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Gaming Interests and Engineering Educational Innovation: Leveraging Student Enthusiasm for Popular Games to Inform Curriculum Development at HBCUs

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Gaming Interests and Engineering Educational Innovation: Harnessing Student Enthusiasm for Popular Games to Inform Curriculum Development at HBCUs

Abstract

As educational institutions strive to enhance student engagement and retention, the integration of effective gamification in curricula presents a promising solution, particularly for engineering students at Historically Black Colleges and Universities (HBCUs). This research aims to identify the popular games that resonate with students and examine how this passion can inform the development of gamified learning experiences. Key research questions include: What popular games do engineering students in a HBCU engage with most passionately? How can these insights guide the creation of educational tools that align with their interests? What game mechanics found in popular video games are most effective at boosting student engagement? To what extent do students' gaming experiences correlate with their problem-solving and critical-thinking skills in an educational context?

To address these questions, a quantitative methodology will be employed, utilizing the Game Engagement Questionnaire (GEQ), a validated survey designed to measure students' gaming preferences, frequency of play, and perceived educational value of games. The survey will be distributed to engineering students in HBCU. The theoretical framework guiding this study is based on Constructivist Learning Theory, which emphasizes the importance of engaging students in meaningful learning experiences that reflect their interests and prior knowledge.

The proposed outcome of this research is to establish a clear link between students' passion for specific games and the potential for developing effective educational interventions that enhance learning outcomes. By identifying game mechanics and themes that students connect with, this study aims to provide actionable recommendations for integrating gamified elements into engineering curricula, ultimately fostering a more engaging and effective educational environment. This will in turn foster innovation and lead to increased productivity.

Key words: Constructivism, Gaming experience, Learning experience

Introduction

Gaming has become an integral part of students' lives, shaping how they engage with and learn about the world. Engineering students, in particular, bring to the classroom not just academic aspirations but also a rich repertoire of skills and experiences cultivated through gaming. Popular games such as Minecraft, Kerbal Space Program, and SimCity serve as virtual spaces where problem-solving, creativity, and teamwork flourish. These attributes align closely with the demands of engineering education, making gaming a powerful tool for pedagogical innovation, especially at Historically Black Colleges and Universities (HBCUs).

Game-based learning (GBL) has proven to be a powerful tool in enhancing cognitive skills that are vital for fields like engineering. Research has shown that games, especially those in action and strategy genres, create immersive environments that mimic real-world problem-solving, offering students the opportunity to experiment with solutions to complex engineering challenges in a virtual setting [1]. The appeal of these games lies in their ability to provide instant feedback, motivating students to learn from their mistakes and continue refining their understanding of difficult concepts [2]. This real-time learning process encourages engagement, which is critical for mastering abstract engineering principles [3].

In fact, studies have highlighted how games can help bridge the gap between theory and practice, offering students hands-on experiences in engineering, such as in games like Kerbal Space Program, which simulates space missions and aerodynamics [4]. Additionally, GBL has shown to improve both technical knowledge and non-technical skills like teamwork and critical thinking, essential for engineering success [5]. Furthermore, the use of games in educational settings has been linked to better student engagement, motivation, and academic performance, with students in gamified courses demonstrating higher grades and increased interest in the subject matter [6][7]. As GBL creates an inclusive, interactive learning environment, it offers a unique opportunity to connect theoretical knowledge with practical application, especially in HBCUs where hands-on engineering resources may be limited [8].

While game-based learning (GBL) holds a lot of promise, it does come with its share of challenges, particularly when it comes to integrating it into the curriculum at HBCUs. One of the main hurdles is the limited resources that many HBCUs face, including outdated technology and a lack of funding for game development or acquisition [9]. For GBL to be effective, schools need the right

tools and infrastructure, as well as support for teachers who need to be trained in how to use these new methods. However, with funding often tight at HBCUs, it might not always be feasible to invest heavily in new technologies. Another concern is making sure that games align well with course objectives and aren't just flashy distractions. Educators have to carefully plan how games fit into the curriculum without compromising on the quality of the content [10]. Plus, not every student will respond to game-based methods the same way. Some students prefer more traditional learning methods, and forcing everyone into the same mold could backfire.

This is especially true when considering different game genres, as research shows that students have varying preferences. While action games might excite some, others, especially older female students might prefer puzzle games or strategy games [11]. And while gaming can improve cognitive skills, there are also concerns like addiction and sleep disruption, which can hurt students' well-being if not kept in check [12]. Moreover, the competitive nature of some games can lead to unnecessary stress or anxiety, taking focus away from learning and causing students to treat games more like a contest than a learning tool [13]. Given these issues, this paper will focus on addressing some key challenges: developing more educational games that align with engineering concepts, creating games that capture the same level of engagement as popular games, and ensuring these games are designed inclusively to cater to diverse students, including women of color, who might feel disconnected from current game-based learning tools [14].

The integration of gamification in engineering education draws on the Constructivist Learning Theory, which emphasizes the value of engaging students through meaningful and personalized learning experiences. By building on previous studies that highlight the educational value of games, this research seeks to provide actionable recommendations for curriculum development that align with students' gaming preferences and academic needs. Through this approach, we aim to bridge the gap between students' personal interests and their professional aspirations, fostering a learning environment that is engaging, inclusive, and effective.

In this work, we seek to 1) identify the games that are popular among engineering students at HBCUs, 2) understand the level of engagement of the students while playing their favorite games, and 3) use the insights gained to determine which of these games elicit the most engagement. From this understanding, we aim to recommend gamified curriculum development strategies to improve engagement, retention, and academic performance.

