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Investigating the Impact of Game-Based Learning on Student Motivation through ”The Legend of Zelda: Tears of the Kingdom”

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Abstract

Game-based learning (GBL) has gained significant attention among educators for its potential to motivate students by enhancing engagement, promoting active learning, and fostering critical thinking through interactive and immersive experiences. However, it has not been well integrated into engineering design curricula, largely due to the challenge of finding suitable and relevant games for machine design. Recently, a second-year course was developed leveraging “The Legend of Zelda: Tears of the Kingdom” as a virtual platform for designing, prototyping, and testing mechanical systems, serving as a medium in the mechanical engineering curriculum to address machine design problems. In this paper, we investigate the effect of game-based learning on student motivation by conducting and analyzing surveys from students enrolled in this course versus those in a second-year computer-aided design course. The results will reveal the potential of GBL to improve student motivation in pursuing STEM-related fields, suggesting that integrating entertainment video games with engineering-relevant gameplay into the curriculum can engage students and enhance proficiency in machine design.

1. Introduction

Student motivation refers to the internal drive, enthusiasm, and determination that compel students to engage in learning activities, achieve their academic goals, and overcome challenges. Among college students, motivation plays a critical role in shaping their academic performance, persistence, and overall success in their educational journey [1], [2].

Motivation plays a pivotal role in the academic journey of engineering students, significantly influencing their learning outcomes, performance, and graduation rates [3]. Intrinsic motivation, characterized by a genuine interest in engineering subjects, drives students to engage deeply with the material, fostering better understanding and retention [4]. Extrinsic factors, such as career prospects and financial incentives, also contribute to sustained effort and perseverance [5].

The impact of motivation extends beyond individual performance to affect overall graduation rates. Interventions aimed at enhancing students' motivation have demonstrated efficacy in improving retention and completion rates [3]. For instance, a study analyzing factors affecting motivation among electrical and computer engineering students in Spain identified key elements influencing dropout rates, emphasizing the importance of addressing motivational issues to enhance student retention [6]. By addressing both intrinsic and extrinsic motivational factors, educators can create supportive learning environments that encourage persistence and success among engineering students.

The ARCS Model Approach is a framework for designing and evaluating motivational instructional strategies, developed by John M. Keller [7]. The ARCS Model emphasizes four key dimensions to foster student motivation: Attention, which involves capturing and maintaining learners' interest through strategies like variability, curiosity, and novelty; Relevance, achieved by making the content meaningful and applicable to learners' goals, needs, and experiences, thereby increasing its personal significance; Confidence, which focuses on building learners' belief in their ability to succeed by setting clear expectations, offering achievable challenges, and providing constructive feedback; and Satisfaction, ensuring that learners feel rewarded and fulfilled through intrinsic rewards, such as personal achievement, or extrinsic reinforcement, such as recognition or tangible rewards [7]. The ARCS model was validated by several research studies across a variety of instructional environments, including classroom-based learning, online education [8], and computer-based instruction [9].

Game-Based Learning (GBL): Importance and Impact

Game-based learning (GBL) is an educational approach that leverages video games and simulations to engage and motivate students, enhancing their learning experiences [10]. By incorporating gaming elements such as challenges, rewards, and interactive storytelling, GBL creates an immersive environment that encourages active participation and fosters a deeper understanding of the subject matter [11]. Unlike traditional teaching methods, GBL emphasizes problem-solving, critical thinking, and collaboration, making learning more dynamic and enjoyable. By tapping into students' natural affinity for games, GBL boosts motivation, promotes retention, and improves overall academic performance. This innovative approach harnesses the power of play to transform education, making it more accessible, inclusive, and relevant in the digital age [12], [13].

The objective of this research is to investigate how the use of a video game as a medium affects students' motivation for learning design. The video game used in this study is *The Legend of Zelda: Tears of the Kingdom*, and the ARCS model has been employed to evaluate the motivation of students enrolled in a video game-based course that incorporates both SolidWorks and the video game, compared to students enrolled in a computer-aided design (CAD) course that exclusively uses SolidWorks (without the video game). In this study, we are not merely using video game technology in the background but actively leveraging Zelda's in-game mechanics—such as its robust physics engine and modular assembly system—as a tool for students to design, prototype, and evaluate mechanical systems. This differs from gamification strategies (e.g., Gradecraft), which focus on alternative assessment and motivation strategies rather than using a game as a primary learning tool.

2. Course Structure

This section provides an explanation of the two courses considered for this study.

