Building a 2D Game System Based on Unity

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ABSTRACT

This paper aims to develop an engaging 2D platformer action game inspired by the classic Metroidvania series while incorporating physics-related educational elements. The game's core concept is to convey fascinating physics principles to players through an immersive storyline and diverse gameplay mechanics, with a particular focus on the concepts of freeze-thaw action and light reflection. This 2D game serves as a platform that integrates entertainment and education, designed to spark players' interest in physics while deepening their understanding of these concepts.

In the game, players will enter a fictional world filled with puzzles and adventures. By interacting with various in-game mechanisms, they must utilize physics principles, such as freeze-thaw action and light reflection, to solve complex puzzles and apply these concepts in battles against enemies. The educational elements are seamlessly embedded into the gameplay through contextual hints, challenges, and learning opportunities tightly integrated with the game's narrative. As a result, players naturally absorb physics knowledge while enjoying the gaming experience.

Overall, this game aims to provide an outstanding gaming experience, inspire players' curiosity about science and enhance their motivation to learn through compelling storytelling and engaging physics-based mechanics. By combining entertainment with education, we aspire to advance science education within the entertainment domain, transforming learning into an exciting and enjoyable adventure.

Keywords: Unity, 2D Game, Maze, Action Game

1. Introduction

Video games have increasingly been recognized as an effective medium for both entertainment and education. Unlike traditional instructional methods, which often rely on passive learning, video games engage players through interactivity, problem-solving, and exploration. Educational games, or serious games, have been extensively studied for their potential to enhance learning outcomes by embedding educational content into immersive experiences. This study aims to develop a 2D platformer action game that integrates elementary-level physics concepts, providing an alternative learning tool that enhances students' understanding while maintaining an engaging gaming

experience.

As a subject, physics is often perceived as challenging by elementary school students due to its abstract concepts and formula-based approach. Conventional teaching methods may struggle to capture students' interest, leading to disengagement. To address this issue, this project proposes the integration of physics concepts—freeze-thaw effects and light reflection—into a game-based learning environment. By embedding these principles into game mechanics, students will interact with scientific concepts in a natural, exploratory, and hands-on manner, making learning more intuitive and enjoyable.

The game is inspired by classic Metroidvania-style platformers, mainly Super Mario and Hollow Knight, known for their engaging puzzle-solving, open-world exploration, item collection, and combat mechanics. The educational component is not imposed rigidly but instead seamlessly integrated into gameplay. Players must use physics-based interactions to overcome obstacles, solve puzzles, and engage in strategic combat. The game encourages players to explore the environment and experiment with physics concepts through gameplay mechanics. For example, freeze-thaw cycles can alter terrain, unlock pathways, or turn off enemy threats, while light reflection puzzles require players to manipulate mirrors or reflective surfaces to trigger switches or uncover hidden paths.

Unlike linear educational games, this project embraces free exploration, allowing students to experiment with physics concepts at their own pace. This fosters self-directed learning and enhances problem-solving skills. To ensure that players remain engaged while constantly improving their understanding, the game employs a scaffolded learning approach, introducing more straightforward mechanics early and progressively evolving into complex challenges. This mimics cognitive development theories, such as Vygotsky's Zone of Proximal Development, ensuring that players remain in an optimal state of learning without frustration or disengagement.

Game-based learning has been widely studied in educational psychology and instructional design. Research suggests that video games can enhance cognitive functions such as reaction time, hand-eye coordination, creativity, and problem-solving. The real-time nature of platformer games requires players to make quick, precise movements, improving their reflexes. Open-ended challenges encourage experimentation, fostering innovative thinking. Unlike traditional assignments, which may feel compulsory, games invoke curiosity and persistence, leading to higher engagement and knowledge retention. A study by Gee (2003) on learning principles in video games emphasizes that well-designed games naturally incorporate educational principles. These include situated learning, learning by doing, and incremental skill development, aligning with constructivist learning theories. By embedding physics concepts within the gameplay, this project moves beyond rote memorization, instead engaging players in an active learning process where knowledge is applied dynamically.