In this study, we also implement a final project across various engineering courses in which students are asked to: 1) Suggest what an ideal game to teach engineering would look like, 2) propose a game-based engineering curriculum, including gaming elements in the course structure, the frequency of gaming sessions, and opportunities for collaboration, 3) identify game elements that could make learning engineering more engaging, 4) list the engineering concepts they are most interested in learning through games, 5) state how they feel about the idea of using games to learn engineering concepts and whether they would prefer in-game rewards, such as badges or unlocking new levels, for completing engineering challenges.

Theoretical Framework

This study is grounded in **Constructivist Learning Theory**, which posits that learners actively construct knowledge based on their experiences, prior understanding, and interactions with their environment. The theory emphasizes the importance of engaging students in meaningful learning activities that are relevant to their lives and future aspirations. This approach aligns with the unique context of engineering education at HBCUs, where students often bring diverse cultural, social, and experiential backgrounds into the classroom.

According to the constructivist perspective, learning occurs when students are actively involved in tasks that require them to explore, hypothesize, and apply knowledge in authentic settings. This theoretical lens suggests that integrating gamification into engineering education can bridge the gap between theoretical concepts and practical application, making learning experiences more dynamic and relatable for students. Research indicates that game-based learning fosters deeper understanding by providing immediate feedback and enabling iterative problem-solving processes [15].

Application to Engineering Education

In the context of engineering, constructivism advocates for hands-on, problem-based learning experiences that mirror real-world challenges. Games such as *Minecraft*, *Kerbal Space Program*, and *SimCity* serve as virtual platforms where students can simulate engineering principles, experiment with variables, and see the consequences of their decisions in real-time. These

interactive environments promote critical thinking and collaborative problem-solving, which are essential for engineering success [16].

By incorporating elements of popular games into the curriculum, educators can create engaging learning environments that reflect students' interests and leverage their gaming experiences. This study applies constructivist principles to identify game mechanics—such as resource management, system optimization, and iterative design—that resonate with students and can be adapted to educational tools.

Cultural Relevance and Inclusivity

Constructivist theory also underscores the importance of cultural relevance in education. At HBCUs, this involves recognizing the unique experiences and challenges faced by students, many of whom are from underrepresented groups in STEM fields. Gamification offers an opportunity to create inclusive learning experiences by integrating diverse narratives, themes, and collaborative approaches that reflect students' backgrounds. For instance, games designed with cooperative missions can encourage teamwork and mutual support, fostering a sense of belonging and shared achievement [17].

Connection Between Gaming and Learning Outcomes

Constructivism further highlights the role of intrinsic motivation in learning. Games inherently motivate players through rewards, progress tracking, and the satisfaction of overcoming challenges. By aligning these game mechanics with educational objectives, gamified curricula can enhance students' engagement and persistence. For example, earning in-game rewards for solving engineering problems or advancing through levels tied to course content can mirror the progression of skill development in engineering practice [18].

Through this framework, the study aims to demonstrate how gaming interests can be harnessed to develop effective educational interventions. By connecting theoretical concepts to practical applications within culturally responsive and engaging contexts, the research seeks to improve retention, academic performance, and student satisfaction in engineering programs at HBCUs.

Methodology

This study employs a quantitative approach to explore how gaming interests among students at Historically Black Colleges and Universities (HBCUs) can inform innovative curriculum development in engineering education. A mixed-methods approach could provide valuable insights into student experiences and perceptions. However, the quantitative approach was chosen as this study focuses on establishing a general baseline understanding of gaming preferences and how the engagement level of students while playing their favourite games can inform the creation of game based learning tools that correlate with improved academic outcomes. By leveraging the enthusiasm for popular games, the research aims to integrate game-based learning into engineering programs to enhance student engagement and learning outcomes. The methodology comprises distinct phases that include data collection, analysis, and pilot implementation [21].

Survey

The study begins with a comprehensive survey to understand the gaming preferences, habits, and attitudes of HBCU engineering students toward educational games. The survey includes demographic information, types of games played, frequency, perceived benefits of gaming, and students' openness to integrating gaming into academic settings [19],[20]. This phase ensures a broad quantitative overview of gaming trends among the target population.

Survey Questions:

1) What is the name of your favorite game?
2) How do you feel when playing your favorite game?
3) What are some of your other favorite video games? (You can mention up to five, if there are none, indicate.
4) What type of games do you prefer? (Check all that apply)
5) In what ways do you feel games help you learn or improve skills? (Select all that apply)
6) How do you feel about the idea of using games to learn engineering concepts (e.g., design, physics, mechanics)?
7) Which engineering concepts would you be interested in learning about through games? (Check all that apply)

8) What game elements do you think would make learning engineering more engaging? (Select all that apply)
9) Would you prefer to have in-game rewards (e.g., badges, points, unlocking new levels) for completing engineering tasks or challenges?
10) If you were to design a game to teach engineering, what would it look like? (Briefly describe the theme, structure, or gameplay that you think would be fun and educational.)

11) If you were to design a game-based engineering curriculum, briefly describe how you would integrate gaming elements into the course structure, the frequency of gaming sessions, and opportunities for collaboration among students.

Table 1: Survey Metrics and Categories

Metric	**Description**
Demographics	Age, gender, academic level
Gaming Preferences	Game genres, platforms, frequency of play
Educational Integration	Perceived benefits of gaming in education

Game-Based Learning Pilot

Based on the insights gathered, a game-based learning pilot is designed and implemented in selected engineering courses at participating HBCUs. This pilot involves incorporating game mechanics into the curriculum, such as problem-solving scenarios inspired by popular games, gamification elements like leaderboards, and interactive simulations. The pilot aims to test the feasibility and effectiveness of these elements in enhancing student engagement and understanding of engineering concepts [22].

