WIP: Gamifying an Introductory Digital Design Course to Enhance Student Engagement

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Abstract

This work in progress (WIP) explores the design and implementation of flexible assessment in an introductory digital design course offered by the Electrical and Computer Engineering (ECE) department through the incorporation of an optional gamified element. The flexible assessment initiative is part of a larger college of engineering effort in collaboration with the Center for Teaching and Learning (CTL) to redesign traditionally structured courses to increase student motivation and engagement.

The digital design class is taken by Industrial and Systems Engineering (ISE) majors in the 3rd or 4th year of their undergraduate education. It introduces the students to the basics of digital logic and digital machines. The students possess varying levels of engagement with the subject, ranging from those who view the course as solely a curricular requirement to those with academic or professional interest in the usefulness of the course. The students in the latter category may continue to take courses from the ECE department as part of the ISE curriculum, while for the former group of students, the class is likely their first and last exposure to electrical engineering.

The course is restructured with an element of gamification, a practice that incorporates elements of game design for educational practices. Optional tasks and assignments are offered to the students throughout the semester, where they are rewarded for completion or success in these extra activities. There is evidence that gamification in science, technology, engineering, and math (STEM) classes improves student motivation and engagement. Gamification provides students with low-stakes opportunities to make mistakes in the process of learning, without fear of ramifications. The optional element of the gamification structure enhances the engagement and learning opportunities for the students who are interested in the subject, while leaving the more traditional route available for other students. However, the goal of gamification is to increase the level of interest and engagement for all students, including those not originally interested.

The work in progress report consists of a detailed description of the gamified elements, the planned statistic study of participation in gamification and grade success in class and the planned survey for student satisfaction and level of interest in the material. The efforts of this work can be replicated in other ECE programs with similar digital systems coursework.

Introduction

In this paper, the ongoing redesign of an introductory electrical engineering class is detailed. This redesign was spurred by an instructor's personal experience with students who demonstrated mastery over course material, yet due to poor exam performance, failed the class. Anecdotally, the instructor saw some of these students go on to become successful engineers. Out of concern that poor exam performance and failure demotivated and ultimately prevented students who had the potential to succeed as engineers, a 'flexible assessment' initiative was created between the College of Engineering and the Center for Teaching and Learning. There is evidence that poor feedback in the form of low grades or failing classes is a factor students cite when leaving an engineering major [1, 2], playing a particularly significant role with students belonging to underrepresented groups [3]. The goal of this initiative is to give students an opportunity to demonstrate content mastery over course material through alternative, substantive means and thereby minimize the negative impact of poor exam scores on grades and self-confidence.

Flexible assessment is a student-centered pedagogical model that can be "customized to fit the unique needs and circumstances [of students] and are adaptable to measure different types of knowledge and skills" [4]. In [4], five main categories of incorporating flexibility were identified: assessment tasks or formats, grade weight, deadlines, format of feedback, and content and learning objectives. It has been found that properly implementing flexible assessment can enhance student engagement and decrease student stress levels [5, 6]. However, there is a balance to be struck when incorporating flexibility. Choice overload can result in student confusion and stress [4].

In August of 2025, the College of Education's flexible assessment initiative began having bi-monthly meetings and planning for a pilot experiment in Spring of 2026 for three different classes. One introductory class was chosen from the Industrial and Systems Engineering department, the Mechanical Engineering department, and the Electrical and Computer Engineering department. These classes are typically taught by the three faculty members who had joined the flexible assessment initiative. In addition to these professors, three graduate students from each department were recruited to the initiative. These graduate students would serve as Graduate Teaching Assistants (GTA) for the three courses in the spring semester. Lastly, a faculty member from the CTL department led the bi-weekly meetings and aided in the redesign plan for all three courses.

The fall semester began with the CTL instructor introducing the initiative members to the theory of flexible assessment through presentations, literature review, and discussions. Later in the semester, each graduate student had the responsibility of selecting a mode of flexibility to incorporate into their respective classes and planning the integration prior to the spring semester.

For the ECE class, the graduate student was set to serve as instructor of record for one section of the class in the spring semester, taking full responsibility for the section, including scheduling the semester plan, creating and delivering lectures, and crafting effective assessments of student learning. The ECE faculty member had experience teaching the course and helped with the development of the course redesign, guiding the graduate student throughout the process. Initially, the graduate student considered redesigning the class through the lens of problem-based learning, an instructional methodology where "learners begin learning by addressing simulations of an authentic, ill-structured problem" [7]. This technique is student-centered, self-directed, self-reflective, and based in collaboration [7], and has been successfully utilized with similar introductory electrical engineering courses [8, 9].

