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Work In Progress: Gamification in Statics

Dr. Seyed Mohammad Seyed Ardakani PE, Ohio Northern University

Dr. Ardakani is an Associate Professor of Civil Engineering at Ohio Northern University. He has previously served as a Project Engineer at Englekirk Structural Engineers and a Lecturer at South Dakota State University. He obtained his Ph.D. in Civil Engineering from the University of Nevada, Reno. His research interests include engineering education, seismic performance and design of reinforced concrete structures, and computational modeling of structures. He received the 2020-21 Professor Henry Horldt Outstanding Teaching Award.

Caleb Collert, Ohio Northern University

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Abstract

Statics has long been recognized as a challenging course for college students, often associated with low engagement and poor performance. This study aims to address these challenges by developing a gamified learning experience designed to increase motivation and improve understanding of key concepts. The purpose of this project is to evaluate whether interactive gameplay can enhance student motivation, engagement, and confidence when dealing with Statics problems.

The method of gamification used was a story-based video game. As the students progress through the story, they come across four puzzles centered around fundamental topics from Statics. The first level introduces a friction problem focused on utilizing their understanding of capstans to lift a door. The second level explores frames and machines. The third level involves truss analysis, challenging the students to find the force in a member to fix a broken bridge. The fourth and final level requires students to create a shear diagram of a simply supported beam holding up the final treasure chest, along with the maximum moment. Each level provides real-time feedback: a deduction of coins when the student enters the wrong answer, and an award of 10 coins for the correct answer. The coins are used to place the students on an anonymous leaderboard between peers, which is shown at the end.

Participants were chosen via a convenience sample of Statics students. Quantitative data, including in-game accuracy and time spent per question, was used to measure if the game difficulty is appropriate, while qualitative survey data captured students' perceptions of engagement, motivation, perceived learning, and confidence. The collected data indicated that the game was sufficiently engaging and motivating for students, with 100% of the students agreeing or strongly agreeing that it was more engaging than regular homework. 80% of the participants agreed or strongly agreed that they felt more confident solving Statics problems. However, with a sample size of only 10 students, a generalization can not be made.

Introduction

A common definition used for Statics is the study of the distribution and effect of forces on rigid bodies that are at rest and remain at rest [1]. In many engineering programs, particularly civil and mechanical, Statics is regarded as a foundational course and is often introduced early in the undergraduate curriculum [2]. The concepts introduced in Statics, such as free-body diagrams, equilibrium, trusses, frames and machines, internal forces, and shear and moment diagrams, serve as important prerequisites for more advanced material. Despite being taught as a first or second year course, Statics consistently proves to be one of the most challenging courses for engineering students. In 2025, a study was conducted at Iowa State University examining around 1200 students. The researchers identified three primary factors contributing to the perceived difficulty of Statics. First, Statics is a concept-heavy course that assumes a level of prerequisite mastery, particularly in mathematics, physics, and vector operations, that many incoming students do not possess. Second, the course has a highly cumulative structure in which early conceptual gaps increase as the course progresses. Third, students' prior mathematics preparation, especially the level of the first college mathematics course completed, was found to be a strong predictor of success in Statics. These researchers noted that the DFW rate for students has risen from 30% to nearly 50% in recent years due to these reasons [3]. A study in a midwestern university reinforced this notion, finding that 26.9% of students in Statics ended with a D, F, or W. This is significantly higher than the 11.4% average across all courses [1]. These outcomes highlight persistent challenges associated with learning Statics. Beyond the conceptual difficulty, Statics instruction often relies heavily on traditional lecture-based methods, which may not sufficiently support student engagement or motivation. When students fail to see the relevance of abstract concepts, their interest may decline, further exacerbating learning difficulties. These factors suggest a need for an updated method that not only supports conceptual understanding but also increases student engagement and motivation. Gamification has emerged as a promising instructional approach to address this problem. Gamification can be described as the application of game design elements or mechanics in non-game contexts, or more simply, making non-game activities more game-like [4] - [6]. Common implementations of gamification in educational settings include electronic badges and leaderboards [7], as seen in Kahoot! [8], role-playing elements, as seen in Classcraft [9], or serious games [10]. A serious game is defined as a fully fledged game and can take many different forms. Gruber and Faßbender created a serious game designed as an escape room to teach STEM to higher education students [11]. Another serious game may involve a turn-based strategy like *Sid Meier's Civilization IV: Colonization*, which was utilized to improve participation in a history class [12]. Puzzle games are another common form of serious games. Idika and Oluwaseyi used a puzzle game to teach undergraduate chemistry students about periodicity. It resulted in the students participating in the puzzle game having the highest mean score compared to video-based learning and conventional learning [13]. Many of these techniques have already been utilized in engineering disciplines closely related to Statics. Recent studies have demonstrated the effectiveness of game-based learning in teaching civil engineering concepts such as infrastructure decision-making and geotechnical engineering. For example, Beck and Cha developed a cooperative board game that simulates infrastructure resilience challenges, requiring students to make multi-criteria decisions about retrofitting electric distribution systems while balancing equity, community impact, and resource constraints. Using a self-assessment on a scale of 1-5, the students felt their skills improved from 3.22 on average to 4.01 after playing the game [14]. Bennet et al. created a mixed-reality learning platform called GeoExplorer that provides a virtual levee inspection experience, enabling students to develop engineering judgment through identifying failure mechanisms and proposing mitigation measures. They found that understanding and retention of key concepts were improved in the students who participated in the game-based learning module [15]. Previous research has shown that gamification has a positive impact on learning fundamental physics as well. In a 2024 meta-analysis of 10 studies involving a total of 385 participants, 8 of the studies reported quantitative results. Synthesizing the data, it was found that gamified learning environments were associated with a statistically significant improvement in student performance, as determined by a random-effects model [16]. The research showed that students in gamified learning environments were approximately 25 times more likely to show improved performance compared to students in traditional learning environments. Examining numerous published studies reveals the same positive correlation between a gamified learning environment and test results when gamification is used in an undergraduate setting. A longitudinal study was conducted, looking at data from 1001 higher education students in the years 2020 to 2023. It compared three methods of teaching: online, traditional, and gamified. In the overall course grade, the gamified experience showed better outcomes than online and traditional. The most drastic increase was in the students' excellence rate. Students said gamification increased their learning outcomes, engagement, productivity, and motivation [17]. In fact, many of the studies reviewed agree that gamification has a positive impact on motivation and engagement in course content. This is important because, according to a cross-sectional study involving 514 students, motivation related to course content is associated with positive effects on learning outcomes and GPA [18]. One major contributing factor to motivation in the classroom is proper feedback. Teacher feedback was found to play a crucial role in course satisfaction and learning outcomes [19]. Games help professors because they provide immediate feedback to players and promote experimentation [20]. The primary objective of the study was to develop a gamified activity that leverages the noted benefits of gamification, such as incentive-reinforced motivation and engagement, to increase student engagement, motivation, and perceived learning outcomes.