Introduction to Computer-Aided Design (CAD) is a 2-credit required sophomore-level course in mechanical engineering that introduces students to the fundamentals of computer-aided design. The course schedule includes one 110-minute in-person combined lecture and studio session per week. The assigned classroom is equipped with 42 personal computers to accommodate up to 42 students. Each semester, five sections of the course are offered. In addition to classroom and computer lab access to SolidWorks—available 24/7 in two dedicated labs—students are provided with individual software licenses, allowing them to install and use SolidWorks on their personal computers. Additionally, students can access a virtual computer lab, enabling them to use SolidWorks remotely without installing the software on their own devices.

The course covers essential topics such as engineering graphics, solid modeling, technical drawings, assemblies, finite element analysis, and animations using SolidWorks. Student learning outcomes are evaluated through a combination of homework assignments, in-class activities, two exams, and two projects. The first project is an individual assignment in which students design and 3D print a cellphone stand capable of holding a phone both horizontally and vertically. The second project is a team assignment where students design a mechanical system in SolidWorks. This involves modeling all components, creating assemblies, producing animations, and performing numerical simulations. Teams are free to choose their project topic, provided the system is mechanical in nature and includes moving parts. Examples of past team projects include designing a V6 engine, a milling machine, a robotic hand, and a catapult.
The course is divided into two main phases. During the first half of the semester (Weeks 1–8), students are introduced to the fundamentals of engineering graphics, sketching, solid modeling, and assemblies. In the second half, students explore advanced CAD applications, including finite element analysis, animation, and design for 3D printing, while working on two design projects.

"The Legend of Zelda: A Link to Machine Design" is a one-credit elective course offered by the Department of Mechanical Engineering for second-year students. The course aims to leverage game-based learning to teach machine design in an interactive environment, enabling students to design, prototype, and test mechanical systems. It is offered in both the fall and spring semesters, accommodating up to 30 students per semester. More detailed information about the course structure, assignments, and sample project deliverables can be found in our earlier paper [10]. The major change since the course was reported in [10] is the reduction of the number of projects to one. The course project focused on designing a bio-inspired transforming robotic vehicle. The final presentation included a class competition where all teams attempted to complete a predefined course as quickly as possible.

Similarities and differences of CAD course and Zelda video game course

Designing in SolidWorks and a video game like *The Legend of Zelda: Tears of the Kingdom* involves similarities and differences rooted in their respective goals and tools. Both SolidWorks and video games like *The Legend of Zelda: Tears of the Kingdom* involve creating and visualizing 3D models within a digital environment, with SolidWorks emphasizing engineering precision and video games focusing on aesthetics and gameplay functionality. They both incorporate physics simulations, though SolidWorks tests mechanical properties and stresses, while video games simulate mechanics such as gravity and object interactions. Iterative design processes are central to both, refining engineering designs in SolidWorks and enhancing visuals and gameplay mechanics in video games. Mastery of specialized tools is essential, with SolidWorks users employing CAD modeling commands and game designers utilizing tools like Blender and Unity. Both also require creativity and problem-solving, whether optimizing manufacturable designs in SolidWorks or designing engaging challenges in a game.

In a CAD course, students practice these skills by modeling individual parts, assembling them in SolidWorks, and conducting finite element analysis or animations to test their designs. In contrast, a Zelda video game course uses both SolidWorks modeling with video game design, where solutions are tested through the interactive environment of the game itself. This integration highlights how digital modeling and simulation can serve varied purposes, from precise engineering applications to immersive and interactive gaming experiences, showcasing the versatility and overlap of these tools in different creative and technical fields.

SolidWorks and video games like *The Legend of Zelda: Tears of the Kingdom* differ fundamentally in purpose, audience, output, and design priorities. SolidWorks is centered on engineering and product development, serving engineers, manufacturers, and stakeholders who require precise CAD models for production. In contrast, *Tears of the Kingdom* focuses on entertainment and storytelling, engaging gamers with artistic and functional in-game assets designed for immersive experiences. Physics simulation in SolidWorks emphasizes real-world accuracy, such as stress analysis, while video game physics prioritize simplified mechanics to support gameplay elements like puzzles and object interactions. SolidWorks prioritizes functionality over visuals, whereas video games balance aesthetics and gameplay, often giving precedence to visual appeal. The tools used also diverge, with SolidWorks and AutoCAD supporting precise CAD modeling, while video game development relies on game engines and asset creation tools. Creativity in SolidWorks is constrained by real-world manufacturability, while video games allow broad creative freedom within the constraints of the game’s lore and narrative. Collaboration also differs, with SolidWorks projects typically involving small, focused engineering teams, whereas video game development involves large, interdisciplinary teams combining art, coding, and storytelling. Unique to *Tears of the Kingdom* is the "Ultrahand" mechanic, which lets players dynamically assemble objects in the game world, a feature loosely akin to SolidWorks' assembly capabilities but tailored for interactive and narrative-driven gameplay. Ultimately, SolidWorks and video games like *Tears of the Kingdom* reflect distinct goals and methodologies, catering to different domains while demonstrating the versatility of digital design tools.