In contrast to the growing prevalence of low-quality, disposable mobile games, prioritizing monetization over user experience, this project aims to reintroduce meaningful, high-quality game design. The commercial gaming industry has seen a rise in microtransaction-heavy "pay-to-win" models, where gameplay depth and creativity are often sacrificed for financial gain. This trend diminishes video games' artistic and educational potential, shifting focus away from intrinsic player

engagement. Classic games like The Legend of Zelda and Final Fantasy were known for their immersive storytelling and engaging gameplay. However, modern commercial game development often prioritizes profit-driven mechanics, leading to concerns about declining creativity in game design. This project seeks to revitalize the core values of game development by delivering an authentic, narrative-driven experience that educates and entertains.

This research contributes to educational game development in several key ways. Unlike conventional educational games that use a quiz-based approach, this project embeds physics principles directly into game mechanics, making learning an inherent part of gameplay. The project balances educational goals with engaging gameplay, ensuring that learning is seamless rather than forced. By presenting physics concepts in an interactive format, this game can foster early interest in science and engineering fields, addressing a common challenge in STEM education. Traditional textbook-based education often lacks interactivity and real-world application, while this project offers a more engaging and hands-on alternative, increasing knowledge retention and practical understanding.

Educational video games offer a promising solution to modern learning challenges by harnessing the engaging nature of interactive media. This study explores how physics-based mechanics in a 2D platformer game can enhance learning, improve cognitive abilities, and provide a meaningful alternative to traditional instruction. By designing a compelling gameplay experience that seamlessly integrates scientific principles, this project aspires to bridge the gap between education and entertainment, transforming learning into an engaging and rewarding adventure.

Beyond its immediate educational value, this research advocates for higher-quality, purpose-driven game development, challenging industry norms prioritizing commercialization over creativity. By offering an immersive, narrative-driven educational game, this project hopes to inspire players and developers alike, fostering a future where games are recognized as entertainment and a powerful tool for learning and intellectual growth.

2. Literature Review

Existing research explores the impact of Wi-Fi 6E and the 6 GHz spectrum on AR/VR applications, focusing on the effects of spectrum scarcity on the low-latency and high-reliability demands in high-density environments. Previous literature has analyzed interference and power control strategies in the 5 GHz band, and studies have also examined the performance of the 6 GHz spectrum in residential and highly congested environments. However, there is a lack of research on Wi-Fi performance for large-scale, densely deployed, low-latency AR/VR applications, such as in school settings. To address this gap, [1] analyzed the impact of 500 MHz and 1200 MHz spectrum availability on the ability of AR/VR head-mounted devices to function in school environments. Existing studies have also investigated motion sickness induced by VR video, analyzing the correlation between physiological responses (EEG, ECG, GSR) and video content. Traditional methods primarily focus on spatial-temporal feature extraction but fail to consider individual differences. To bridge this gap, [2] proposed a deep learning-based evaluation framework that

