ACTIVE LEARNING AND GAMIFICATION IN GAME DESIGN COURSES

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Abstract

Engineering instructors often rely on the traditional lecture model where they lecture on a topic, with or without a slideshow, to a classroom of students. In this model, student engagement is low or non-existent with students neglecting to engage with the material until an assessment (i.e. an assignment or examination) is due. Further, students often do not get much practice with the soft-skills that are critical for successful professional interactions in industrial practice and future academic work in these passive learning environments. However, there have been alternative approaches proposed to help address the engagement and skill gaps. We describe our experiences in revising two game design courses at the University of Michigan – Dearborn where we replaced a traditional, lecture-heavy, course delivery model with one involving active-learning, role-play, and gamification. We track a cohort of students through a two-course game design sequence and report our findings from daily and term assessments.

Introduction

Engineering instruction typically follows the traditional lecture model throughout higher-education. This model is based around long periods of instruction which in some classes contain as much as three hours of nearly non-stop instructor-to-student presentation of course material. Pure lecture provides little opportunity to help engineering students develop soft-skills (i.e. inter-personal, communication, and other social skills) necessary for successful careers in industry and academia. These issues are further complicated because of student distraction caused by using electronic devices during class time (Risko, Buchanan, Medimorec, & Kingstone, 2013). However, other methods such as active learning have been proposed to help fix the engagement and skills gap (Prince, 2004).

The University of Michigan – Dearborn offers a two-course undergraduate sequence, CIS 487 and 488, in game design (CIS 487, 2017; CIS 488, 2018). These courses traditionally involved a weekly three-hour lecture of material with slides and involved little in-class interaction between students. In our experience following students throughout the two-semester sequence, the majority of the students spent the time more engaged with their laptops than with the course material. We wanted to change the structure of the course to better engage the students with the course material. We describe

our experiences in altering the course to include active-learning, role-play, and gamification as well as student feedback from daily and term assessments.

Literature Review Active Learning

According to Prince (2004), active learning is broadly defined as "any instructional method that engages students in the learning process" (p.223). Further, Prince (2004) outlines the core requirements of active learning: student activity, student engagement, and those students think critically about the activity. The University of Utah's College of Engineering (2016), which references the University of Minnesota Center for Teaching and Learning, makes it clear that active learning does not include the traditional lecture model of instruction which stands as the antithesis to active learning.

Active learning, as stated by Samavedham and Ragupathi (2012), is regarded by many engineering institutions, instructors, and governmental bodies as the best method to teach the next generation of engineers that are arriving ill-prepared for professional environments post-graduation. Techniques for active learning focus on complementing or entirely replacing lectures with numerous alternatives that engage students with the material and encourage the development of soft skills such as problem-solving, reasoning, and analytical skills that are necessary for successful post-graduation employment (Prince 2004).

Role-Play

Simkins (2015) 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 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 (2009) and Seland (2009) used role-play in human computer interaction courses to engage students with the requirement engineering process in order to better understand system behavior from the users' point of view. Similarly, Zowghi and Parvani (2003) 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 (2005) to teach students object-oriented programming concepts with class-responsibility-collaborator cards. Vold and Yayilgan (2013) achieved greater student engagement with role-play in an information technology course. Further, we draw inspiration from a study that used the Second Life (Linden Labs, 2018) online virtual world as a platform for students to role-play a fictional company for enterprise resource planning (Rudra, Jaeger, Aitken, Chang, & Helgheim, 2011). Other on-line role-play simulations focus on students taking the role of project managers with students receive immediate feedback on their decisions (Nakamura, Maruyama, Takashima, & Sambe, 2012; Maxim, Kaur, Apzynski, Edwards, & Evans, 2016; Navarro & Hoek, 2004).

The redesign described in this paper builds upon the work of Maxim, Brunvand, and Decker (2017), which used role-play in the re-designed game design course, CIS 488, at the University of Michigan – Dearborn. We re-use this work with some slight modifications as the second course in our two-

course game design sequence. The course from 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 (Epic Games 2018) (Maxim, Brunvand, & Decker, 2017). The failing game company backstory used to motivate the role-play in our course is discussed further in Decker and Simkins (2016). 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 secondary learning objectives based in business and legal concerns that naturally arise during the role-play (Maxim, Brunvand, & Decker, 2017). The decision was made to continue to use the term long role-play activities created CIS 488 since those students had a good grasp of software engineering and game design from the pre-requisite course CIS 487.

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 task (Domiguez, 2013; Simoes, 2012). 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 the active learning can help mitigate this problem.