3. Research Method

To investigate the effect of video games on students' motivation, an Institutional Review Board-approved survey, adapted from the ARCS Model Approach [7], was conducted among two classes: the CAD course (control group) and the Zelda course (experimental group). The survey evaluated students' motivation based on four factors: 1) attention, 2) relevance, 3) confidence, and 4) satisfaction. The CAD course had 40 students enrolled, while the Zelda course had 27 students. Some students in both courses have a background in CAD software or experience playing Zelda; however, quantitative data on this was not collected in the survey. A link to the survey was sent to both classes during their last session. Students were informed that the survey was anonymous and participation was voluntary. Consent was obtained verbally from the students. Specifically, the consent statement, as stated in [10], was read aloud to all students. After reading the statement, the course instructor left the classroom to allow interested students to complete the survey privately. The survey uses a Likert scale from 1 to 5 where 1 is strongly disagree with the survey questions and 5 is strongly agree. The survey statements are as follows:

1. When I first looked at the in-class activities (or course materials) and expectations, I had the impression that it would be easy for me.
2. The in-class activities (or course materials) and expectations were more difficult to understand than I would like for it to be.
3. After reading the introductory information (first few weeks and syllabus), I felt confident that I knew what I was supposed to learn from this lesson.
4. As I worked on the in-class activities (or course materials), I was confident that I could learn the content.
5. The assignments/projects in this course were too difficult.
6. After working on this course for a while, I was confident that I would be able to pass a test on it.
7. I could not really understand quite a bit of the material in this course (lesson).
8. There was something interesting at the beginning of this course that got my attention.
9. This course is so abstract that it was hard to keep my attention on it.
10. This course has things that stimulated my curiosity.
11. I learned some things that were surprising or unexpected.
12. The variety of in-class activities, exercises, illustrations, etc., helped keep my attention on the lesson.
13. Completing the exercises, assignments, and projects in this course gave me a satisfying feeling of accomplishment.
14. I enjoyed this course so much that I would like to know more about this topic.
15. I really enjoyed studying this course.
16. The wording of feedback after the exercises, or of other comments in this course, helped me feel rewarded for my effort.
17. It is a pleasure to work on such a well-designed course.
18. It is clear to me how the content of this course is related to things I already know.
19. There were stories, pictures, or examples that showed me how the in-class activities (or course materials) could be important to some people.

20. Completing this course successfully is important to me.
21. The content of this course is relevant to my interests.
22. There are explanations or examples of how people use the knowledge in this course.
23. The content and style of writing in this course convey the impression that its content is worth knowing.
24. I could relate the content of this course to things I have seen, done, or thought about in my own life.
25. The content of this course will be useful to me.
26. The good organization of the content helped me be confident that I would learn this material.

4. Results and Discussion

The statistical analysis of the survey results collected from students in both classes includes descriptive statistics and comparative analysis of the survey responses. A summary of the results for the CAD course is provided in Figure 1. This graph presents the percentage distribution of responses, ranging from strongly disagree (a1 in Figure 1) to strongly agree (a5 in Figure 1). A total of 30 students completed the survey for the CAD course, while 8 students participated in the Video Game course.