Game Design

According to prior research, puzzle games have consistently shown to increase students' cognitive performance [13], [21], [22] and motivation [23]. According to a 2017 study analyzing the effects of Digital Story, digital storytelling can greatly increase student achievement and motivation. A group of 31 students was randomly selected as the experimental group, and their performance was compared with that of 30 students in the control group in the Turkish Literature-II course at the Recep Tayyip Erdoğan University Education Faculty Turkish Education Department. The experimental group was taught using Digital Story (stories told in an online environment), and the control group was taught traditionally. The Achievement test was used to examine the students' knowledge of Turkish literature. The results showed that the experimental group outperformed the control group on the post-test “Achievement Test” by an average of 12.66% [24]. In the current study, a puzzle game was created for the game-based learning tool. Additionally, an overarching narrative was included in the game due to its benefits. The narrative for the game is loosely based on the Indiana Jones movies. The player takes the role of a treasure hunter who receives a call from a colleague about hidden gold. They fly to the temple where the treasure is and try to collect the maximum number of coins along the way. In this mission, the player is faced with four puzzles set up by the ancient civilization to protect their treasure. After completing the four puzzles, the player is awarded the final treasure, and the game ends. This storyline offers many opportunities to implement Statics-based challenges without breaking the narrative's immersion. The puzzles set up by the ancient tribe are solved using Statics concepts, and the number of coins collected throughout the game is used in the scoring system. The gameplay process is linear and proceeds as follows. On startup, the player is prompted to enter their gamertag. This is used for tracking the player's performance. After submitting the name, the game starts with exposition and a cutscene of the player taking their plane out on a search for the treasure. When the player lands in the jungle, they are greeted by two sets of steps, both leading to the entrance of the temple, and floating text explaining how to control the character, as seen in Figure 1. The user interface is also minimal, showing only the total time, the current question time, and the total coins collected. The game tracks these statistics for each player.