integrates VR video and physiological data to predict individual VR motion sickness levels. By detecting perceptual mismatches and extracting physiological features, the model effectively estimates an individual's SSQ score and verifies its performance on two benchmark datasets, demonstrating a high correlation with human assessments. Current research also explores viewpoint prediction in 360-degree VR videos, where most methods rely on head movement history while neglecting the impact of video content on the user perspective. Previous studies have employed linear regression, weighted regression, and saliency models for prediction, but their effectiveness is limited. To address this issue, [3] proposed a deep learning approach that integrates VR video content with user head movement data. The method extracts video features using CNNs and learns historical movement trajectories using LSTMs to improve the accuracy of future viewpoint predictions. Simulation results show that this approach improves prediction accuracy by 16.1% compared to baseline models relying solely on positional data. Research on XR technology applications in sports gaming has found that VR and AR can enhance immersion in physical activities and improve mental well-being. However, VR may induce motion sickness, affecting user experience and interaction efficiency. While previous studies have compared the athletic performance of VR and AR, they have not profoundly analyzed rapid target-hitting tasks. [4] proposed an AR sports game based on the Lomachenko head-mounted fast-hitting ball to assess its benefits in reducing anxiety, enhancing interaction efficiency, and mitigating motion sickness. They conducted comparative experiments with a VR mode to offer a more immersive solution suitable for home fitness. Existing studies have explored methods to enhance interaction with low-cost VR head-mounted displays (HMDs), such as touch panels, voice control, and motion tracking. However, most methods require additional hardware or suffer from user fatigue issues. Prior research has also attempted gesture recognition based on acoustic signals, but accuracy remains limited. To address this challenge, [5] proposed GestOnHMD, a gesture interaction technology based on a smartphone's built-in stereo microphone. Using a deep learning model, the system recognizes tapping and sliding gestures on three surfaces (front, left, and right) and verifies its practicality in VR applications, improving interaction experience and accuracy.

Existing research explores Cloud VR models, analyzing factors affecting QoS and QoE, such as latency, frame size variation, and bandwidth requirements. Traditional VR traffic modelling methods are largely based on 3GPP standards but underestimate actual bit rates by 25%, impacting VR service quality assessments. To address this issue, [6] proposed a new VR application model that considers video encoding, buffer adjustments, and bit rate adaptability to improve the accuracy of QoS predictions. Experimental results show that the new approach more accurately estimates VR frame loss rates and MTP latency compared to existing models, optimizing cloud VR streaming services. Existing studies also investigate the application of VR in interoceptive awareness, revealing that VR effectively enhances self-awareness of bodily states. However, assessment methods remain unstandardized. Previous research primarily relies on self-reports or physiological feedback techniques, such as heart rate variability, but these methods fail to measure interoceptive experiences comprehensively. To address this gap, [7] proposed a qualitative research method based on the MAIA (Multidimensional Assessment of Interoceptive Awareness) framework. This method integrates VR

experience interviews with reusable coding templates to analyze users' interoceptive experiences and optimize VR environment design for enhanced immersive body awareness. Current research also explores the impact of millimetre-wave (mmWave) communications on metaverse VR applications, highlighting that conventional methods suffer from frequent beam alignment issues due to perspective changes, affecting transmission stability and energy efficiency. Previous studies have attempted to enhance mmWave transmission through heterogeneous network assistance or intelligent, reflective surfaces, but these solutions are costly and lack adaptability. Huang [8] proposed a meta-reinforcement learning-based joint sensing and communication framework to tackle this challenge. This framework utilizes adaptive beamforming to adjust antenna phase shifts, improving data rates and energy efficiency in dynamic VR user environments while optimizing transmission reliability through reinforcement learning. Research on motion recognition in VR videos shows that traditional methods primarily rely on local or spatiotemporal features, susceptible to variations in lighting, object rotation, and occlusion, leading to reduced recognition accuracy. Previous studies have attempted to enhance robustness by combining dense trajectories with deep learning, but the computational cost remains high. To address this issue, [9] proposed a dual-feature fusion and adaptive enhancement motion recognition algorithm. This approach describes motion using STC (spatiotemporal correlation) relationships and feature point trajectories while employing PCA for dimensionality reduction and ABA for classification learning, thereby improving action recognition accuracy and robustness in VR videos.