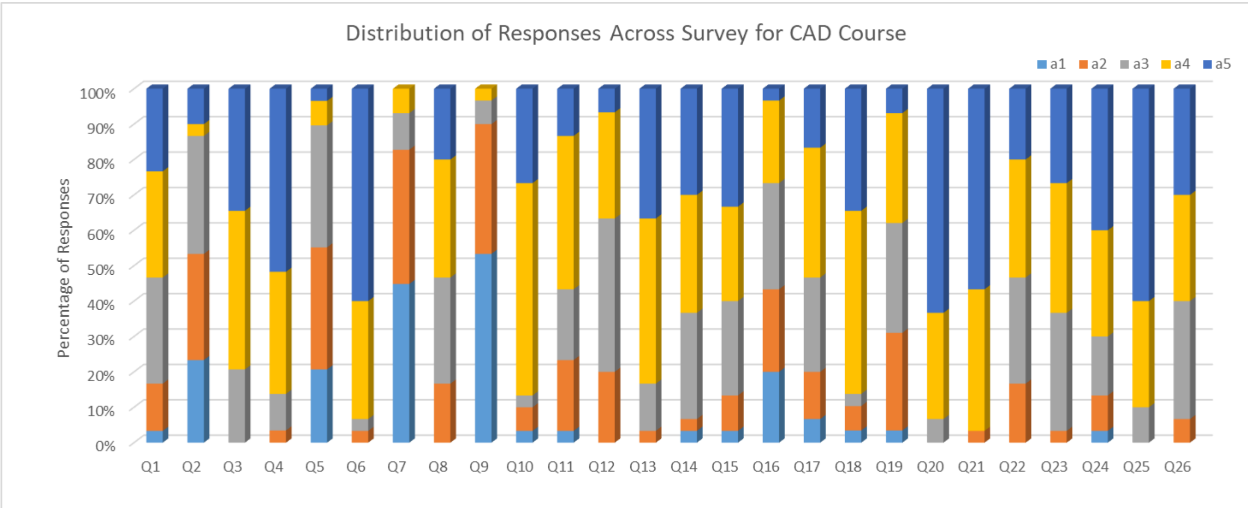

Figure 1: Stacked histograms of survey responses collected from CAD class. This graph presents the percentage distribution of responses, ranging from strongly disagree (a1) to strongly agree (a5).

The distribution of responses for CAD course provides insight into how students perceived the course in terms of difficulty, engagement, and motivation. The 100% stacked histograms illustrate the varying levels of agreement or disagreement with each survey statement, allowing us to observe trends in student sentiment. For instance, questions related to course difficulty and confidence (e.g., Q1, Q2, and Q3) show a relatively balanced spread of responses, indicating that while some students found the course manageable, others struggled with understanding the material. Notably, a significant portion of responses leaned toward neutral or slightly positive agreement, suggesting that while the course was challenging, most students felt capable of handling it.

From a descriptive statistics perspective, the mean responses for most questions fall around the middle of the Likert scale, with some skewness depending on the theme of the question. For instance, questions related to course difficulty (Q2, Q5, Q7) tend to have a higher proportion of disagreement (a1 and a2), indicating that students found certain aspects of the course challenging. Conversely, questions assessing relevance and accomplishment (Q20, Q25) show higher agreement (a4 and a5), suggesting that students recognize the practical value of the course content. The standard deviation of responses varies across questions, with engagement-related items (e.g., Q8-Q12) displaying wider variability, reflecting diverse student experiences in terms of interest and attention.

In a comparative analysis between classes, the responses from the CAD course will serve as a benchmark to assess whether the video-game based class led to a notable shift in motivation, engagement, and perceived difficulty. If the game-based learning approach is effective, we would expect to see a higher concentration of responses in the a4 and a5 categories, particularly in areas such as engagement (Q8-Q12) and enjoyment (Q14-Q17). Additionally, if game-based learning reduces perceived difficulty, we may see lower agreement with statements like Q2 and Q7 in the Zelda class.

Overall, the CAD results indicate that while students acknowledged the course's relevance and felt a sense of achievement upon completion, engagement remained a challenge. These findings can serve as a baseline for comparison with the video game course, helping to determine whether game-based learning methods significantly enhance student motivation and interest in engineering design concepts. The survey results for the video game course are presented in Figure 2.