Table 2: Game-Based Learning Pilot Design

Component	Description
Game Mechanics	Problem-solving scenarios, gamification elements
Integration Points	Specific engineering concepts addressed
Evaluation Metrics	Engagement, comprehension, and retention scores

Quantitative Analysis

Quantitative data from the survey were analyzed using statistical methods to evaluate patterns in gaming preferences and their correlation with student engagement and academic performance. Metrics such as course grades, retention rates, and participation levels are examined to assess the impact of game-based learning interventions [19],[21].

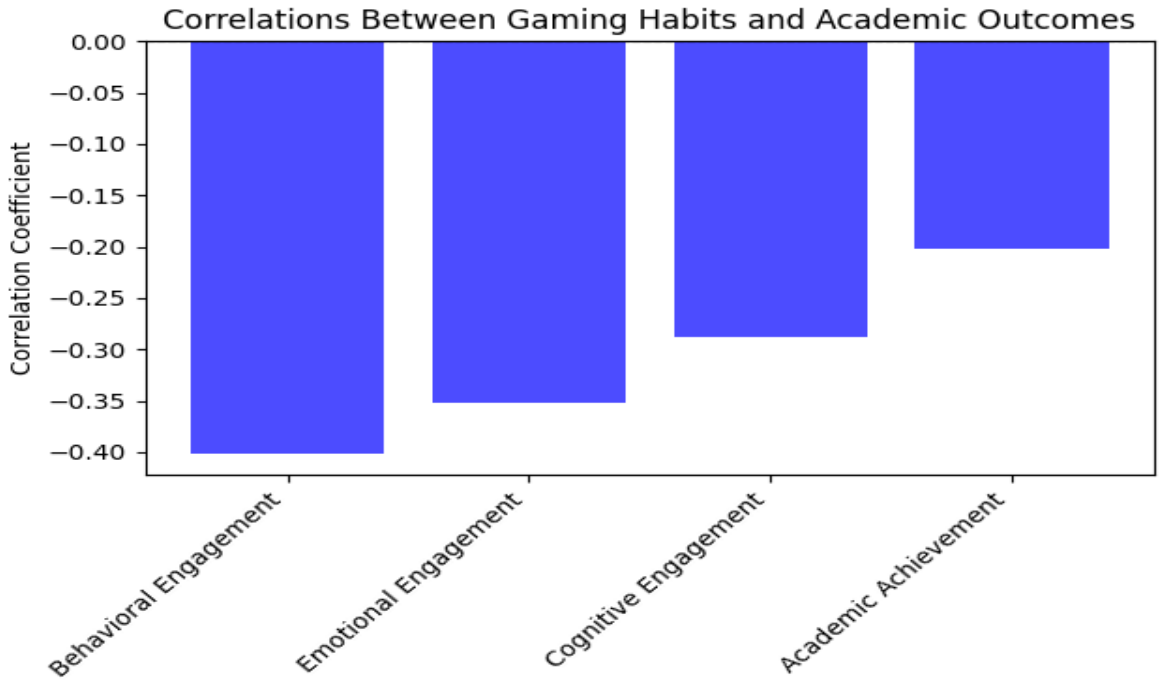

Figure 1: correlations between gaming habits and academic outcomes

Explanation of Data:

- Behavioral Engagement: Strongest negative correlation (−0.402), suggesting gaming habits significantly impact students' behavioral involvement in learning activities.
- Emotional Engagement: Moderate negative correlation (−0.352), indicating reduced emotional connection to learning due to gaming.
- Cognitive Engagement: Slightly weaker negative correlation (−0.288), reflecting diminished cognitive focus on academic tasks.
- Academic Achievement: Lowest negative correlation (−0.202), showing a smaller but still notable reduction in overall academic performance.

This analysis highlights the potential adverse effects of excessive gaming on student engagement and academic success.

Curriculum Development

The findings from the analysis inform the design of a game-based curriculum framework tailored to the needs of HBCU engineering students. This framework outlines strategies for integrating gaming elements into course content, instructional design, and assessment methods to foster engagement and learning outcomes [23].

Table 3. Game-Based Curriculum Framework

Strategy	**Description**
Gamified Assessments	Interactive quizzes and challenges
Simulation-Based Learning	Virtual labs and engineering simulations

Implementation and Evaluation

The curriculum framework is implemented in engineering programs across participating HBCUs. Its effectiveness is evaluated through ongoing assessments, including student surveys, instructor feedback, and academic performance metrics. The evaluation focuses on measuring improvements in student engagement, retention, and comprehension of complex engineering concepts [24].