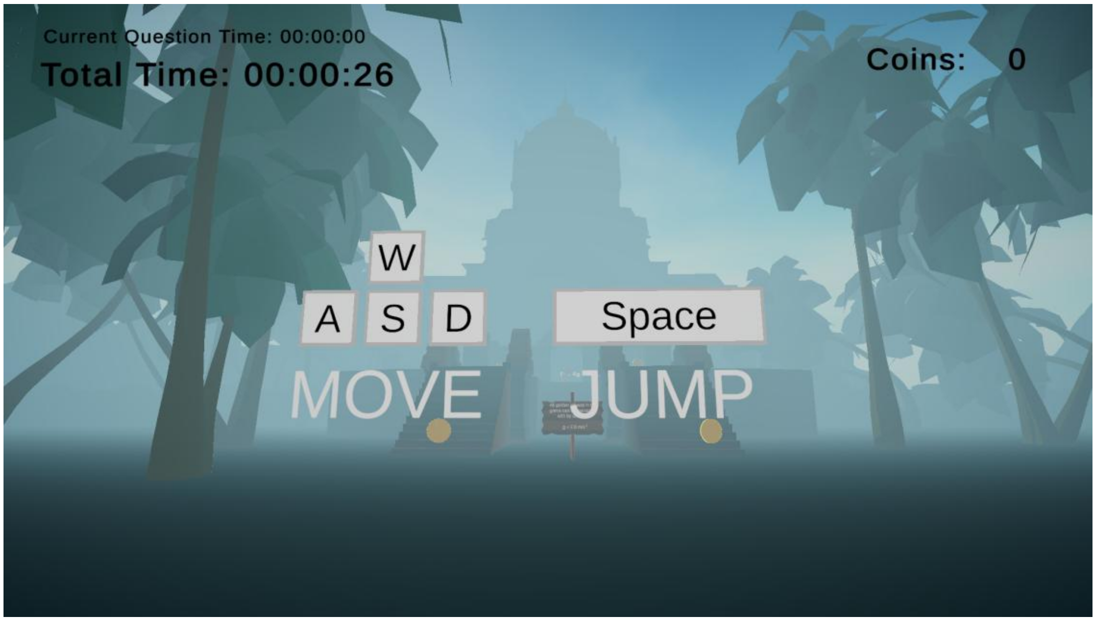

Figure 1: Temple entrance and controls display

As the player approaches the temple entrance, they will notice it is blocked by a large door (Figure 2). This is the very first problem, one that tests the player on their knowledge of friction. Particularly, the students must determine the maximum force required to lift the door. The rope is attached at the top of the door in the center and wrapped around a pole above the door. Throughout all of the problems, some of the values are randomized. In this problem, the friction coefficient between the rope and the pole, and the mass of the door are randomized. Once solved, the player can continue into the temple.

Figure 2: Friction problem (Puzzle One)

Once inside, they will see a massive frame holding up a sculpture of the sun (Figure 3). The sun sculpture problem addresses frames and machines. The player needs to find the horizontal and vertical components of the force at pin B. The problem involves the students identifying the two-force member and isolating the appropriate members of the frame to construct a free-body diagram. This process emphasizes a critical learning outcome: the ability to separate a complex structure into simpler components and apply equations of equilibrium. The mass of the sculpture being held by the pulley, along with the dimensions of the frame, are the values being randomized. Once the values of Bx and By are properly identified and entered into the text box, the machine will release the sun sculpture, as shown in Figure 3.

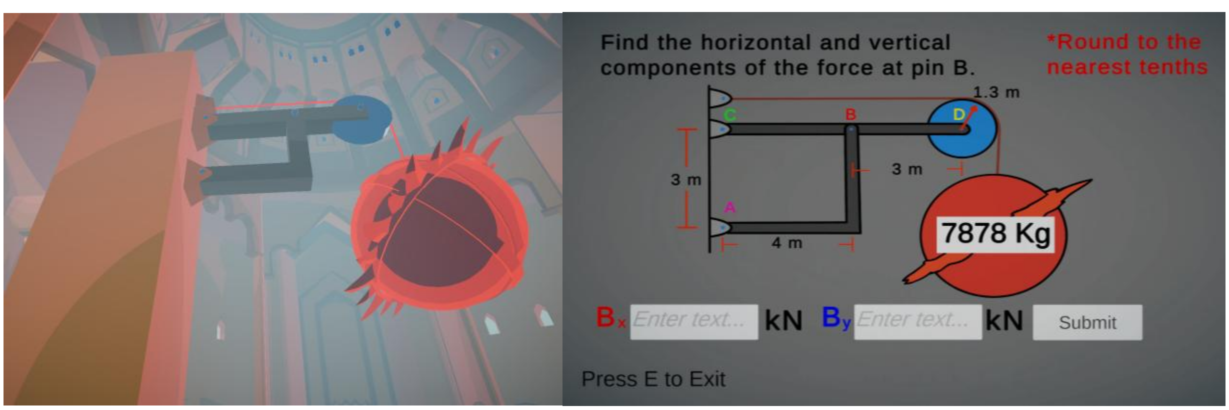

Figure 3: Frames and machine problem (Puzzle Two)

After the release of the sun sculpture, it will crash through the floor, revealing tunnels. On top of the sun sculpture, there is a key that the player needs to collect in order to unlock the door to the treasure room (Figure 4).