However, the plan for the ECE class was eventually shifted away from problem-based learning to gamification, which is a pedagogical technique characterized by "the use of game components such as score, challenge, and achievement to learning objectives, in an effort to motivate and engage the student" [10, 11]. Gamification was eventually chosen due to consideration of the course's audience, ISE students. Throughout the fall semester, the graduate student attended an ISE section of the course to learn the material and prepare to teach. Through interactions with the ISE students, they became aware of the disinterested attitude of the students, who thought of the class as somewhere between an unnecessary major requirement and a dreaded, intimidating subject. A majority of the students seemed to have low levels of interest and intrinsic motivation for the course. For this reason, gamification was decided as a better fit for the ISE students. There is evidence [11, 12, 13] that gamified classes can help convert extrinsic motivation, engagement in learning "because it is a means to an end, relatively disassociated from the content and subject of learning" [14, 15], to intrinsic motivation, engagement in learning "for pleasure, or satisfaction derived from performing an act" [11].

The original structure of the course

The introductory electrical engineering class which is the subject of this work-in-progress is Foundations of Digital System Design. The course description reads,

> *"[This class] introduces the many levels of abstraction that enable today's digital computing systems. It explores design at the layers of a computing platform from switches and wire to a programmable machine. At each layer, the design process of transforming a specification into an implementation is introduced and practiced. Design tools are used to build, evaluate and compare implementation approaches."*

The course outcomes set by the school are as follows:

1. Realize a Boolean expression with electronic switches and DeMorgan equivalent gates using a basic schematic design and simulation environment.
2. Simplify Boolean expressions in product-of-sums (POS) and sum-of-products (SOP) forms using Karnaugh Maps.
3. Implement encoders, decoders and multiplexers using basic gates (including pass gates).
4. Use basic design tools to analyze first-order combinatorial logic delay and energy dissipation.
5. Express signed, unsigned, fixed-point and floating-point values in binary representations.
6. Perform signed and unsigned addition and subtraction, observing errors.
7. Implement latches and registers and use these in state machines and register files.

8. Implement toggle cells for designing divide-by-N counters.
9. Analyze sequential logic timing and power consumption using different tools.
10. Design storage systems using memory arrays composed of basic static and dynamic cells.
11. Implement a datapath using register files, functional units, and a three bus architecture.
12. Describe the instruction types and formats of a RISC instruction set.
13. Implement instruction sequences in a datapath using a RISC instruction set.
14. Describe the operation of a branching, single-cycle controller.

During fall and spring semesters, this class typically has six sections; three dedicated to ECE majors and three for ISE majors. Over time, some divisions have grown between what material is covered and emphasized for the different majors. For the ECE students, this class is an important introduction to knowledge and techniques that they will go on to use throughout the completion of their degree. For the ISE students, this is one of two classes they can take to satisfy a requirement from their department, and this is likely the first and last time they will be exposed to ECE content during their degree. Between the different sections, the ECE students have historically been required to purchase and utilize a National Instruments myDAQ device for the laboratory sessions of the class, whereas the ISE students use an online software for circuit simulation during laboratories.

For both ISE and ECE sections, the class has always been taught and assessed in a traditional manner. While there are slight variations between different instructors and semesters, a typical semester has the following mandatory assignments and weighting scheme:

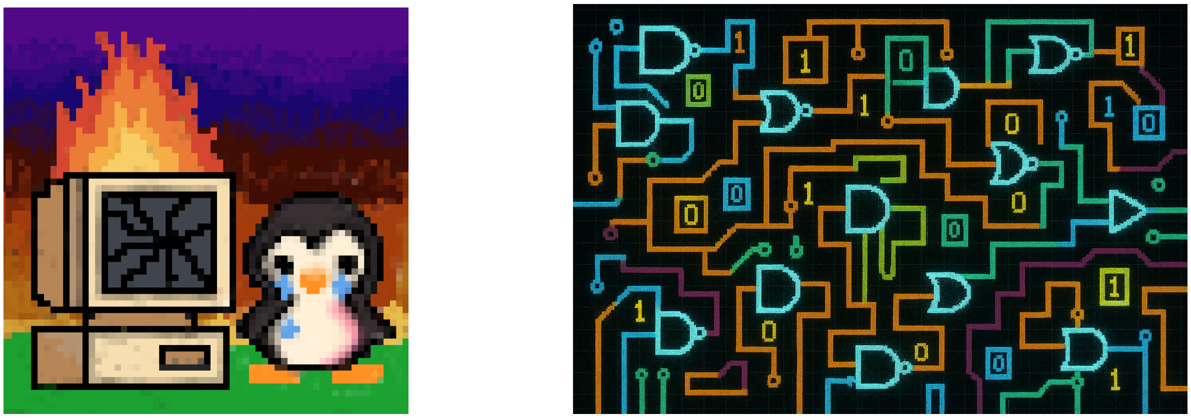
- Final exam, 31%
- Four exams, 11% each
- Approximately 7 homework assignments, 7% total
- Two laboratories, 5% each
- Participation opportunities, 8% total