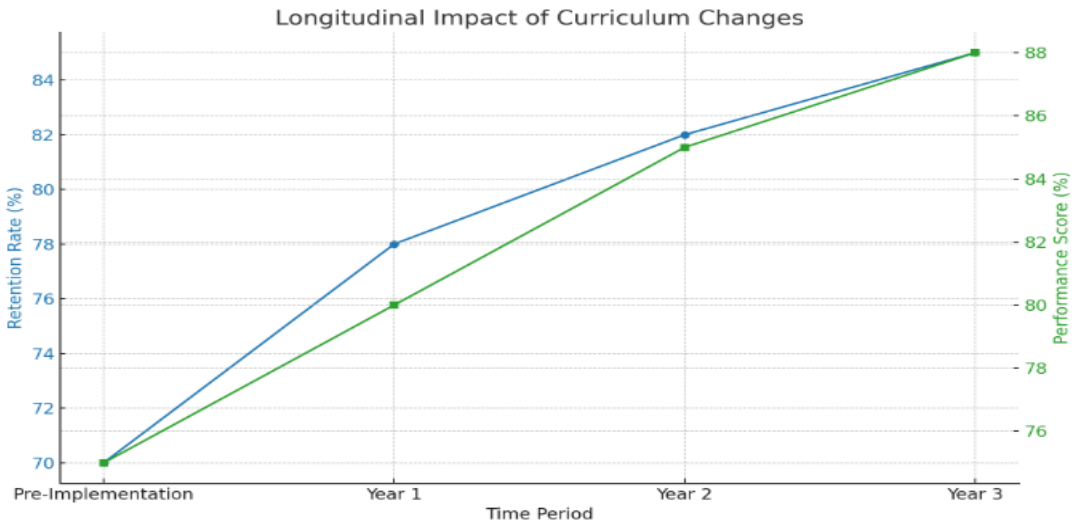

Figure 2: Longitudinal impact of curriculum changes on student

Results and Discussion

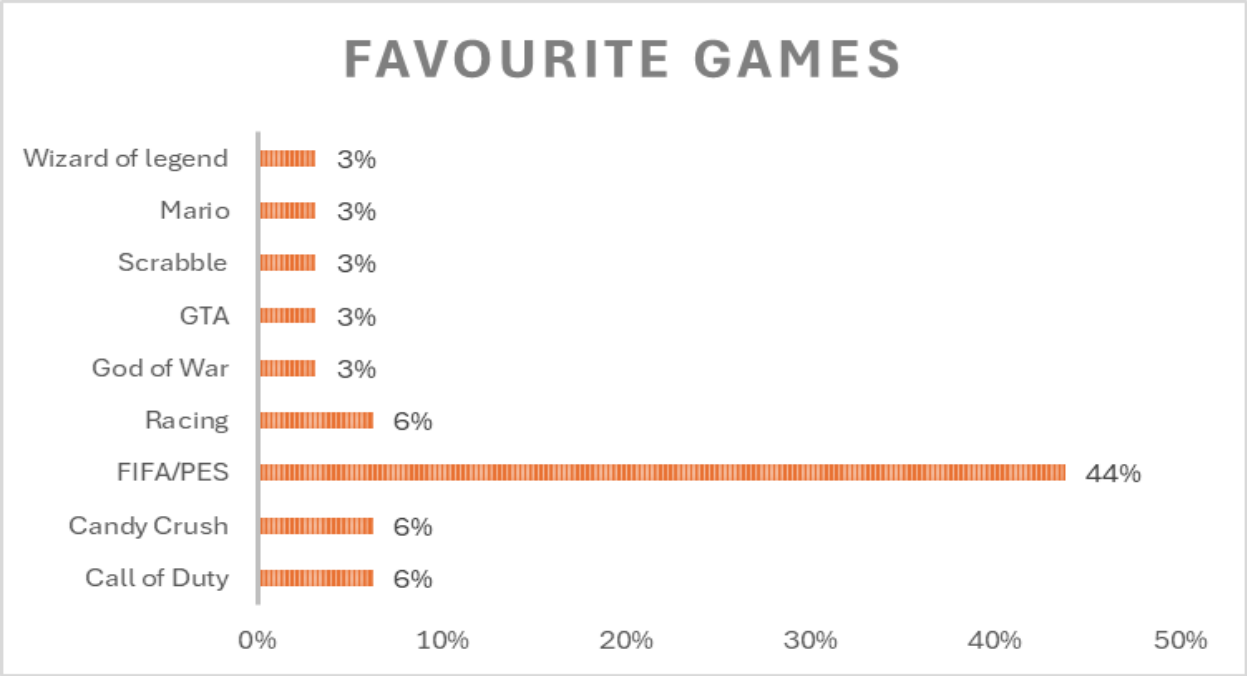

Figure 3: Students' Favorite Games

As illustrated in figure 3, FIFA/PES (44%) was the favourite game among the participants, followed by racing games (6%), candy crush (6%) and call of duty (6%).

This shows that integration of gaming into engineering education can enhance student engagement, problem-solving, and critical-thinking skills by aligning game mechanics with engineering principles [25]. Game-based learning can be embedded into courses through physics-based simulations like Kerbal Space Program for aerodynamics, strategy games like Civilization for resource management, and coding platforms like Minecraft Education Edition for robotics and automation [26].