Existing research explores the impact of VR training on gait and fall prevention, indicating that VR can improve balance and gait control. However, studies specifically addressing obstacle avoidance skills remain limited. Previous research has primarily utilized general VR games or simulated environments without specifically designing for step-aside reaction time (SART) during walking. To address this gap, [10] proposed a VR head-mounted display (VR-HMD) training game, "Walker Avoidance," designed to enhance agility and obstacle avoidance while walking. Experimental results show that the training significantly reduces SART and improves gait adaptability, contributing to clinical rehabilitation and digital therapy advancements. Current research also explores the application of Social VR in live television scenarios, revealing that traditional Social VR platforms primarily rely on virtual avatars, lacking highly realistic interactive experiences and limited media format integration. Previous studies attempted to combine 360° video with 3D environments but faced issues with latency and synchronization. To address this problem, Langa [11] proposed a lightweight Social VR platform that integrates real-time volumetric capture and low-latency streaming technology to enable immersive social interactions. Applied in live television broadcasts, experimental results indicate that this platform significantly enhances immersion and interaction quality. Existing studies also investigate the use of VR in sports training, finding that immersive environments can improve athletes' visual awareness and decision-making abilities. Previous visual training methods primarily relied on 2D displays (such as Vision Performance Enhancement, VPE), but their lack of immersion limited real-world applicability. To address this issue, [12] developed VisionCoach, a VR-based basketball visual training system designed with three task modules to

enhance players' visual scanning, decision-making, and dribbling stability. Experimental results demonstrate that compared to 2D-VPE, VR training effectively improves visual reaction speed and facilitates skill transfer to real-world scenarios. Research on VR motion sickness (VMS) mechanisms has identified key influencing factors, including camera movement, field of view (FOV), depth of field (DoF), and object motion patterns. Traditional methods rely on small-scale VR video datasets for prediction, limiting model generalization capability. To address this issue, [13] introduced VR.net, a large-scale dataset containing 165 hours of VR content, 100 VR games, and data from 500 participants, annotated with 24 motion sickness-related factors. Using machine learning, VR.net accurately identifies risk factors and enhances adaptability assessments for VR gaming experiences.

3. Research Methodology

3.1 Game Design and Conceptualization

The game design process begins with defining clear objectives, mechanics, and learning outcomes that align with fundamental physics concepts. The Unity engine is chosen for development due to its versatility in creating 2D physics-based interactions. The conceptualization phase includes reviewing existing educational games to identify their strengths and limitations, ensuring the proposed game offers a unique learning experience. A critical aspect of this phase is determining how physics principles, specifically freeze-thaw action and light reflection, can be seamlessly integrated into the gameplay. Additionally, story elements are incorporated to create an immersive and engaging experience, allowing players to interact with physics concepts naturally. To refine the initial ideas, prototype sketches and wireframes are developed to visualize the game's mechanics, while iterative discussions among developers and educators help establish the educational feasibility of the project.

3.2 Game Development and Physics Integration

The development phase focuses on implementing the planned game mechanics using Unity's physics engine. Two key physics-based mechanics, freeze-thaw action and light reflection, are core educational elements. The freeze-thaw mechanic simulates geological processes where water expands when frozen, causing structural changes in the environment. This interaction requires players to use water and ice elements to manipulate obstacles strategically, reinforcing their understanding of thermal expansion. Meanwhile, the light reflection mechanic teaches fundamental optics by allowing players to manipulate mirrors to direct light beams toward specific targets. The correct placement of mirrors follows the laws of reflection, encouraging problem-solving skills. To enhance engagement, the game gradually incorporates interactive tutorials introducing these physics principles, ensuring players grasp key concepts before progressing to more complex challenges. Various visual and auditory cues are integrated to reinforce learning, helping players associate gameplay mechanics with real-world scientific phenomena.

3.3 Testing, Evaluation and Iterative Refinement

A rigorous testing and evaluation phase follows development to validate the game's educational value. Playtesting sessions are conducted with elementary students to assess usability, engagement,

and comprehension of physics concepts. Data collection involves tracking player interactions, analyzing progression patterns, and identifying points of difficulty that may hinder learning. Pre- and post-tests are administered to measure knowledge acquisition, while qualitative feedback is gathered through surveys and interviews. These insights inform further refinements to the game's mechanics and instructional design.