The letter grade is typically defined as $A \geq 90\%$, $B \geq 80\%$, $C \geq 70\%$, $D \geq 60\%$, and $F < 60\%$.

This division between audiences and content has made the ISE sections of the course a good candidate for redesign, specifically through incorporation of flexible assessment and gamification. A goal when redesigning the course is to keep the different audience, ISE students, in mind and to create a course that better fits their educational needs and interests.

The redesigned course plan

For the first trial of the redesigned course in the spring 2026 semester, it was decided that all elements of gamification would be optional for the students. This way, the students can choose to



(a) Depiction of a student avatar. (b) Depiction of Zone 1: Logic Labyrinth.

Figure 1: Graphics used in the redesigned course syllabus.

follow a traditional route for class if they feel they do not have the time for the extra elements. The following mandatory assignments and weighting schemed were decided for all students:

- Final exam, 30%
- Three exams, 16% each
- Two laboratories, 6% each
- Approximately 7 homework assignments, 10% total

The letter grade distribution was kept the same, $A \geq 90\%$, $B \geq 80\%$, $C \geq 70\%$, $D \geq 60\%$, and $F < 60\%$. In comparison to the previous plan for the course, the number of exams has decreased and class participation has been shifted to entirely optional. The weighting of the laboratories has increased slightly, as well as the weighting of the homework.

The design and style of the game was inspired by the course content. The game is titled 'Pixel Pilgrimage.' The following excerpts explaining the game are included in the class syllabus.

> *"**Game Premise:** You are a pixelated avatar who once lived inside a thriving digital home, a computer. But one day, the system crashed. You have been forcefully ejected from your home and find yourself in the frightful wasteland known as the Glitchlands. You are surrounded by fragments of corrupted files, broken circuits, and missing design building blocks. The only way to return to your home is to rebuild your computer home, piece by piece. You have fifteen weeks to master the core concepts of digital design and earn points to restore your beloved home." (See Figure 1a)*
>
> *"**The Journey:** You are currently stranded in the Glitchlands. To rebuild your home, you must acquire the tools from each of the four zones:*
>
> 1. *Logic Labyrinth (Digital Logic) – A maze of flickering circuits and broken gates. You need to solve puzzles using logic gates to find your way through the labyrinth. (See Figure 1b)*

2. *Binary Basin (Number Systems) – A shimmering basin made up of streams of numbers, all in different bases (binary, decimal, hexadecimal). The clash of these streams yields dangerous waters, impossible to cross. It is your job to learn how to convert and manipulate the numbers so that you can pass to the other side in peace.*
3. *State Machine Stronghold (Finite State Machines) – A fortress whose doors only open in specific sequences. Finite state machine stand guards, demanding that you design and predict state transitions to progress.*
4. *Assembly Arena (Basic Assembly Programming) – A gladiatorial arena filled with corrupted code. You must wield the language of the land, assembly programming, to rewrite instructions and vanquish your enemies."*

The optional assignments offered through Pixel Pilgrimage are termed 'challenges.' Completion of each challenge corresponds to a certain amount of 'Pixel Points,' the in-game currency that can be converted to a reward at the end of the semester.

- Participation question, 1 Pixel Point: Answer short, in-class questions through Canvas.
- System sync connect, 2 Pixel Points: Write a few sentences (no more than four) explaining the connection between a topic from each day's lecture to a concept or process you have learned about in industrial engineering.
- System sync reflect, 2 Pixel Points: At the end of a lecture, submit a well-posed question regarding something taught in the class that was confusing. Ex: "What is the difference between gray code and binary?", "Can finite state machines be used for traffic lights?"
- Weekly debug, 10 Pixel Points: Complete a short canvas quiz on basic material from the past week of lecture. These questions will be easier than the homework.
- Zone mapping, 10 Pixel Points : Create a concept map/diagram showing the connection between different topics/processes in one zone. Some labels will be provided as a starting point, but more can be added as you see fit.
- Laboratory preparation, 15 Pixel Points: Answer preliminary open-ended questions and familiarize yourself with any software that will be used in a laboratory.
- Boss battles, 15 Pixel Points : Solve multi-step problems that incorporate the information from the whole zone.
- Exam corrections, 20 Pixel Points: Review your graded exam, explain your original error for any incorrect answers, and provide the corrected solution. Answer a short survey reflecting on your exam preparation and any changes you will make for future studying.