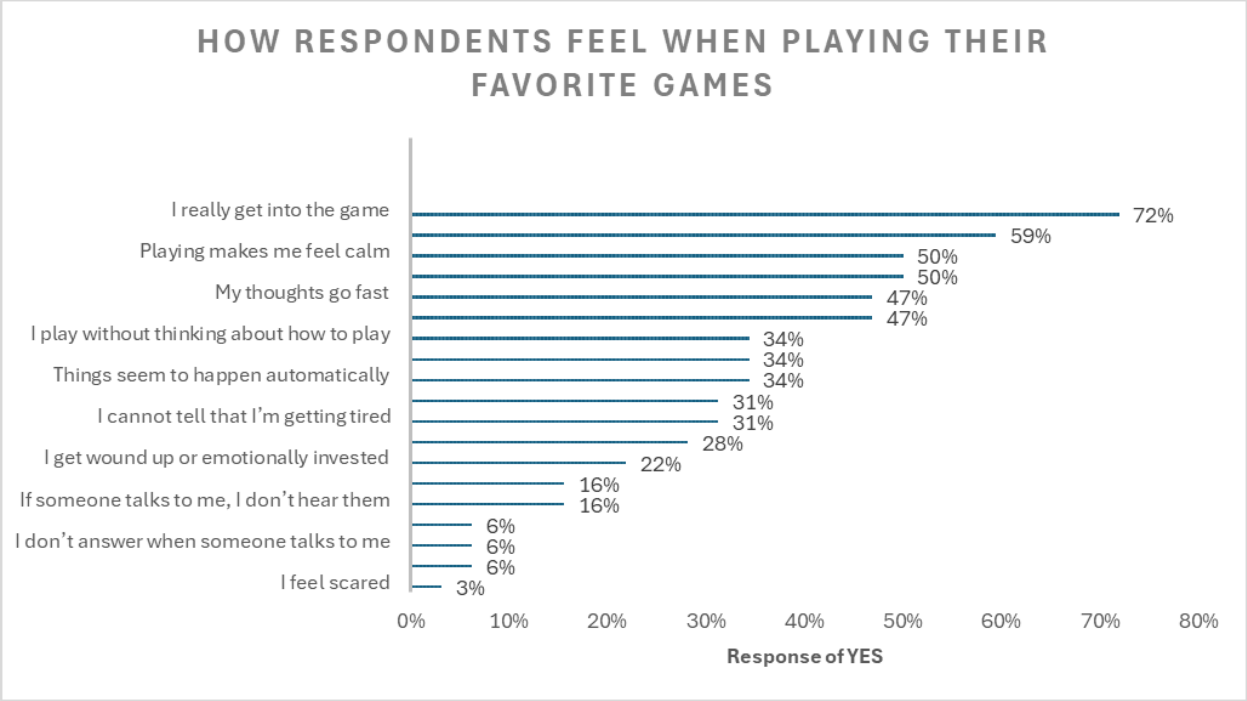

Figure 4: Chart Showing Students' Feelings When Playing Their Favorite Games

The results data from the figure 4 provide insight into how gaming interests and feelings can inform curriculum development in engineering education, particularly at Historically Black Colleges and Universities (HBCUs). The study focuses on harnessing student enthusiasm for popular games to foster innovation in engineering education.

The data reveals that students show a strong preference for games with problem-solving, critical thinking, and collaboration elements. Popular genres include puzzle/problem-solving, strategy/simulation, and action/adventure games. Sports and driving games, such as FIFA and Need for Speed, also rank highly, indicating that students are drawn to competitive and immersive experiences.

When asked about their feelings during gameplay, many students reported experiencing deep engagement, losing track of time, and becoming emotionally invested in the game. These responses suggest that games have a strong potential to captivate students, making them an effective tool for educational purposes. Students also noted that games help improve skills such as strategic planning, teamwork, creativity, and technical competencies like coding or circuit design.

Regarding the integration of gaming into engineering education, students expressed interest in using games to learn concepts such as robotics, computer engineering, and environmental engineering. Many emphasized the appeal of interactive challenges, real-time strategy, open-world exploration, and role-playing scenarios. These preferences point to a desire for hands-on, experiential learning that mirrors real-world engineering tasks.

Students suggested innovative ideas for game-based learning. For example, one respondent proposed a futuristic simulation game where players take on the role of engineers solving real-world challenges across various fields, such as building bridges, designing power grids, or programming robots. Another idea involved using games with CAD-like tools to teach concepts such as structural design and resource optimization.

In terms of curriculum design, students favored weekly or biweekly gaming sessions that integrate theoretical lectures with practical, game-based applications. They highlighted the importance of collaboration, with multiplayer missions and peer feedback fostering teamwork. Some proposed a leaderboard system to motivate students and encourage healthy competition.

The enthusiasm for gaming as a learning tool underscores the potential for engineering education to be both engaging and effective. By incorporating elements of popular games into the curriculum, educators at HBCUs can leverage students' existing interests to make learning more interactive, collaborative, and relevant. This approach can also address challenges in traditional teaching methods by providing a platform for real-world problem-solving and creativity.