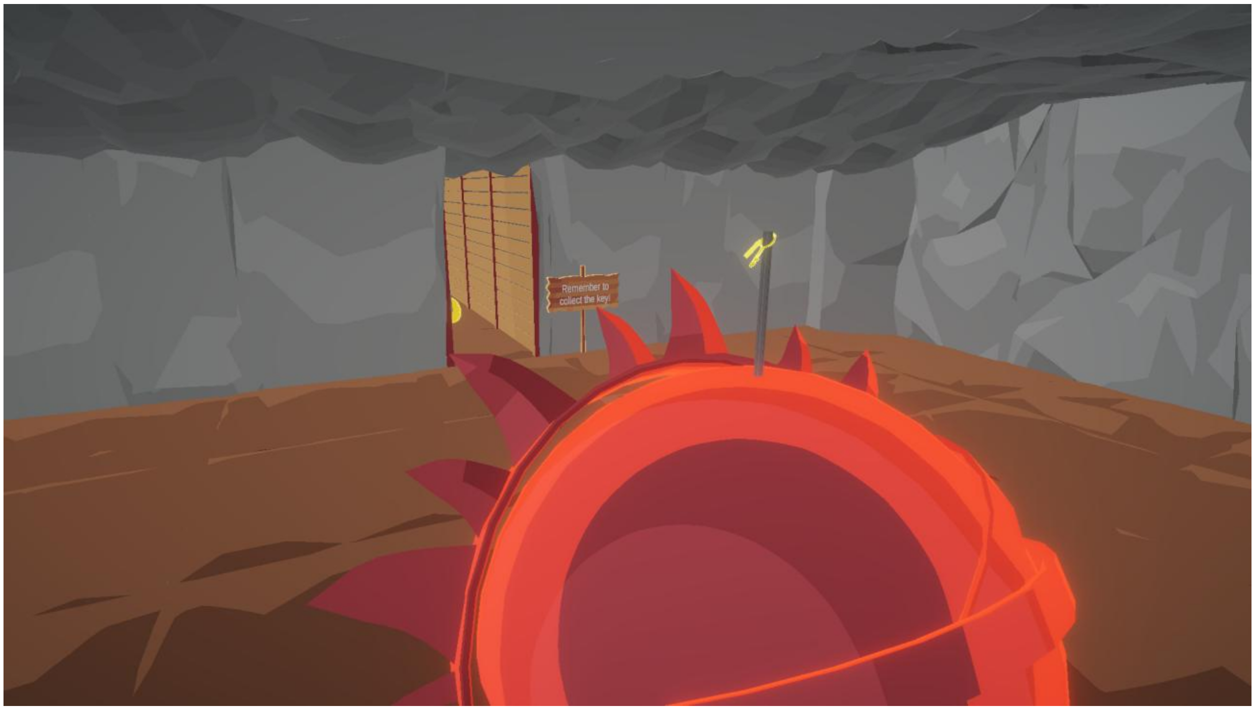

Figure 4: Tunnel and key

Down in the tunnels, the player will pick up the key to the treasure room and continue onward towards a broken bridge. In order to repair the bridge, one must employ truss analysis to determine the force acting on the missing members (Figure 5). This level reinforces the method of joints or the method of sections, depending on which route the students take. It also teaches the importance of assuming correct force directions and interpreting tension versus compression. In this challenge, the values of the forces acting on the joints are randomized.

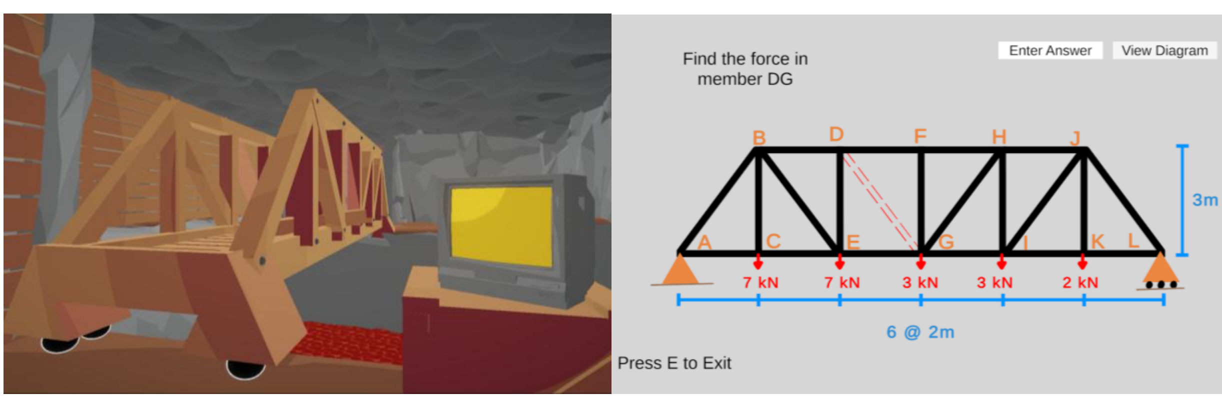

Figure 5: Truss problem (Puzzle Three)

Once solved, a door will open up, giving the player access to the two missing members. The player must pick up the members and place them in their spots on the bridge. When completed correctly, the bridge becomes usable, and the player can cross to the treasure room. The final puzzle takes place in the treasure room. As seen in Figure 6, the golden chest that the player has been searching for is on a simply-supported beam. The chest remains locked unless the player can input the correct shear diagram and maximum moment (Figure 6). Students must properly understand distributed load, shear, and moment diagrams to answer the question correctly. The values randomized are the weights of the objects on the beam.