Each challenge was informed by evidence-based teaching and assessment strategies. For instance, the 'system sync connect' and 'zone mapping' challenges are techniques intended to improve the robustness of the students' knowledge networks, where they are tasked with connecting new information to familiar concepts [16] and to find the connections between new material [17]. The 'participation questions' and 'system sync reflect' are active learning techniques to improve in-class engagement [18]. The 'weekly debug' and 'laboratory preparation' challenges are designed to help students with retrieval of the previous week's concepts and prediction with the material to come in the following week [19, 20]. The 'boss battles' borrow elements from problem-based learning to test the limits of the students' knowledge through open-ended and realistic problem solving [8]. Lastly, 'exam correction' challenges are designed to prompt self-reflection and metacognition [21]. A course calendar is provided to the students to keep track of all mandatory assignments and optional Pixel Pilgrimage challenges.

The amount of Pixel Points accumulated by a student over the semester is then converted to a reward. The rewards are decided based on the total amount of Pixel Points offered throughout the semester. All students who earn more than 80% of the total points offered earn 'The Pilgrim's Seal,' which allows them to replace their lowest exam score with their highest exam score. In the context of the game, The Pilgrim's Seal is the last piece needed to repair their computer and return home. All students who earn less that 80% but more than 50% of the total amount of points earn 'The Hallowed Pixel,' which allows them to replace their lowest exam score with their second-lowest exam score. In-game, The Hallowed Pixel allows the students to mostly repair their digital home, but glitches and sparks remain.

In addition to the threshold-based rewards, six ranking-based rewards are awarded to the top six Pixel Point earners of the semester. The six top earners earn bonus points added directly to their final exam score. The first-placed student earns six bonus points, the second-placed student earns five, and so on, with the sixth-placed student earning 1 bonus point on their final exam score.

This reward system was ultimately decided on in conjunction with the course coordinator in order to ensure that academic rigor is maintained for the students participating in Pixel Pilgrimage.

Methods

Early-Course Feedback

In the sixth week of the semester, early-course feedback was conducted for the gamified section of the course. This feedback was conducted through a 20-minute focus group-style discussion between the CTL faculty member and the students, with the instructor not present in the room. Following this discussion, the students had the option to fill out a short survey on their gamification experience. At this point in the semester, the students had just completed the first zone of the game, i.e., they had taken their first exam and those participating had completed exam corrections. The students had therefore had the opportunity to experience each facet of the gamified course by this time.

This survey consisted of the questions:

1. How clear are the gamification assessment options for this class?
    - (a.) I understand how the gamification option works
    - (b.) I somewhat undertand how the gamification option works, but some aspects are unclear

(c.) I am confused by the gamification option

2. What are your thoughts on the potential reward for completing the gamification option?
   (a) The potential reward is motivating and achievable.
   (b) The potential reward is too difficult to achieve
   (c) I am planning to become one of the top three placed students
   (d) Both (a.) and (b.)

End-of-Semester Survey

At the end of the semester, the students are asked to fill out an anonymous survey. We aim to use these answers to inform changes that need to be made to the gamified class in future semesters, and to see if there are any signs of increased interest or intrinsic motivation. The survey questions are as follows:

1. How interested are you in the topics this course addressed?
   (a) A great deal of interest in the topics
   (b) Mild interest in the topics
   (c) Not interested in the topics
2. In this course, you got to choose the way your grade was determined. (e.g. you may choose to complete different assessment types with different weighting and/or impact to your final grade). How did you feel about this flexibility?
   (a) I liked the flexibility because it benefited my learning and performance in the course
   (b) I felt indifferent about the flexibility because I didn't believe it would affect my learning or performance in the course
   (c) I disliked the flexibility because it negatively impacted my learning and performance in the course
3. How do you feel about a flexible grading scale (options on what assessment types you complete and/or how each assessment type impacts your final grade) as compared to a traditional grading scale (all students complete the same assessment types, including exams, which have the same weight on everyone's final grade)?
   (a) I prefer a flexible grading scale over a traditional grading scale
   (b) I prefer a traditional grading scale over a flexible grading scale
   (c) I do not have a preference between flexible and traditional grading scales
4. How stressful did you find each of the course assessment types? Please select 3: extremely stressful, 2: moderately stressful, or 1: not at all stressful for each type of assessment
   - Exams
   - Homework