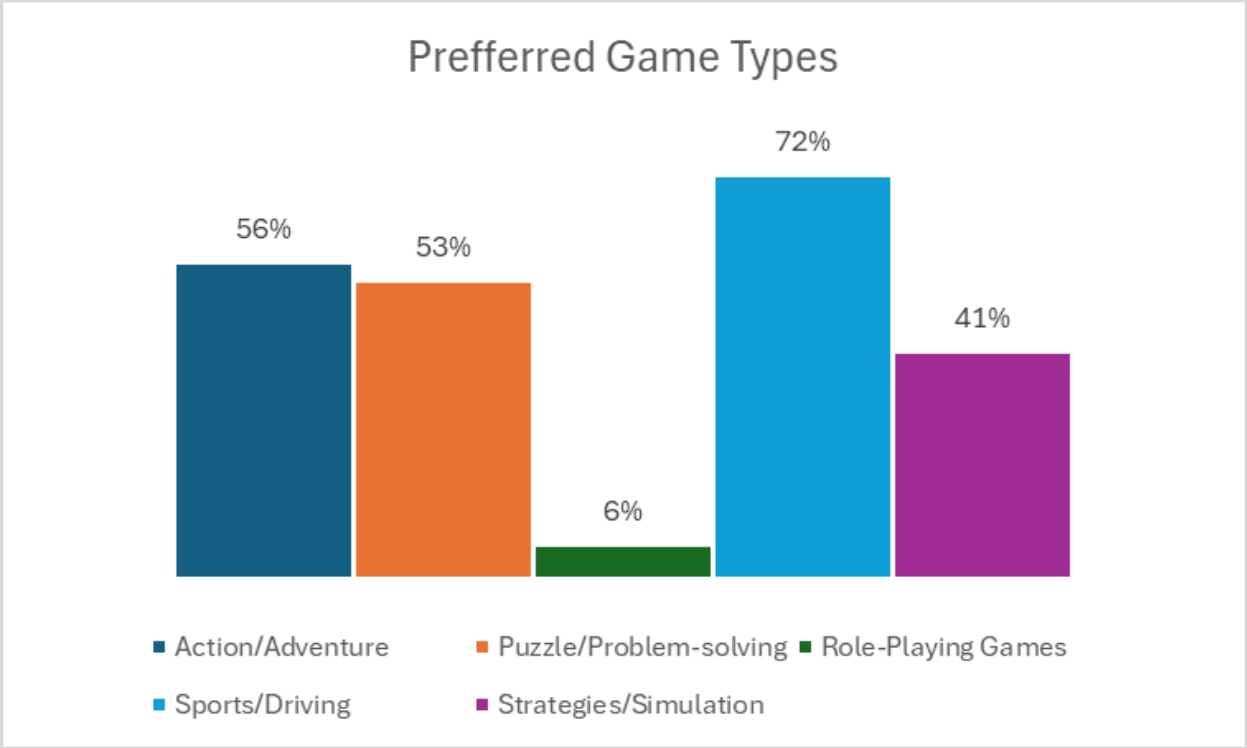

Figure 5: Chart Showing the Type of Games Students Prefer

The chart indicates that a significant percentage of HBCU students prefer Action/Adventure (53.1%), Puzzle/Problem-solving (53.1%), and Sports/Driving (75%) games. This suggests that engineering education at HBCUs could benefit from incorporating game-based learning approaches that utilize these genres. For instance, action-adventure games can be used to teach problem-solving and decision-making skills in engineering design. Puzzle/problem-solving games can be integrated to enhance critical thinking and computational skills. Additionally, sports/driving simulations can be used to model real-world engineering challenges in areas like transportation and logistics.

Figure 6: Chart showing the ways games can help improve skills

The chart reveals that HBCU students perceive gaming as a valuable tool for developing essential skills relevant to engineering education. A majority of respondents believe games help improve critical thinking (90.6%), problem-solving (68.8%), and creativity (65.6%). This suggests that educators can leverage these perceptions by integrating game-based learning approaches into their curricula. For example, games that require strategic planning and time management can be used to teach engineering project management principles. Additionally, games that foster teamwork and collaboration can be incorporated to enhance group dynamics and communication skills among engineering students.

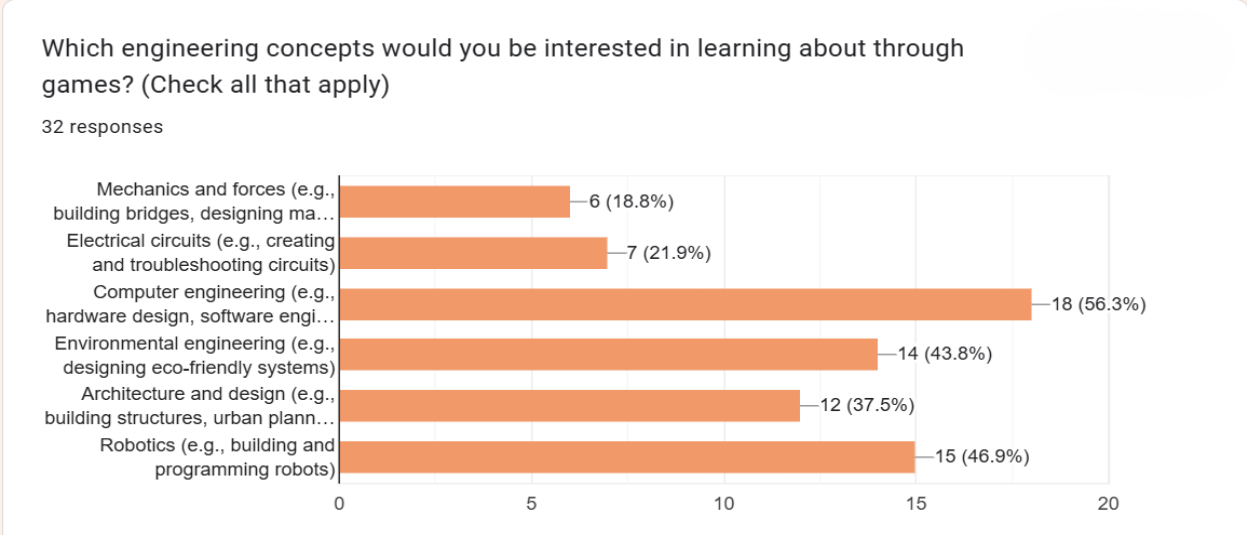

Fig 7: Chart Showing Engineering Concepts Students are Interested in Learning

The chart indicates that a significant percentage of HBCU students express interest in learning about Computer Engineering (56.3%) and Robotics (46.9%) through games. This suggests that engineering education at HBCUs can effectively utilize games to teach these concepts. For example, games that involve coding or programming challenges can be used to teach computer engineering principles. Similarly, games that simulate robotics applications, such as controlling robots to navigate environments or complete tasks, can provide hands-on learning experiences in robotics.