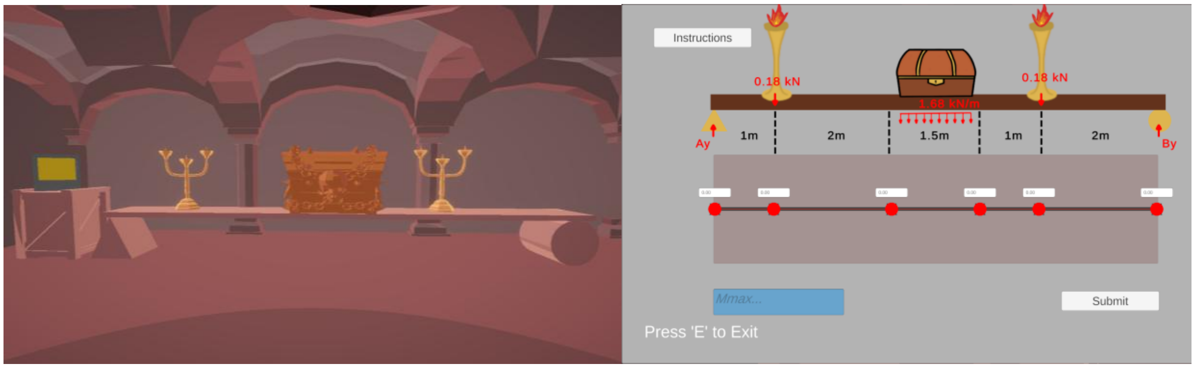

Figure 6: Shear diagram and maximum moment (Puzzle Four)

Once all four questions are answered correctly, the player reaches the final screen, congratulating them on completing the game and showing the number of coins collected. The coin system was one of the many systems of feedback and rewards utilized in the game. In the introduction, the players are informed that 52 coins can be collected. These coins are either earned from answering problems correctly or found scattered throughout the world. The coins in the world are used to guide the player as the line of coins draws players from problem to problem. Collecting all 52 coins is a challenge, as coins are not only used for positive reinforcement but also for negative punishment. When a question is answered incorrectly, the game removes 1 coin from the total coin count. There is also auditory feedback when interacting with parts of the game. High-pitched ding sounds for getting questions right or collecting coins, and low-pitched buzz for answering questions wrong. When getting questions wrong, there is also a red text pop-up telling the player they were incorrect for accessibility reasons. Another form of reward used for correct answers is environmental changes. The players get to see things such as the fixed bridge, the falling sun sculpture, or the rising door. The four different types of problems were chosen due to their alignment with the content on the Statics exam.

Study Design and Methodology

12 students enrolled at the time in a Statics class volunteered to play the game. The game was utilized as a tool to give participants extra practice before their upcoming exam. The study was split into two different sessions: a morning session and an evening session. There was no time

limit placed on the players, and playthroughs did allow intervention from those conducting the study. If a student got stuck, they were able to ask for help. The game was connected to a Google Sheet during the playthrough to hold the students' performance data. The Google sheet tracked total time, time for each problem, total coins, and the number of failed and successful attempts on each problem. After the players completed their playthrough of the game, they were given a 20-question survey through a Google Form. The survey featured multiple-choice, open-ended, and 5-point Likert scale questions. Figure 7 displays the questions and their types.

Question	**Question Type**
What is your current grade in Statics?	Multiple Choice
How would you rate your prior confidence in the Statics concepts covered in this game before playing?	Likert Scale
The challenges or puzzles in the game reinforced concepts I learned in class	Likert Scale
I feel more confident solving problems related to the topics covered in the game.	Likert Scale
I feel more confident applying Statics concepts to real-world problems.	Likert Scale
The difficulty of the problems felt appropriate.	Likert Scale
Which Statics problem was most effective? Why?	Extended Response
Which Statics problem was least effective? Why?	Extended Response
I felt motivated to continue playing and complete the challenges.	Likert Scale
The game was more engaging than a typical homework assignment.	Likert Scale
There was a good balance between learning and gameplay.	Likert Scale
I would prefer more learning activities in this format.	Likert Scale
The game interface was easy to navigate.	Likert Scale
The interactive visuals helped me better understand the problems.	Likert Scale
The length of the game was appropriate	Likert Scale
Were there technical performance issues? If so, what were they?	Extended Response
I am satisfied with the game as a learning tool	Likert Scale
Would you play this game again?	Multiple Choice
Would you recommend this learning game to other students	Multiple Choice
Any final comments or suggestions for improvement?	Extended Response

Figure 7: Survey questions

Results

The survey was conducted anonymously, with 10 students participating. Figures 8 to 10 show the students' responses. Since the survey was anonymous, the results of how the students performed on their test following the study were not accessible. Therefore, it is unknown how the game may have affected their performance. The survey results indicate that the students felt the game had a positive effect on their learning. Looking at Figure 8, 60% of participants strongly agreed that the game reinforced concepts they were taught in class. When given the open-ended question asking which Statics problem was most effective, students were roughly equally split between the second, third, and fourth. The game also seemed to have a positive impact on their confidence in relation not only to the questions covered in the game, but also to Statics problems in general. Figure 8 shows that 80% of the respondents felt more confident in both categories after playing the game. Overall, a majority of the students were satisfied with the experience and the game's potential as a learning tool.