- Labs
- Pixel Pilgrimage

5. How did each of the course assessment types affect your motivation in this course? Please select 3: boosted my motivation, 2: had no effect on my motivation, or 1: was demotivating
   - Exams
   - Homework
   - Labs
   - Pixel Pilgrimage
6. How did each of the course assessment types impact your grade in the course? Please select 3: helped improve my grade, 2: didn't have a major impact on my grade, or 1: brought my grade down
   - Exams
   - Homework
   - Labs
   - Pixel Pilgrimage
7. How well did you feel each of the course assessment types allowed you to demonstrate your learning in this courses? Please select 3: ideal demonstration of learning, 2: weak demonstration of learning, of 1: misrepresentation of learning for each type of assessment:
   - Exams
   - Homework
   - Labs
   - Pixel Pilgrimage
8. How clear was it what was expected of you for each course assessment type? Please select 3: the expectations for the assessment were clear, 2: while most expectations for this assessment were clear, I had some questions that needed to be addressed, or 1: I found this assessment confusing and was not sure what was expected of me
   - Exams
   - Homework
   - Labs
   - Pixel Pilgrimage
9. What is your major?
10. What year are you in the program?

How clear are the gamification assessment options for this class?	Responses	Percentage of Respondents ($n = 31$)
a. I understand how the gamification option works.	20	65%
b. I somewhat understand how the gamification option works, but some aspects are unclear.	11	35 %
c. I am confused by the gamification option.	0	0%

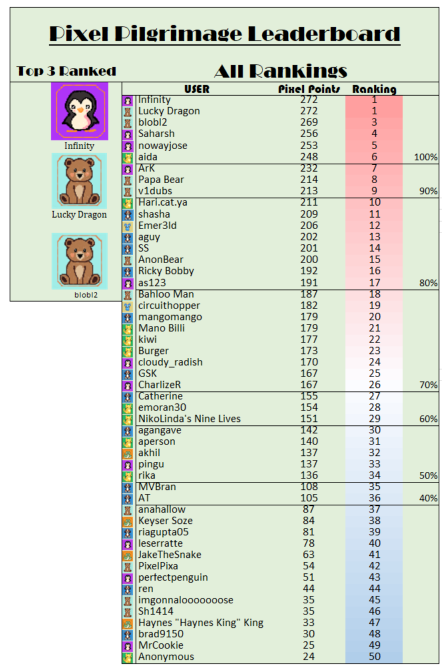
Table 1: Early-course feedback survey clarity of gamification repsponses.

Following all Questions 1-8, there is an optional free response box for students to use to elaborate on their answers.

Post-Course Statistic Analysis

Once the final grades are determined for the class, statistic measures of performance will be gathered and compared. Particularly, we plan to analyze the traditional grade performance of the students who participated in Pixel Pilgrimage and those who didn't, by comparing what grade both groups would achieve if the rewards offered through Pixel Pilgrimage were not utilized. These statistic measures will then be compared with the rewarded final scores of those students who participated in Pixel Pilgrimage.

Additionally, we will investigate the level of participation in the optional assignments as the semester was carried out. Changes in the level of participation could be used to inform the value students placed on the specific categories of assessments.



Pixel Pilgrimage Leaderboard

Top 3 Ranked: Infinity, Lucky Dragon, blobl2

All Rankings

USER	Pixel Points	Ranking	
Infinity	272	1	
Lucky Dragon	272	1	
blobl2	269	3	
Saharsh	256	4	
nowayjose	253	5	
aida	248	6	100%
ArK	232	7	
Papa Bear	214	8	
v1dubs	213	9	90%
Hari.cat.ya	211	10	
shasha	209	11	
Emer3ld	206	12	
aguy	202	13	
SS	201	14	
AnonBear	200	15	
Ricky Bobby	192	16	
as123	191	17	80%
Bahloo Man	187	18	
circuithopper	182	19	
mangomango	179	20	
Mano Billi	179	21	
kiwi	177	22	
Burger	173	23	
cloudy_radish	170	24	
GSK	167	25	
CharlizeR	167	26	70%
Catherine	155	27	
emoran30	154	28	
NikoLinda's Nine Lives	151	29	60%
agangave	142	30	
aperson	140	31	
akhil	137	32	
pingu	137	33	
rika	136	34	50%
MVBran	108	35	
AT	105	36	40%
anahallow	87	37	
Keyser Soze	84	38	
riagupta05	81	39	
leserratte	78	40	
JakeTheSnake	63	41	
PixelPixa	54	42	
perfectpenguin	51	43	
ren	44	44	
imgonnaloooooooose	35	45	
Sh1414	35	46	
Haynes "Haynes King" King	33	47	
brad9150	30	48	
MrCookie	25	49	
Anonymous	24	50	