James Gee (2014) 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. For instance, good games provide players with information when they need it and within the context in which the information will be used (Gee, 2003). 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 (Vygotsky, 1978). Having students, or players, operate within this optimal learning zone helps keep them engaged and encourages them to learn more in order to meet the demands of the next challenge.

According to Gee (2003), 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 (Granic, et al., 2014). Gee contends that well designed games are motivational specifically because of the different learning principles outlined previously (Gee, 2003). Working at the limits of their abilities keeps players engaged as they continue to take on new challenges (Ott and Tavella, 2009). Gee refers to this process as a cycle of expertise, which requires players to constantly learn, act, revise and learn again in order to demonstrate mastery and be successful in a game (Gee, 2014).

In addition to the motivational aspect of the cognitive element of games, Lee and Hammer (2011) 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 (Dominguez et al. 2013). A well-designed game can also motivate players to stay engaged by enhancing the value of the task or tasks being completed (Yang, 2012). This is particularly beneficial with educational games focused on school related subjects that students might not otherwise choose to immerse themselves

within. Toth and Kayler (2015) created a role-playing game that made use of quests to motivate students' assignment completion.

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". In this way, the authors hope 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 them point values for successful completion. Students were allowed to negotiate their own tasks within their team structures while also being encouraged students to work on a variety of different tasks in order to earn points towards their final course grade. These tasks encouraged development of soft-skills through team communication, planning, and problem-solving. Allowing students to negotiate the nature of their activities and rewards up front often goes a long way to ensuring that all students are engaged for the entire semester. It is our expectation that, by providing more diverse learning opportunities, our students will be better equipped for the engineering profession upon graduation. The authors are using student feedback and their lessons learned to plan the next iteration of our game design courses.

It is important to acknowledge the debate that centers around gamification. There are critics such as Ian Bogost who colorfully proclaim, "Gamification is bullshit" and that it is little more than a marketing term for exploitative practices (Bogost, 2011). A more nuanced criticism from Casey O'Donnell argues that gamification at its heart is a form of algorithmic surveillance that provides data of dubious merit and use (O'Donnell, 2014). However, as we show with our course designs, gamification can be accomplished in a non-manipulative and non-exploitative manner where the goal of the gamification is to provide different opportunities for involvement in the courses thereby increasing student agency by allowing students to work on what interests them the most.

Course Design 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 fourteen-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 (Unity, 2018). The revisions to this course focused primarily on introducing active-learning activities on game design as an alternative to the lecture heavy focus for presenting course content.

The weekly class was split in to three principal components. The first component was a short interactive presentation on the game design material for the week. These presentations were reduced to approximately 30-45 minutes on average. These presentations were then followed by the second component, an activity designed to engage the students more deeply with the material. Finally, the third component was a 30-minute, live, Unity engine tutorial on a particular topic usually related to the game design content for the week. These live demonstrations provided the opportunity for student interaction and questions not possible with the video tutorials that were previously used for the course. Table 1 shows a week-by-week listing of the topics for the course.

CIS 487 Syllabus	
Week	*Class Content*
1	Video Game Evaluation Criteria, Intellectural Property
2	Game Design, Story Telling Puzzle Design, Unity Basics
3	Game Evaluation Presentations
4	Game Play, Balance, Paper Prototyping, Design Documents
5	Sprite Animation, Movement, 2D Physics
6	User Expereince Design, Agile and SCRUM
7	2D Design Document Technical Review
8	Terrain Construction and Level Design
9	2D Game Festival
10	Prototype 2, Game Artifical Intelligence
11	3D Game Concept Presentations
12	Playtesting, Alpha Prototype Demos
13	Team Organization, Game Production and Marketing
14	3D Game Festival

Table 1

The students were evaluated on the completion of five projects, four of which were team-based assignments and one which was an individual assignment. The group assignments involved the use of gamification to reward differential student project contributions that were broken down into elective components each with its own point value. Students could select any number of electives from the assignment to complete to earn a maximum amount of points on the assignment. Table 2 provides a list of activities covered during the semester. The gamification strategies used in the courses is discussed further after the course overviews.

The first project was an individual review of a professionally produced computer game. Students prepared their reviews of the game and their critiques in a PowerPoint. They were then required to present them to the class. The reviews were to cover the basic information of the game (i.e. title, type, price, authors), a summary of the game, which was to include items such as the story, gameplay, user interface, etc., and their thoughts on a number of questions such as the quality, fun, comparison to similar games, design mistakes, strengths, and weaknesses. The reviews are available at the University of Michigan – Dearborn CIS course website: http://groups.umd.umich.edu/cis/course.des/cis587/reviews/game.html.