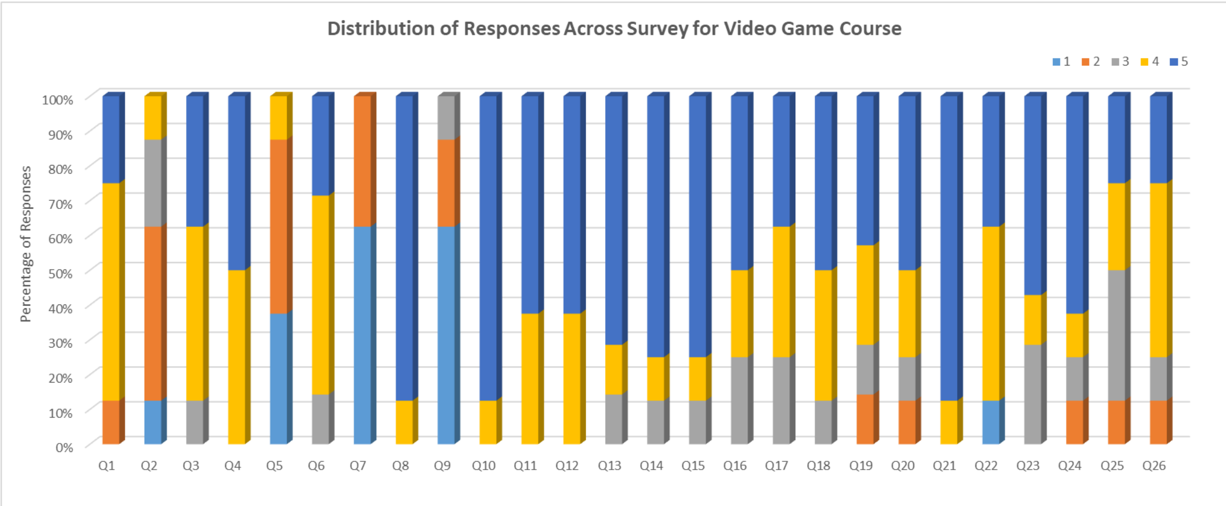

Figure 2: Stacked histograms of survey responses collected from video game class. This graph presents the percentage distribution of responses, ranging from strongly disagree (1) to strongly agree (5).

The distribution of responses for video game course provides insight into how students perceived the game-based learning in terms of difficulty, engagement, and motivation. The 100% stacked histograms illustrate that students generally had a more positive perception of this course compared to the CAD class. For example, engagement-related questions (Q8-Q12) show a strong skew toward 5 (strongly agree), suggesting that most students found the course highly engaging. Additionally, interest and enjoyment-related questions (Q14-Q17) also have a higher concentration of 4 and 5 responses, indicating that students enjoyed the game-based learning experience and were motivated to learn more.

From a descriptive statistical perspective, the responses in the game-based course are skewed more positively compared to the CAD course. Questions measuring difficulty perception (Q1, Q2, Q5, Q7) show that fewer students strongly disagreed with the statements, meaning that students generally found this course more manageable than the CAD course. Additionally, motivation-related questions (Q20-Q25) show a strong clustering in 4 and 5, reinforcing that students found the content relevant, useful, and engaging. The mean scores for most questions in this course are higher than in the CAD course, and the standard deviation is lower, indicating greater consensus among students regarding the course's effectiveness.

When comparing CAD and course-based class, there are notable differences in engagement, motivation, and perceived difficulty. The Zelda-based class shows a higher concentration of responses in 4 and 5, particularly for engagement and curiosity-related questions (Q8-Q12). This suggests that game-based learning significantly enhanced student engagement compared to traditional CAD instruction. Additionally, enjoyment-related questions (Q14-Q17) also lean more toward strong agreement in the game-based course, indicating that students had a more positive and enjoyable learning experience compared to the CAD course. Furthermore, questions related to perceived difficulty (Q1, Q2, Q5, Q7) show a greater proportion of disagreement in the game-based class, suggesting that students found this course easier to understand and navigate than the CAD class. This may indicate that the game-based learning approach helped simplify complex concepts, making learning more intuitive and engaging.

5. Conclusion

The comparison between the CAD course and the Video Game course reveals notable differences in student perceptions of engagement, difficulty, and motivation. The CAD course responses showed a more evenly distributed range across the Likert scale, with a significant number of students expressing neutral to positive agreement with course content and difficulty. In contrast, the Video Game course had a stronger skew toward higher agreement (a4 and a5), particularly in questions related to engagement, curiosity, and perceived relevance. This suggests that students in the Zelda-based course found the material more engaging and motivating compared to those in the CAD course. However, given the smaller sample size for the Video Game course, these differences should be interpreted with caution. The t-test results further support this, indicating that while some trends are observable, the overall differences between the two classes are not statistically significant.

This study opens the door for future research on the impact of game-based learning across various educational contexts and disciplines. To build on these findings, subsequent studies could explore the long-term effects of game-based approaches on knowledge retention and skill acquisition. Expanding the sample size and incorporating a broader range of courses would also provide a more comprehensive understanding of how different teaching strategies influence student outcomes. Additionally, qualitative research methods, such as student interviews or focus groups, could uncover deeper insights into the specific elements of game-based learning that drive motivation and engagement. By continuing to investigate these dynamics, educators can refine instructional design to foster more inclusive and impactful learning experiences.

6. Limitations on Comparability of Groups

The main limitation of this experiment is that the groups differ in course structure (a two-credit required course vs. a one-credit elective), class sizes, and content focus, making direct comparisons challenging. To address this, we centered our survey and analysis on motivation rather than performance, focusing on how game-based elements influence engagement. While the content varies, our primary interest is in students' self-reported motivation rather than learning outcomes. Future studies could better control these variables by using a more uniform course structure or testing game-based and traditional learning approaches within the same course content.

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