Figure 2: Leaderboard

In-Progress Results

In the second week of the semester, the students were asked to select a username and an avatar if they wished to participate in the optional gamification of the course. All of the 50 students in the class opted to participate in Pixel Pilgrimage, with a couple students first clarifying that there could be no negative impact to their grades if they participated.

On the Canvas home page for the course, a leaderboard was displayed throughout the semester and updated weekly. Displayed in Figure 2, this helped the students keep track of their Pixel Points and instilled a friendly level of competition.

During early-course feedback, the majority of students indicated that they understood the mechanics of Pixel Pilgrimage, with results displayed in Table 1. A minority of students expressed that some aspects were unclear, particularly the reward structure. No respondents reported being confused by the gamification option.

Prior to the start of this trial semester, it was difficult to predict the amount of points that should be awarded for each challenge type and what the reward thresholds should be. As the semester went on, it became clear to the instructor that the point scheme should be rearranged and that the threshold for rewards should be lowered. It was a concern that if the reward threshold was kept where it was, Pixel Pilgrimage would discourage students rather than motivate the students early on in the semester.

What are your thoughts on the potential reward for completing the gamification option?	Responses	Percentage of Respondents $(n = 31)$
a. The potential reward is motivating and achievable.	14	45%
b. The potential reward is too difficult to achieve.	11	35 %
c. I am planning to become one of the top 3 placed students.	0	0%
d. Both a. and b.	6	19%

Table 2: Early-course feedback survey second question responses.

In the sixth week of the semester, early-course feedback was carried out with the students. The CTL faculty member who facilitated the discussion noted that the majority of time was spent discussing the gamification. The results of the survey questions are reported in Tables 1 and 2. In discussion, the students unanimously agreed that the reward thresholds should be lowered. Initially, the highest reward required the students to earn 90% of the total Pixel Points offered throughout the semester, with the lower reward requiring the students to earn 70% of the total Pixel Points. After early-course feedback, the instructor agreed with the students that the thresholds should be lowered to 80% and 50%, respectively. In addition, the students requested that the top five students in the ranking be awarded bonus points on the final exam. The instructor agreed with this suggestion and changed the ranking rewards to be for the top six students rather than just the top three.

When the reward thresholds were shifted, the instructor also made the following changes to the amount of Pixel Points awarded for the different challenge types. Originally, the system sync challenge, which served as an exit ticket for lecture, was included in the count of the total points offered to the students, from which the threshold levels were calculated. However, this seemed to incentivize students to ask ill-formed questions for the sake of earning Pixel Points, instead of out of true confusion. The two points per lecture that could be gained through system sync were excluded from the total point count that would be used for thresholding as a result, becoming an opportunity for bonus points instead.

The amount of points earned for the zone map challenge was lowered from 25 points to 10. The instructor initially anticipated that the task of creating a visual study guide prior to exams would be more time-consuming and difficult than it proved to be.

The biggest point change was made for the boss battle category. Before the semester started, the instructor anticipated that these challenges would be projects that would require the students to integrate and apply most of the material from each section. For this reason, boss battle challenges were to be rewarded 40-60 Pixel Points. In reality, the amount of time that a project of this scale would take was incompatible with the workload and time constraints of the class. Instead, these