Week	*Activities*
1	Bartok Rule Changes Exercise Copyright Card Games
2	Storyline Exercise Shocking Puzzle Design
3	Paper Prototype for First Person Shooter Brainstorming new game feature storyboard
4	Ideation and One Page Creation Create Game Pitch for One Page Game Tradeoff Analysis for Feature Addition to Game
5	Analysis of 3 Dot Game Scrum Trigger Film Process Improvement Game (PIG) Contest
6	Skit using 2D Games Sounds Only Create new 2D Game level outline
7	Peer Review 2D Pitch Document
8	Design Finite State Game AI to add to 2D game Gender Mag Persona Creation Exercise
9	Peer Review 2D Game Prototype
10	Cognitive Walkthrough of Persona for 3D Game
11	Peer Review 3D Game Concept Presentations Playtesting Paper Prototypes
12	Peer Review and Playtesting of 3D Alpha Prototypes
13	Marketing exercise for 3D game
14	Peer Review and Playtesting of 3D Beta Prototypes

Table 2

Projects two and three were completed by a group of two with the same students completing both projects together. Students selected their own partners for the projects. The two projects were comprised of a 2D Unity game pitch and the production of the game itself. The game pitches involved creation of a pitch document that outlined the game story, game play look and feel, and the development specifications. The 2D game required a playable game with at-least one playable character, one level transition, and some rudimentary physics and AI.

The fourth and fifth projects were also team-based but the students were required to form teams of three to four individuals. The students again could choose their own partners but were not required to work with the same partner from their 2D game. The fourth and fifth projects were to design and implement a 3D game alpha and beta prototype. The game requirements were like those for the 2D game with the expectation of a more polished and complete game.

Course Overview: CIS 488 Computer Game Design II

The CIS 488 course design builds on our previous work (Maxim, Brunvand, & Decker, 2017). The course contains a semester-long role-play in which the students act as the employees of a struggling game company. Also, the course makes use of gamification and active-learning elements similar to those described for its predecessor, CIS 487. We made one major alteration from the previous revision based upon student feedback. When the course was redesigned in 2017 we no longer included instruction on the Unreal game engine. In order to assist students in becoming familiar with the required engine we added back in instruction on it for the 2018 version of the course in the form of live, interactive demonstrations of 30-45 minutes duration each class period. These demonstrations focused on the class topic of the day. Students reacted very positively to this addition stating in reviews the "in-class instructions were very helpful. They were informative, plus having [them in class] allowed questions to be answered as they occurred." Table 3 shows a summary of the week-by-week topics of the course.

CIS 488 Syllabus	
Week	*Activity and Content*
1	Course Intro, Role-Play Intro, Intro to Unreal 4
2	Game Pitch Presentations
3	Teams Formed - Brainstorming Game, Studio Process Model Definition, Unreal Level Editing
4	Cubicorn Games - Consultants Presentation, Game One-Page Presentation, Intro to Unreal Blueprints Programming
5	Game Treatment Presentations and Market Analysis
6	Elevator Pitches, Unreal Materials / Lighting / Terrain
7	Two Pitch Swaps, Matinee and Bot Navigation in Unreal
8	Alpha Release Presentations, Play Testing
9	One Sheet Evaluations, Unreal Scripting and AI
10	Intellectual Property, Unreal Actors and Characters
11	Beta Release Presentations, Play Testing
12	Sequel Creation, Unreal Interfaces and Particle Effects
13	Team Management, 3D Game Marketing Presentations
14	3D Project Game Festival

Table 3

Gamification of Assignments

A problem the authors have observed in many student project classes, including but not limited to this course, is that some students contribute very little meaningful effort to the final work products. Sometimes students feel their individual contribution to the final work products was not reflected in their final grades. Students in both courses work on teams to create the milestone documents and prototypes delivered as part of their project work. In previous courses the instructor asked each student to grade the participation of each team member (including themselves) using a score of 0 to 5. Students were also expected to create a bulleted list of the tasks completed by each team member. The average of these scores was added to the team score. The instructor penalized people who failed to make significant contributions. Often the loss of 2 or 3 points on an assignment was not enough to encourage students to be active team contributors.