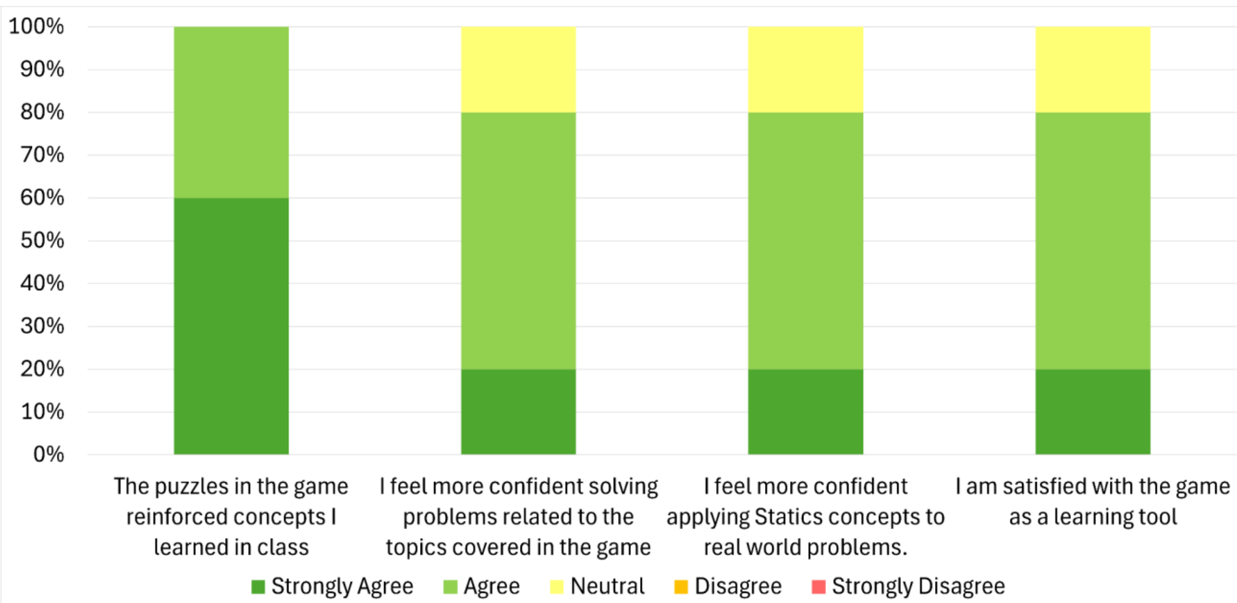

Figure 8: Responses related to learning and confidence

The students also felt that the game improved their motivation. 70% of the participants reported feeling motivated to continue playing and completing challenges, as shown in Figure 9. All of the respondents agreed that the game was more engaging than a typical homework assignment. However, not all of the students said they preferred more activities in the same gamified format.