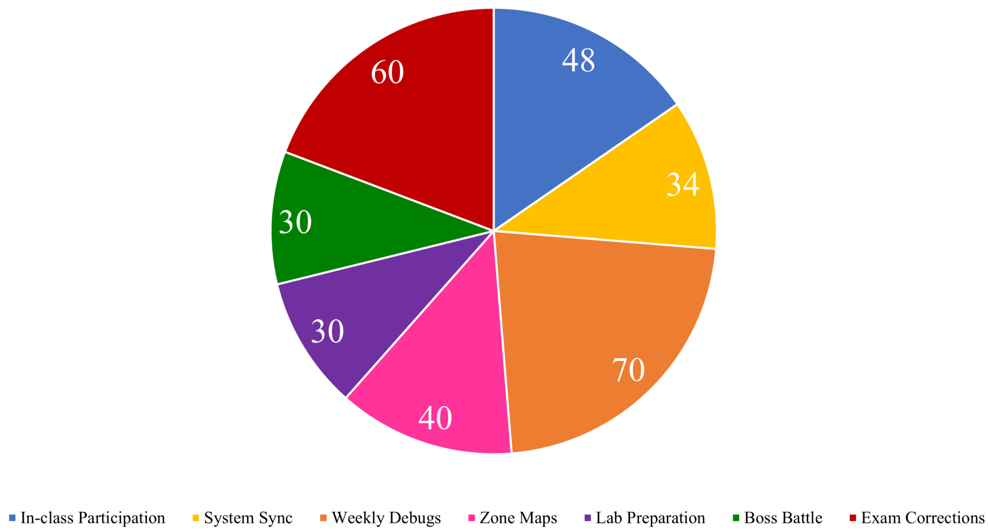


Figure 3: In total, 312 Pixel Points were offered over the semester. This chart shows the number of points that came from each category.

tasks ended up being extensions of the mandatory laboratory assignments. Correspondingly, the Pixel Points per challenge was changed to 15. In future iterations of this gamification, if boss battles as originally anticipated were to be implemented, it would be recommended that these challenges be planned by the instructor well in advance of the start of the semester, so that the students would have adequate time to work on these larger projects.

With the point distribution changed, this left exam corrections to be the challenge with the highest amount of points offered at 20. After the instructor experienced an entire cycle of the gamification in action at the six week mark, they believed that this challenge was the most valuable for the students. Therefore, it was kept as the only category that could earn 20 points in order to heavily incentivize completion by the students.

Figure 2 shows the proportion of Pixel Points that came from each category of challenge over the semester. In total, 312 points were available (including system sync challenges), with the majority of points coming from Weekly Debug quizzes followed by Exam Corrections.

Figure 3 catalogs the level of student participation over the semester for each category of challenge. The graph also marks where each zone began and ended. The in-class participation steadily decreased over the semester, which could be considered typical for an undergraduate class without mandatory attendance. The system sync challenge very quickly established an average of around 10 student respondents for each lecture period. The Weekly Debug quizzes had the highest level of sustained participation, with an average of 37 students completing the challenges. From the early-course feedback, the sentiment that “weekly debug quizzes are useful for reviewing what we learned” was endorsed unanimously. The proportion of students completing the Zone Map study guide challenge increased after the first exam to a little over half of the class. While on average, 33 students participated in exam corrections. The amount of students who participated in the boss battles was relatively low, averaging 19 students.

After the shift in the point and reward structure, many students re-engaged with the gamification

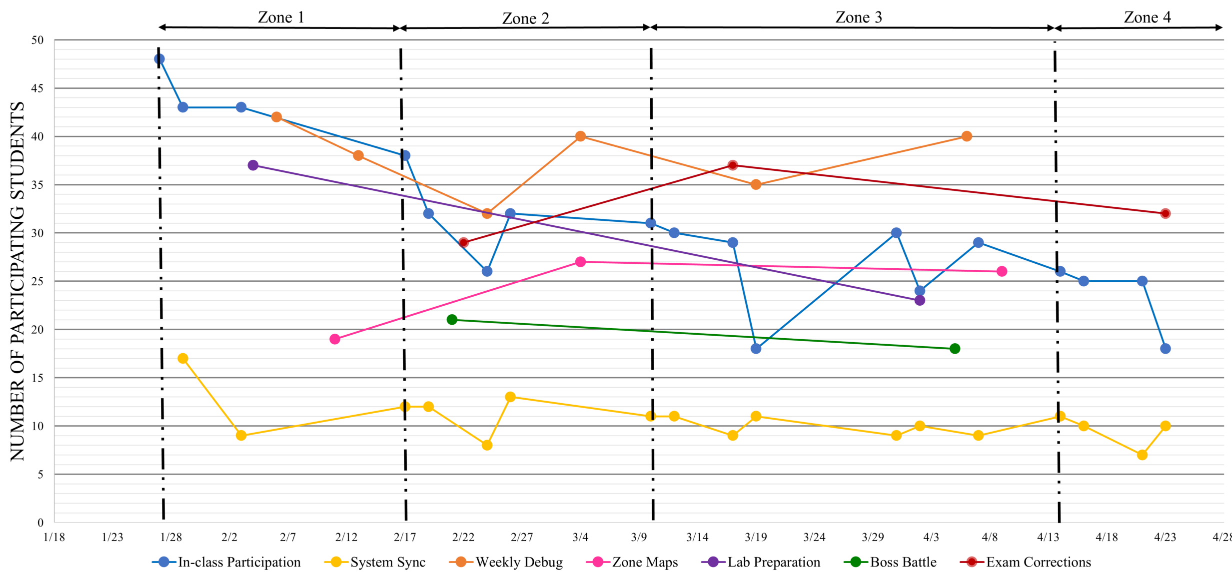


Figure 4: Level of participation in Pixel Pilgrimage over the spring semester.

