T-test at the 95% confidence level. It is interesting to note that the over grade for the LH students appears slightly lower (87.7%) than the AO students (88.8%). Students in the in-person section (FF) also had far fewer missing (1.6 vs. 3.5) and late assignments (0.2 vs. 0.4) on average than online students. The average number of missing assignments per student was found to be statistically different with the Student T-test at 95% confidence while the average number of late assignments was not found to be statistically different. We attribute the statistical difference of missing assignments to student engagement with the course as students 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. In the lecture class, there were fewer graded assignments overall so missing assignments could disastrous.

Table 5: Canvas Data - Based on CIS 488 Section Enrollment

	Winter 2017 Lecture - LH (N=17)	**Winter 2022 In-person - FF (N = 17)**	**Winter 2022 Online - AO (N = 10)**
Average Overall Course Grade	87.7%	95.1%	88.8%
Average Number of Late Assignments Per Student	0.6	0.2	0.4
Average Number of Missing Assignments Per Student	2.9	1.6	3.5

In both CIS 487 and CIS 488 the two 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 on their engagement with the course material particularly for CIS 488 and while the grade difference may not have been statistically different, we think that this may have still had some impact on their final performance in each course.

Course Surveys

We surveyed the students during the final weeks of each semester, to gather the students' own perceptions of their levels of engagement with the class, active learning, and gamification. The CIS 487 survey emphasized active learning and engagement (Table 6). The CIS 488 survey emphasized gamification and engagement (Table 7). No comparable survey data is available for the LH students.

RQ2: Do in-person students have a different perception of their level of engagement as reported on the CIS 487 or CIS 488 final surveys than online students?

The students in all sections were asked a series of online questions designed by the authors to elicit candid responses. The survey was conducted separately from the regular student course evaluations and was completed before the final course grade postings. 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 487 survey data are summarized in Table 6.

Table 6: CIS 487 Final Survey Student Perceptions of Engagement for Fall 2021 FF (N = 20) vs. AO (N = 6)

Survey Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Course
1. **There were opportunities for me to actively engage in learning**	0 0	0 0	1 (5%) 0	4 (20%) 2 (33%)	15 (75%) 4 (67%)	FF AO
2. **Course activities were useful way to learn**	0 0	0 0	1 (5%) 0	6 (30%) 2 (33%)	13 (65%) 4 (67%)	FF AO
3. **Course activities let me apply what I learned**	0 0	0 1 (17%)	0 2 (33%)	6 (30%) 3 (50%)	14 (70%) 0	FF AO
4. **Course is an example of active learning**	0 0	0 0	1 (5%) 0	2 (10%) 2 (33%)	17 (85%) 4 (67%)	FF AO
5. I prefer to learn primarily through lecture.	16 (80%) 3 (50%)	3 (15%) 3 (50%)	0 0	1 (5%) 0	0 0	FF AO

Students rated each statement on their perceptions of active learning and their engagement in the survey from 1 (strongly disagree) to 5 (strongly agree). 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. Question 3 was the only question with statistical differences between the responses at the 95% confidence level. This indicated that while individual students may have reported feeling less engaged in the AO modality, for the class as whole there were no detectable differences in the group opinions.

From this we conclude that the AO modality was at least no worse than the FF modality for student perceptions of engagement in our active learning course. Of significance was that only six 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. For future course implementations we will look for ways to increase participation in the course surveys particularly for the online section.

RQ3: Does gamification effect the choices of in-person students differently than students in online active learning course delivery as reported on the CIS 488 final survey?

Gamification was examined in the CIS 488 final survey (see Table 7). Students submitted their responses as a 1 (strongly disagree) to 5 (strongly agree). We performed a statistical analysis of the responses using the Mann-Whitney U Test. We found no statistical differences between the responses at the 95% confidence level. This indicated that students in the AO and FF modalities seemed to view the effect of gamification on their choice similarly.