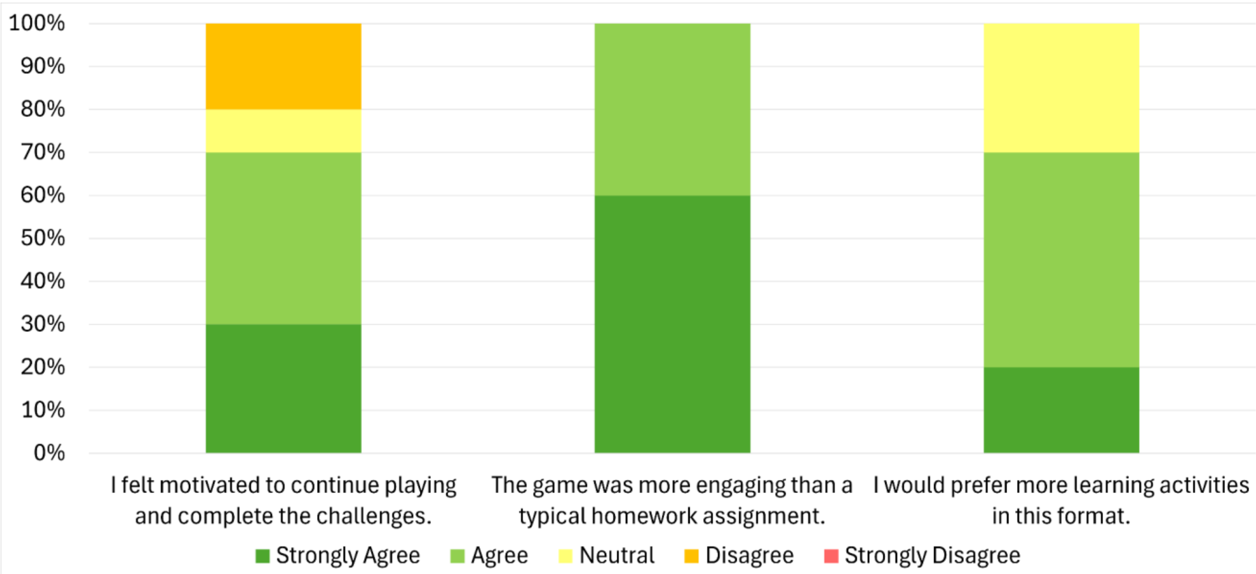

Figure 9: Responses related to motivation

In general, the students felt that the game's user interface and experience were good. Figure 10 shows that 80% of the students responded saying they felt the game's interface was easy to navigate. 90% of the students felt the interactive visuals in the game helped them better understand the problems. In the open-ended questions, a few students noted there was a technical difficulty on the third question, which did cause some user experience issues.

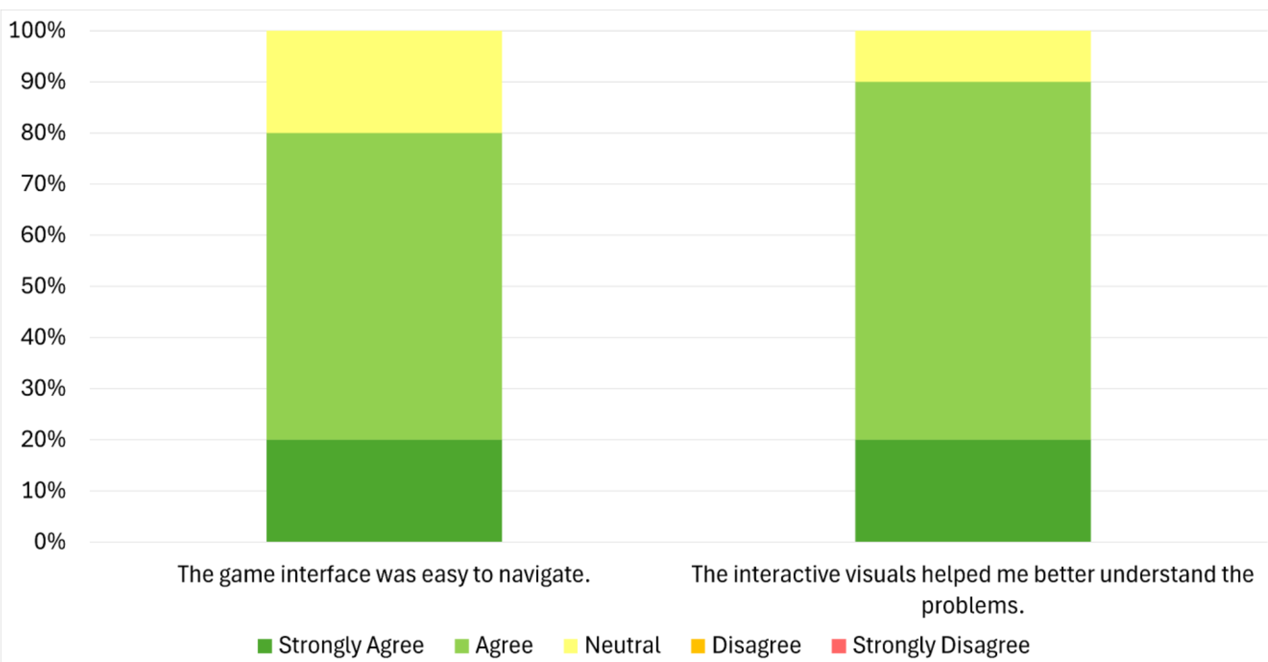

Figure 10: Responses related to game design

The quantitative data reflects the trends showing up in the survey. For example, in one of the survey questions, the students were asked if the difficulty felt appropriate. A majority of them agreed it was, and this aligns with how the students performed. The highest scoring student had a total failed attempts of 5, with 3 coming from the friction question, 1 from the frames and machines question, and 1 on the shear diagram. The average number of failed attempts on question one was 9, with 100% of the students attempting it. The average number of failed attempts on question two was 13.88, with 100% of the students attempting it as well. 88% of the students attempted question 3, and averaged 6.43 failed attempts. Finally, only 44% of the students attempted question 4 and averaged 12 failed attempts. However, a large portion of the failed attempts came from the second session, which is the session that did not have an instructor intervening to give hints. 67% of the students from the first section completed the final question, while only 33% of the students from the second session completed the final question.