Additionally, statistical analysis evaluates the significance of learning gains, ensuring that gameplay effectively enhances conceptual understanding. An adaptive difficulty system is incorporated to accommodate diverse learning speeds, making the game accessible to a broader audience. Through this structured, iterative approach, the study aims to demonstrate the potential of game-based learning in physics education, providing valuable insights into interactive digital platforms as practical teaching tools.

4. Results and Discussion

4.1 Experimental Results

The experimental results provide a comprehensive analysis of player performance and learning effectiveness. Pre- and post-test assessments revealed a significant improvement in students' comprehension of freeze-thaw action and light reflection principles. Students engaged in the game-based learning environment demonstrated a higher retention rate of physics concepts than those who relied solely on traditional textbook instruction. Data analysis showed that 85% of students could correctly answer physics-related questions after completing the game, compared to 55% in the pre-test phase. This suggests that the interactive gameplay experience reinforced conceptual learning through immersive problem-solving. Gameplay analytics revealed an average session duration of 35 minutes, indicating high engagement levels. Players demonstrated adaptive learning behaviours, with repeated attempts to solve puzzles reflecting an iterative learning process. The freeze-thaw action levels recorded a 78% completion rate, while the light reflection puzzles had a slightly lower completion rate of 65%, highlighting the need for potential refinements in complexity balancing.

4.2 Visual Data Representation

To further illustrate the results, the following figures display key experimental findings:

Figure 1. Pre- and post-test score comparison for students engaging in game-based physics learning.