Table 7: CIS 488 Final Survey Student Perceptions on Gamification Winter 2022 FF (N = 17) vs. Winter 2022 AO (N = 10)

Survey Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Course
1. When picking the assignments you submitted for this course, how important to you when deciding was how many points I could earn by doing the assignment?	2 (12%) 0	0 1 (10%)	11 (65%) 3 (30%)	1 (6%) 2 (20%)	3 (18%) 4 (40%)	FF AO
2. When picking the assignments you submitted for this course, how important to you when deciding was how much the assignment allowed me to collaborate with my classmates?	0 3 (30%)	4 (24%) 1 (10%)	7 (42%) 5 (50%)	3 (18%) 0	3 (18%) 1(10%)	FF AO
3. I put more effort into assignments for this class than I normally do for the course I take.	0 0	0 2 (20%)	2 (12%) 2 (20%)	8 (47%) 1 (10%)	7 (42%) 5 (50%)	FF AO
4. I felt like I had more control and choice over the assignments I completed than I normally do.	0 0	0 1 (10%)	2 (12%) 3 (30%)	7 (42%) 3 (30%)	8 (47%) 3 (30%)	FF AO
5. In this course, I did what I had to, but I didn't feel like it was really my choice	2 (12%) 1 (10%)	7 (42%) 4 (40%)	3 (18%) 1 (10%)	3 (18%) 3 (30%)	2 (12%) 1 (10%)	FF AO
6. In this course, I picked assignments based on what interested me	1 (6%) 0	1 (6%) 2 (20%)	3 (18%) 2 (20%)	5 (29%) 1 (10%)	7 (42%) 5 (50%)	FF AO
7. In this course, I feel I had control over how I demonstrated my understanding of the course material.	0 0	1 (6%) 1 (10%)	1 (6%) 2 (20%)	6 (35%) 3 (30%)	9 (53%) 4 (40%)	FF AO

The only major, but not significant disagreement between the student groups was on their answers to how important were the points on assignments when selecting a task to complete. Students in-person were more neutral (65% FF vs. 30% AO) while students online felt points were more important (24% FF vs. 60% AO). This suggests that gamification may be important in giving students in both modalities more control over their assignment choices and ways they demonstrated competency in the course. Yet, it seems for students online that the points mattered slightly more than the choice of assignments which might again be due to feeling less connected with course and various tasks since most of their group were making decisions without them in-person.

Course Evaluations

Students on our campus are requested to complete a standard set of course evaluations at the end of the semester. The evaluation form is completed online and anonymously; prior to receiving their final course grades. We wanted to compare the course evaluations of the FF and AO students in active learning conditions. Completion of course evaluation forms is voluntary. Student completion rates for the course evaluations dropped during the Covid19 lockdown and has been slow to improve following a return to normal campus activities. Questions are rated from 1 (strongly disagree) to 5 (strongly agree). We have included the most pertinent survey questions for CIS 487 in Table 8 and for CIS 488 in Table 9.

RQ4: Do online students have different course experiences than students in in-person active learning delivery modes in CIS 487 and CIS 488?

Table 8 shows the mean scores for the synchronous vs asynchronous sections. Mann Whitney U test was used to compare the student responses for FF to AO, LH to FF, and LH to AO groups. No significant differences in results ($p < 0.05$) between groups were found for any of these questions. One student failed to answer one question in the AO group and one FF student failed to answer one question as well. The course evaluation form completed by the LH student was missing three questions included in the current form.

**Table 8: Selected CIS 487 Course Assessment Questions Fall 2021
LH vs FF vs AO**

CIS 487 **1 = *strongly disagree*,** **5 = *strongly agree***	**Fall 2016** **LH** **N=(12/24)**	**Fall 2021** **FF** **N = (11/23)** ***(N= 10/23)**	**Fall 2021** **AO** **(N = 11/19)** ***(N = 12/19)**
Course met my expectations.	4.4	4.6	4.5*
Course objectives were clear.	4.3	4.6	4.7
Typical workload compared to other courses.	4.5	4.0	4.6
Course advanced my understanding of subject.	-	4.7	4.7
Lab activities increased my understanding of lecture topics.	-	4.8	4.9
I knew what was expected of me.	-	4.3*	4.6
Overall course rating.	4.6	4.6	4.6

Table 9 shows the mean scores for the in-person vs asynchronous sections. Mann Whitney U test were used to compare the student responses for FF to AO, LH to FF, and LH to AO groups. No significant differences in results ($p < 0.05$) between groups were found for any of these questions. One FF student failed to answer two questions.