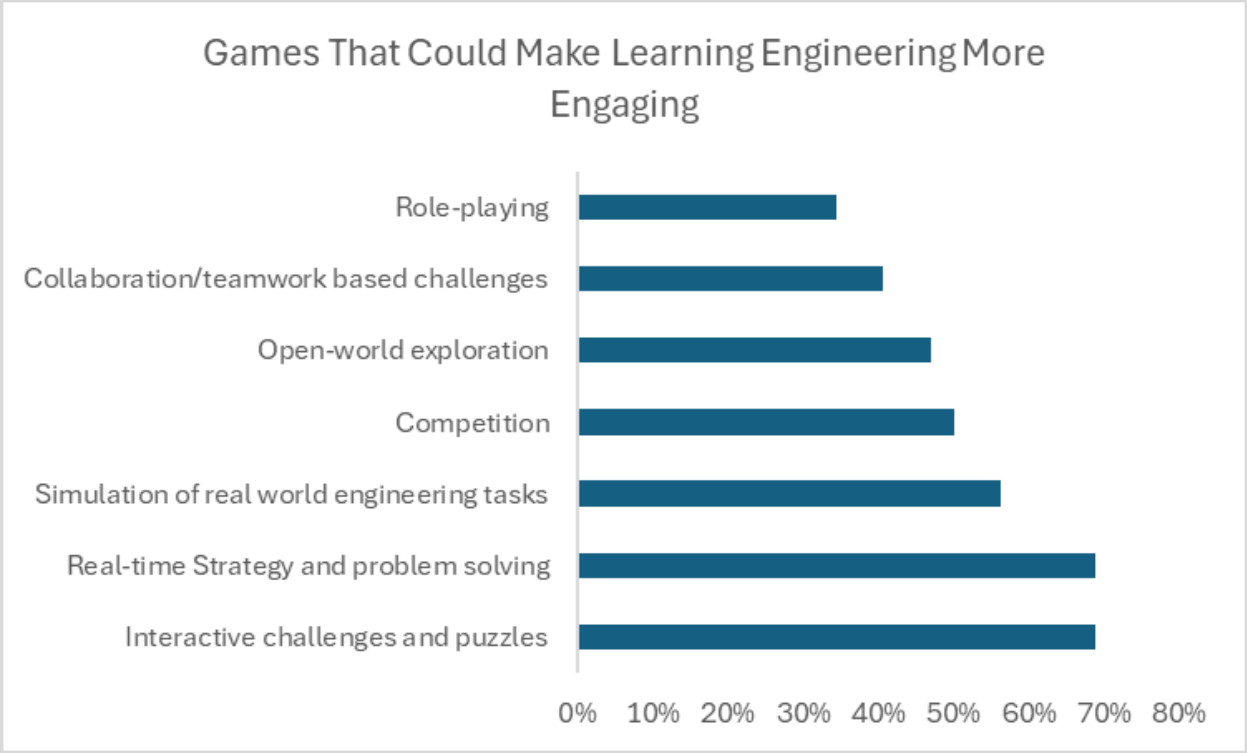

Figure 8: Chart showing games elements that can help learning engineering more engaging.

The chart indicates that HBCU students believe game elements like interactive challenges and puzzles (68.8%), real-time strategy and problem-solving (68.8%), and simulation of real-world engineering (56.3%) would make learning engineering more engaging. This suggests that engineering education can be enhanced by incorporating game-based learning approaches that utilize these elements. For example, interactive challenges and puzzles can be used to teach problem-solving and design principles. Real-time strategy and problem-solving can be integrated to enhance decision-making and resource management skills. Additionally, simulations of real-

world engineering scenarios can provide students with hands-on experience and a deeper understanding of engineering concepts.