In the CIS 488 course offered Winter 2017, a gamification framework was created, where the points for the team artifacts became part of the core or required work for everyone and the individual work products become part of the elective work. The individual work included the peer evaluations, individual presentations, attendance, programming, level design, testing, project management, and art asset creation. In keeping with the spirit of allowing students to customize their course experience, students were allowed to pursue the game production activities which were of greatest interest to themselves. The students in each class determined the relative point values (5, 3, or 2) for these activities based on the perceived importance to the goal of completing a working game. These point values are shown in Table 4.

Points	Tasks
5	Programmer, AI Programmer, UX Programmer, 3D Prop Builder, Character Animator
3	Level Designer, 2D Texture Artist, Project Management, Document Manager, Repository Manager
2	Audio Designer, Test Engineer, Cinematic Artist

Table 4

These points were mapped to a time card where the maximum points the students earned for their individual prototype work matched the maximum number of points awarded to the team documents submitted for that turn in. The students were required to earn at least 10% of the time card points from a programming category. Pair programming was allowed with each member of the pair splitting the points earned for completing a user story. The completed time cards were submitted to the team leader for approval and then forwarded to the instructor for grading.

In some cases, these activities were further refined. For example, level designers were awarded separate points for completing story board and level design templates in addition to hours spent editing a game level. Test engineers were rewarded for writing test cases, executing test cases, and documenting the test results. Programmers were not credited with work completed unless a user story satisfied its acceptance criteria. Some tasks such as asset creation or management tasks were better rewarded on an hourly basis. Typically, 1 point an hour was awarded for these tasks.

The gamification framework was implemented using the Gradecraft class management system (Gradecraft, 2018). This allowed the implementation of a leaderboard and provided access to a grade predictor tool. A badge system was also initiated to recognize outstanding achievement in many categories (leadership, game development, marketing, creative activities). The time card system and gamification framework were adapted for CIS 487 in Fall 2017 and refined for CIS 488 in Winter 2018.

Evaluation

The two courses were both evaluated using daily assessment and term assessments. The assessments followed the same format as those initially designed in our previous study (Maxim, Brunvand, & Decker, 2017). The daily assessments were given to the students at the end of each class period and used to assess the students' views of that day's lecture and activity. The term assessments were given at the last class period and consisted of two online questionnaires. The first questionnaire was the standard course assessment form for the University of Michigan – Dearborn. The second form was a custom questionnaire we designed to more properly assess the students' views on the active learning and gamification components of the course and follows from the questionnaire originally derived for our previous study (Maxim, Brunvand, & Decker, 2017). A summary of the term assessments of the courses can be found in Table 5.

The two classes consisted of a mix of students at the undergraduate and graduate level. CIS 487 had twenty-four undergraduates and one graduate student enrolled. Of those students, twenty-three were male and five were female. CIS 488 had twenty-one undergraduates and two graduate students enrolled. Of those students, nineteen were male and four were female. In both courses, all students except one were from the College of Engineering and Computer Science. However, for the purposes of the assessments we only considered in-class, undergraduate student responses. We did not ask for identifying information which means that we cannot break down our responses based on the demographic data of the course enrollment.

From the term assessments we observed that students in CIS 488 were overwhelmingly (with a 4.5/5 average score) choosing assignments based on interest level. We believe this contributed to the high quality of the games produced by the students during the semester. We suggest this was due to an

increase in motivation caused by being permitted to pursue their individual interests. As one student wrote reflective of multiple other comments, "I'm more driven to do a good job, since I choose to do it". Meanwhile, another student commented "This inspires creativity and forces students to solve real world problems, along with delivering a full product". Interestingly, the point valuation seemed less important to the students when picking an assignment even if it meant fewer points were awarded. This contrasts a bit with the previous study where interest level, time to complete, and point value all seemed to be significant factors (Maxim, Brunvand, & Decker, 2017). However, this assessment's students seemed to agree with the previous year's students that they put more effort in to assignments, felt they had more control, and could work on what interests them all with fairly high agreement (Maxim, Brunvand, & Decker, 2017). Also, of interest, is that both the CIS 487 and CIS 488 students had high agreement with the same sentiments (i.e. the last 5 statements from Table 5), which we interpret to mean that the gamification additions to the course are working as intended.