Table 9: Selected CIS 488 Course Assessment Questions Winter 2022 LH vs FF vs AO

CIS 488 **1 = *strongly disagree*,** **5 = *strongly agree***	**Winter 2017** **LH** **N=(8/15)**	**Winter 2022** **FF** **N = (7/17)** ***(N=6/17)**	**Winter 2022** **AO** **N = (3/10)**
Course met my expectations.	5.0	4.7*	4.3
Course objectives were clear.	5.0	4.7	4.7
Typical workload compared to other courses.	4.9	4.1	4.0
Course advanced my understanding of subject.	-	4.5*	4.3
Lab activities increased my understanding of lecture topics.	-	4.5	5.0
I knew what was expected of me.	-	4.7	4.7
Overall course rating.	4.9	4.6	4.3

Overwhelmingly, the projects are the biggest strength cited by students in the course evaluation open comments questions. Their comments reinforce the positive effect of projects on practical learning as well as the development of collaborative, critical thinking skills. Students also indicated that replacing exams with projects provided a more meaningful learning experience and knowledge that would be otherwise difficult to assess with a traditional assessments approach.

Threats to Validity

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 CIS 487 and 488 course offerings may also account for the lack of significant differences on the evaluation measures. We also acknowledge that the small number of students in the sample populations make it hard to generalize the results to other populations. It is hard to combine the results from classes offered with vastly different course delivery modes over the past four years. It is our hope that the course delivery modes (both in-person and online) for CIS 487 and CIS 488 will be repeated to allow use to combine results from multiple course offerings.

In recent years, this university implemented a policy which required the pairing of an asynchronous, distance learning section with a face-to-face section of the same course. The live 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. AO students were even allowed to attend FF sessions voluntarily, in-person attendance by AO students was not allowed in 2021 or 2022. It is possible the 2021 and 2022 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. Students in the CIS department know each other from other classes that they have taken together. 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. In other words, the asynchronous student may not be totally isolated from knowledge learned in the group activities.

Student engagement can only be measured indirectly in online courses using surveys and course analytics. In previous studies, direct observation of student behavior was used to provide insight into their levels of engagement. We did not include direct observation of students in the socially distanced in-person section. Trying to measure student engagement using chat comments or interaction with shared Google documents is a practical alternative but also lacks the immediate visual feedback an instructor experiences with a real-time view of a student's face.

There was limited student completion of the course survey in CIS 487 only 6 out of 19 students in the CIS 487 Fall 2021 AO course. This represents too small a population to draw strong conclusions from averages. In future courses, we will need to consider methods to potentially increase student participation.

The 2021-2022 school year presented extraordinary challenges for students. While it would be expected that students were excited to return to face-to-face instruction, it may also be expected that many felt anxious or even distracted with the fresh look of face-to-face instruction. It is difficult to assess what effects, both positive and negative, this might have had on the return to an active learning classroom in 2021.

Conclusions and Future Direction

During the past few years, many 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 students simply watching online lecture videos and taking exams. In this paper we demonstrated that it is possible to move an in-person active learning two-course game design sequence to online delivery, without significant loss of student satisfaction or perceptions of engagement. We take this as evidence that it is possible to design an asynchronous active learning course that can be as engaging as its in-person counterpart. We credit the active learning components of the classes and the levels of student interaction that accompany them for making this possible. We encourage other instructors to adopt active learning practices and modify them as needed which can help to satisfy requirements in their course deliveries to achieve higher levels of student satisfaction and engagement.

It may be important to develop ways in which asynchronous students are encouraged to be a part of some sort of face-to-face experience, even if it is not during a formal online class meeting. Informal study or discussion groups that could meet online, with flexible meeting times, might be a way to increase engagement with activities. Experiences from the Fall 2021 course delivery of CIS 487 and Winter 2022 course delivery of CIS 488 will be used to revise the next offering of these courses and the corresponding active learning materials. We will continue to search for activities which better match the course topics.

The current plan is to make use of the revised modules in the Winter 2023 and Fall 2023 offerings of CIS 488 and CIS 487 which will be offered both fully online and fully in-person. We are continuing to develop tools to provide scaffolding assistance for student activities.

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