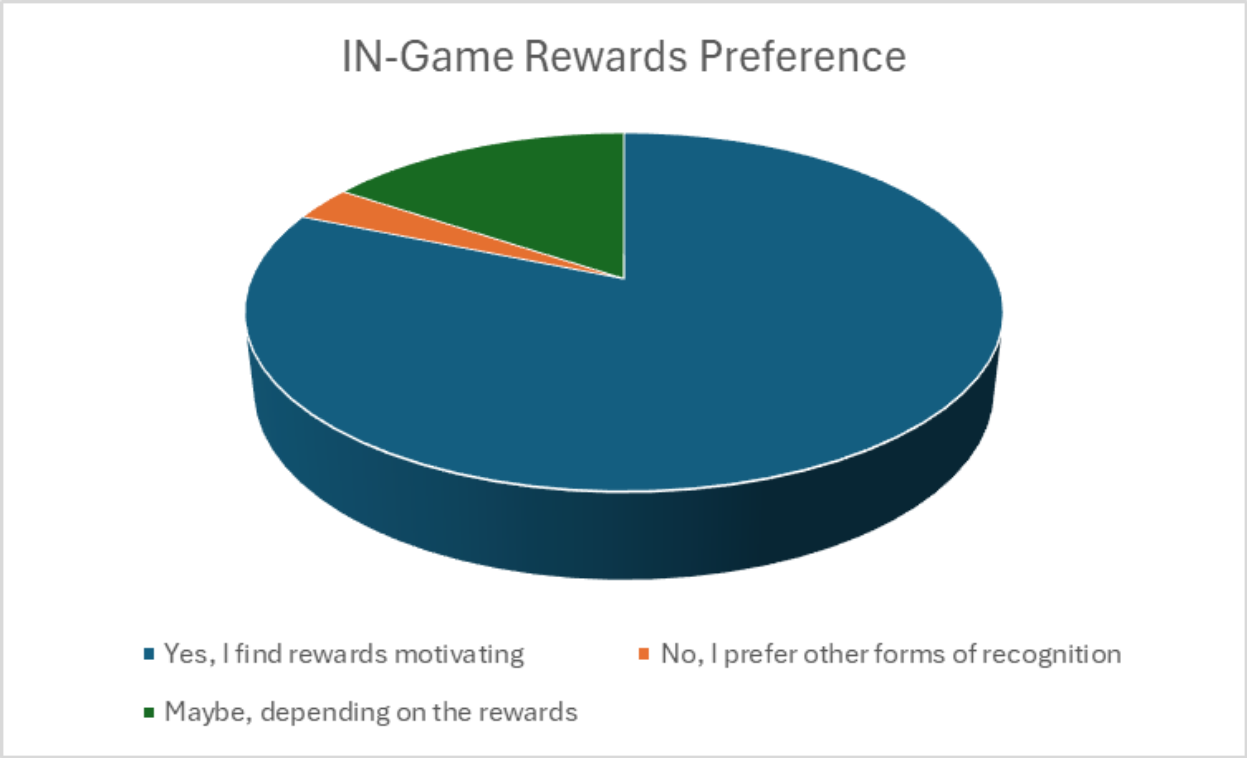

Figure 9: Chart Displaying In-game Rewards Preference

This pie chart shows that most students (81.3%) find in-game rewards motivating (largest dark blue section). A smaller group (15.6%) represented by green is motivated depending on the type of rewards, while very few (3.1%) represented by orange prefer other forms of recognition. This suggests that while rewards are effective for most, some players value different incentives, requiring a mix of reward strategies in game-based settings.

Gamification elements such as in-game rewards, leaderboards, and multiplayer collaboration can further motivate students and create real-world engineering challenges [27]. A flipped classroom model can be used, where students engage with gaming simulations outside of class and apply concepts through hands-on projects during in-class activities [28]. Regular game-based sessions can reinforce learning and enhance retention [29].

By incorporating game-based learning, educators can create an interactive and immersive environment that aligns with Constructivist Learning Theory, which emphasizes learning through

experiences relevant to students' interests [32]. This method not only makes engineering concepts more accessible but also enhances academic performance and real-world problem-solving skills [25].

Study Limitations

While this study provides valuable insights into student gaming preferences and potential applications for curriculum design, it has some limitations. The sample is limited to a single HBCU, which may not fully represent gaming trends among all HBCU engineering students. Second, the sample size of the study is relatively small, which may limit the generalizability of the findings. Third, the study does not account for external factors that may influence students' engagement level with their favorite games. Finally, a mixed-methods approach is not employed to get deeper insight. Future research may incorporate qualitative methods to further investigate individual perspectives and perceptions. Overall, all these limitations should be considered when interpreting the findings, and future studies should aim to address them by incorporating a bigger sample and alternative data collection methods.

Conclusion

The analysis of the Game Engagement Questionnaire reveals several key insights relevant to engineering education at HBCUs. Firstly, the data highlights a diverse range of gaming interests among students, with popular choices spanning casual mobile games like Candy Crush to action-adventure titles like God of War Ragnarok and sports simulations like PES. This diversity presents an opportunity for educators to create engaging and relevant learning experiences by incorporating a variety of game genres into their curriculum.

Secondly, the student responses suggest that game-based learning approaches can be highly effective in fostering essential skills for engineering success. Students perceive games as valuable tools for developing critical thinking, problem-solving, creativity, teamwork, strategic planning, and time management. These skills are crucial for success in engineering fields and can be effectively integrated into game-based learning activities.

Thirdly, the data indicates a strong interest among students in learning engineering concepts through games, particularly in areas like computer engineering and robotics. This suggests that

educators can leverage this interest by developing game-based learning modules that cover these topics. For example, games that involve coding or programming challenges can be used to teach computer engineering principles, while simulations that involve controlling robots can provide hands-on learning experiences in robotics.

Finally, the student responses highlight the importance of certain game elements in making learning engineering more engaging. Interactive challenges, open-world exploration, real-time strategy, role-playing, competition, collaboration, and simulations of real-world engineering scenarios are all perceived as valuable elements that can enhance the learning experience. Educators can incorporate these elements into their game-based learning activities to create more immersive and effective learning experiences.

The findings of this study provide valuable insights into the gaming interests and preferences of HBCU students. By harnessing this enthusiasm and leveraging the potential of game-based learning, engineering educators can create innovative and engaging learning experiences that inspire students and enhance their understanding of complex engineering concepts. By incorporating game-based learning approaches into their curriculum, educators can make learning more fun, interactive, and relevant to students' interests, ultimately leading to improved student engagement and academic success.

Building on the findings of this study, future research could explore how specific mechanics of students' favorite games, which also generate the highest levels of engagement, can be incorporated into engineering curricula through experimental interventions. A follow-up study could test game-based learning modules in real classroom settings, assessing their impact on student engagement and academic performance. Additionally, future research could adopt a mixed-methods approach, incorporating interviews or focus groups to gain a deeper understanding of how students perceive and interact with educational games. Exploring faculty perspectives on game-based learning implementation at HBCUs could also provide valuable insights into potential challenges and opportunities for curriculum development.

Although the study focuses on HBCUs, its findings are applicable to other institutions, including Predominantly White Institutions (PWIs) and community colleges. Given the widespread enthusiasm for gaming, this approach can be adapted across various educational settings to

improve STEM learning outcomes [30]. Future research can explore how gaming preferences and engagement levels vary across different student populations [31].

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