Term Assessments			
CIS 487 Mean Score *n = 10*	**CIS 488 Mean Score** *n = 12*	**Mann-Whitney U Test Ustat** *Ucrit = 40 @ 0.10*	**When picking assignments for this course what criteria was important when deciding which assignment to complete?**
			1 = not very important, 5 = very important
3.6	2.8	41	How easy an assignment appeared to be
4.0	2.8	31	How long I thought it would take me to complete the assignment
4.2	4.5	47.5	How interested I was in doing the assignment
3.5	3.3	52	Whether I had the necessary prior knowledge and skills to complete the assignment
3.9	3.2	41.5	How many points I could earn by doing the assignment
3.1	3.3	53	How much the assignment allowed me to collaborate with my classmates
			Which of the following had an impact on your ability to complete assignments in this class?
			1 = very little impact, 5 = very big impact
3.9	4.4	47.5	The amount of time required to complete an assignment
3.5	4.0	51	The complexity of the assignments
3.3	3.4	58	Your understanding of the assignment guidelines and expectations
4.2	4.3	58	Your ability to manage your time successfully
			Please indicate your agreement with the following statements.
			1 = completely agree, 5 = completely disagree
2.2	1.8	47	I put more effort into the assignments for this class than I normally do for the courses I take.
2.1	1.6	52.5	I felt like I had more control and choice over the assignments I completed for this class than I normally do.
3.1	3.8	43	I did what I had to, but I didn't feel like it was really my choice.
1.9	1.6	50	I picked assignments based on what interested me.
2.1	2.1	59	I feel I had control over how I demonstrated my understanding of the course material.

Table 5

The standard course assessment forms at University of Michigan – Dearborn have five questions of

interest that are relevant to assess the course redesign. Tables 6 and 7 show the assessment results for CIS 487 and 488 respectively. For CIS 487, the results between 2016 and 2017, the old course and new course, are very close with a slight preference for the new version of the course. The new course had slightly higher rating on four of the five categories. We suspect the course ratings of the new course are similar to the previous version of the course because this is a popular elective course that students look forward to taking since their entry into the computer and information science and software engineer programs. The CIS 488 assessments are more interesting. Table 5 shows that between 2016 and 2017 there is a nearly full point difference in between most scores. We believe this is due to the course redesign which occurred between these years and the fact that students went from a non-gamified, lecture heavy course for CIS 487 in Fall 2016 to the active-learning and gamified second course in the sequence in Winter 2017. The numbers decreased slightly from 2017 to 2018 but remain higher than 2016, which was the non-gamified version of the course. We suspect that this could be due to the students being previously introduced to the active-learning and gamification in the previous course and therefore were not as pleasantly surprised as the 2017 students at the changes in the course.

CIS 487 Selected Course Assessment Questions **1 = strongly disagree, 5 = strongly agree**	2016 N = 17/31	2017 N = 19/24
Course fulfilled my needs	4.3	4.5
Course objectives were clear	4.3	4.4
Course was challenging and interesting	4.6	4.6
Course never repeats other course material	4.4	4.5
Overall course rating	4.5	4.7

Table 6

CIS 488 Selected Course Assessment Questions **1 = strongly disagree, 5 = strongly agree** ***11/20 Respondents**	2016 N = 8/23	2017 N = 11/21	2018 N = 12/20
Course fulfilled my needs	4.1	4.9	4.4
Course objectives were clear	4.2	4.9	4.3
Course was challenging and interesting	4.1	4.8	4.7
Course never repeats other course material	4.0	4.8	4.3*
Overall course rating	4.0	4.8	4.6

Table 7

Conclusions and Future Work

We were encouraged by the enthusiasm that students exhibited while working with the active

learning modules. Engagement is hard to measure, but students rarely had their laptops open during the class activities unless the group activity was facilitated by their use. It was interesting to observe that the students did not lose momentum from CIS 487 to CIS 488. This was the first year that no incomplete grades were awarded in either class. The use of time cards and badging seemed to be having their desired effect of encouraging students to work beyond the maximum points allowed for the assigned projects. The number of students completing the on-line course assessments is lower than desirable. Perhaps additional gamification elements might be helpful. The addition of the game engine Q&A sessions in both CIS 487 and 488 were welcomed by the students this year.

Experience from the Fall 2017 course delivery of CIS 487 is being used to revise the next offering of this course and the corresponding active learning materials. We will revise the module instructions and address the completion time issues. We need to introduce the use of gamification before the project work begins in CIS 487, which means we need to revise the gamification framework created in Gradecraft. The revised gamification elements added to CIS 488 during Winter 2018 were well received and Gradecraft was used a little more regularly by students than in Winter 2017. It may be desirable to add some gamification elements to both courses to reward students for coming to class with the assigned homework completed. This suggests we may need to find a way to reward viewing tutorial videos before coming to class. We plan to study student engagement and participation patterns in more systematic manner in our next active learning course offerings.

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