challenges. This likely came from both a renewed belief in the attainability of the rewards and possibly from a dissatisfaction with their first exam performance. It is crucial for students to be able to recognize their own shortcomings and abilities in order to properly engage with flexible assessment [4]. The instructor of the course is interested in how engagement and enjoyment in gamification would differ in a future semester if Pixel Pilgrimage were to begin after the first exam.

Discounting the System Sync, points which do not factor into the threshold values, the projected threshold for the highest reward which allows students to replace their lowest exam score with their highest exam score is 218. The threshold for the lower reward which allows students to replace their lowest exam score with their second-lowest exam score is 136. These thresholds are quite achievable, and offer multiple routes for earning the required number of points. For instance, if a student attends and participates in class, does all the weekly debugs, and does at least one exam correction, they would attain 138 points. On the other hand, a student that prefers assignments could obtain the lower reward by doing three exam corrections, the two boss battles, the two lab preparations, and two zone maps. Students aiming for the highest reward also have different paths of achievement available. One could be attending and participating in all classes, completing the weekly debugs, completing all exam corrections, and all zone maps.

Six out of the 50 students in the course are projected to finish the semester with Pixel Points above the 100% threshold. These students consistently did every challenge available, including a majority of the optional system sync challenges. In the classroom, these students were open about the competitive spirit of the leaderboard and the ranking rewards being their main motivation. Though in addition, three of these students expressed early-on in the semester that they were planning to earn as many points as they could due to believing themselves to be poor exam takers.

Future of the flexible assessment initiative and concluding thoughts

Following the conclusion of the pilot semester, the preliminary survey and statistic information will be used to make changes to the flexible courses. This semester was greatly helpful for determining a proper Pixel Point distribution and reward structure. As more semesters are used to experiment with this format, a possible consideration would be shifting the reward and gamification structure further away from exam replacements, which remains a fairly traditional reward mechanism. It is crucial to maintain academic rigor when flexibility is implemented, so a different reward, such as doing a final project instead of a final exam, could be trialed in the future as the challenges continue to be refined.

Along this track, there is room for improvement in both the Boss Battles and Lab Preparation challenges. In this first semester, these challenges ended up being fairly equal in their level of difficulty. For a more project-based course, these could be tweaked with adequate pre-planning to shift the point balance to more highly favor these assignments. The boss battles could be used to contribute to a semester-long, ongoing project that allows students to demonstrate mastery in a truly different manner than through exams.

In this semester, it does not seem that the in-class Pixel Points were weighted highly enough to keep up a high level of attendance. In future iterations of this course, the amount of Pixel Points gained through in-class participation should be increased if a higher level of attendance is desired by the instructor.

The weekly debug quizzes and exam corrections were highly valued by both the students and the instructor. The quizzes gave students frequent opportunities to check their conceptual understanding of new material. Throughout the semester, the ability to retake the weekly debug quizzes before the due date was frequently used as a tool to increase the amount of Pixel Points earned by the students. Additionally, the students requested that the quizzes remain available even after the due dates so that they could be used as a study tool prior to exams.

The instructor felt that exam corrections, specifically the short, reflective questionnaire that was required in addition to corrected answers, was a helpful tool to encourage students to frankly check-in with themselves and the instructor regarding their progress in the class. The instructor used the student responses on these surveys as a tool to redirect and offer help to students when they recognized they were struggling, especially if these students did not reach out for guidance or help on their own. This challenge prompted the students to keep in mind the cumulative nature of both the course material itself and the final exam, encouraging them to identify past topics they needed to spend more time on as the class continued to progress.

As this work is in-progress, we do not yet have data regarding the students' final grades or their end-of-semester feedback survey. We anticipate that this information will further impact future iterations of this gamified course. As this initiative continues, if a positive impact is found between the implemented flexibility and student satisfaction and performance, we plan to share our findings and course templates with other engineering faculty members. We hope to spend the future trial semesters altering the flexible assessment experience for students, and then turning our attention to ease of implementation for the instructors. Ultimately, we plan to create a refined flexible template that improve the students' quality of education without much trial and error needed on the side of the instructor.

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