Discussion

Overall, the results of this study suggest a positive impact of the gamified learning activity, particularly in terms of student engagement and perceived learning. Survey data demonstrates strong student acceptance: 70% of participants reported that they would prefer the game over traditional homework assignments, 100% indicated that they would play the game again, and 100% stated that they would recommend it to other students. These findings suggest that students not only engaged with the activity but also viewed it as a worthwhile experience. The fact that the students performed worse without an instructor present suggests a need for a hint system in case questions are unclear or the students get stuck. While the small sample size precludes making strong claims in the field of gamification, it is noteworthy that the data align with previous studies. A notable outcome in this study is how positive the responses were towards the game. Looking at all the questions related to motivation, engagement, and learning impact, the participants felt the gamified experience was beneficial overall, even preferring it to traditional homework. If one is able to get the balance right between gameplay and teaching, then a gamified learning experience could go a long way in helping students better conceptualize Statics problems. Most students reported increased confidence in solving Statics problems after playing the game. Although this does not necessarily convert into improved accuracy, confidence is definitely a key performance factor. Another major positive that proves this could be a viable method moving forward was the students' willingness to replay the game and recommend it to other students. But this study did have its limitations. The small sample size and limited survey responses were already addressed previously, but they significantly restrict the generalizability of the findings. The absence of post-study exam or quiz data further prevents any conclusion about the game’s impact on academic performance. Additionally, self-reported measures of confidence and engagement are inherently subjective and may be influenced by other factors. In terms of how the students rated the game, one reason for a negative score could have been caused by their dissatisfaction with a bug on Puzzle Three that some students encountered. After completing the truss problem, the students were able to obtain the missing members required to build the bridge. However, if a student picked up the missing members and dropped them before the bridge, they were not able to pick them up again to use them to fix the bridge. This resulted in them being unable to move on. Due to this, some students had to stop early or restart. It was mentioned by four students in the open-ended question asking about the game's performance. Finally, the difficulty level of the game may be the reason for the 20% that disagreed with feeling motivated to keep playing. This suggests that while the students value the experience overall, the difficulty may still demotivate some students with a lower mastery level of the course content.

Future Work

In the future, a study should be conducted without the major limitations this study had. There should be a larger pool of students, a hint system after so many incorrect answers, so that an instructor does not have to be physically present to help a student who is stuck, and access to test grades before and after, to look for a possible positive correlation between playing the game and academic performance. This study was anonymous to encourage greater honesty from the students and to alleviate pressure about the game. However, the future study would need to be made non-anonymous to compare test results before and after, which could have some effect on the outcomes. It may also be a good idea to make a mobile version of the game. As of now, the game is solely a Windows desktop application, which is less convenient for the students. A mobile version would give them access to the game from anywhere via the use of their phone, but it would also require some 3D graphical concessions for the sake of optimization. A 2D style of game could be a possibility here. Other improvements that need to be made on the game are fixing the bug that occasionally occurs on level 3 and implementing other features, such as an anonymous leaderboard system, allowing students to see how they fare against their contemporaries. There could also be multiple games for different sections of the course, or different "chapters" of the game. As of now, only the four topics are covered, but there are many more topics that the game(s) should support to help students study.

Conclusion

This study demonstrates the potential of gamification as an instructional approach for teaching Statics, a course that has historically challenged undergraduate students. By developing a story-based puzzle game that integrates four fundamental Statics concepts, friction, frames and machines, truss analysis, and shear and moment diagrams, this research explored whether a game-based learning experience could increase student engagement, motivation, and perceived learning outcomes. The results, though limited by a small sample size of 10 participants, revealed positive student perceptions. All participants agreed that the game was more engaging than traditional homework assignments, and 80% reported increased confidence in solving Statics problems after gameplay. The integration of a narrative, immediate feedback mechanisms, environmental rewards, and a coin-based scoring system appeared to sustain student motivation, with 70% of participants reporting they felt motivated to continue playing and completing challenges. However, some limitations must be acknowledged. The convenience sample and the lack of performance data, such as test scores before and after, both hinder the ability to make claims about the game's impact. Instead, most of the conclusions are based on self-reported perceptions of confidence and understanding. Additionally, the bug that a few students encountered on problem 3 may have influenced their overall opinion of the game. Despite these limitations, the study provides promising preliminary evidence that gamified learning activities can serve as a valuable tool in Statics education. The student's willingness to replay the game and recommend it to peers suggests that a well-designed gamified experience has the potential to increase positive attitudes towards challenging course material. As the Engineering faculty continues to search for ways to improve the DFW rates, innovative approaches that leverage game mechanics, narrative storytelling, and interactive problem-solving with immediate feedback warrant further investigation. Future research with larger sample sizes, control and experimental groups, and objective performance measures will be essential to validate these findings and establish if a gamified learning experience is the correct approach for improving student success in engineering Statics.

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