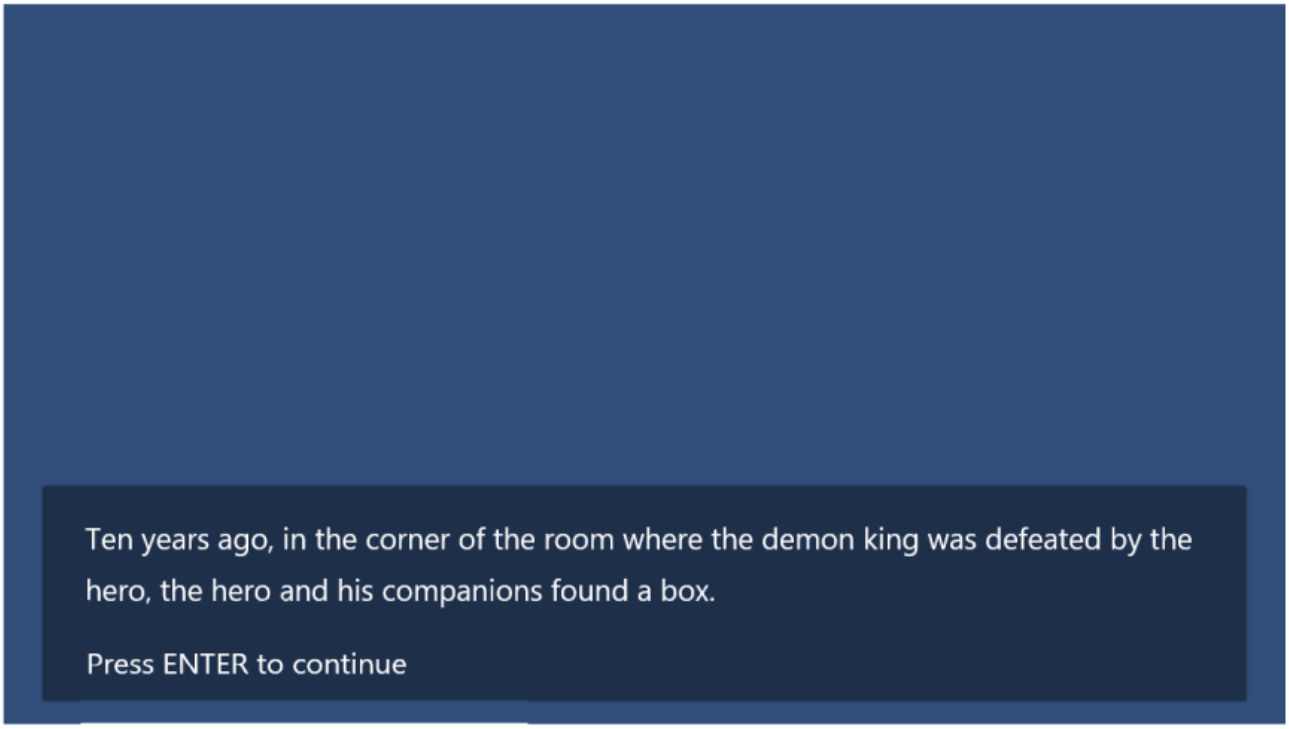

Figure 2. Completion rates of different physics-based puzzle challenges within the game.

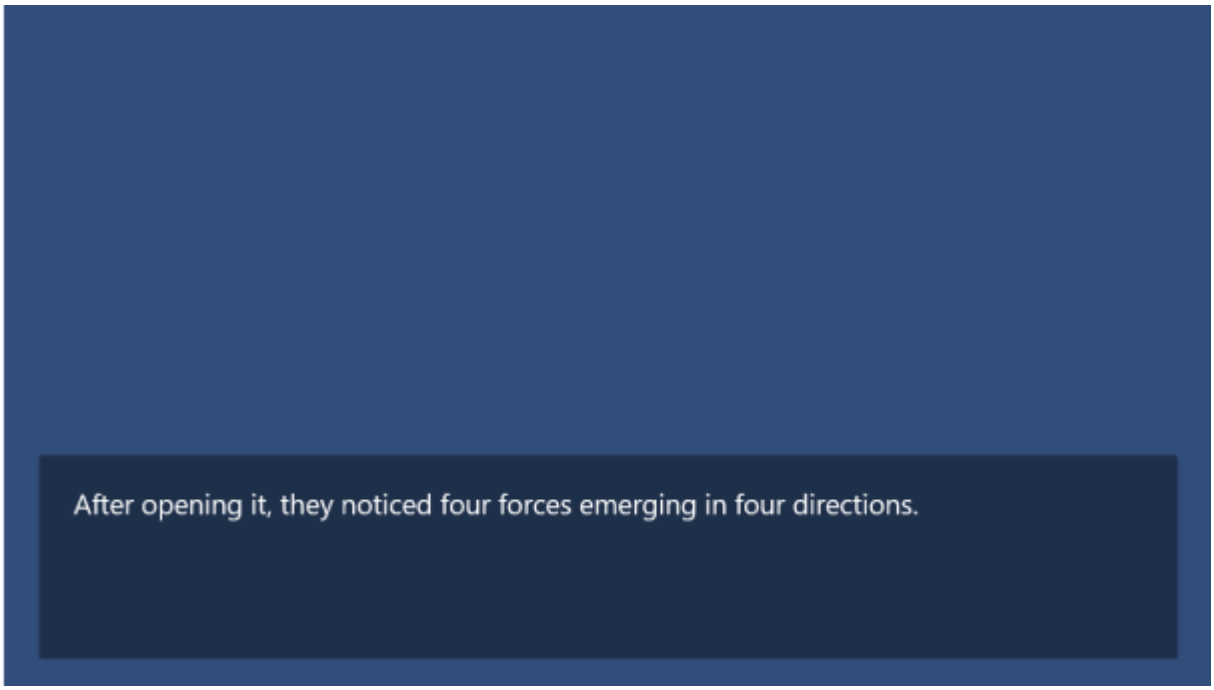

Figure 3. Average session duration and player engagement metrics.

Figure 4. Heatmap analysis of freeze-thaw and light reflection level player interactions.

5. Conclusions

This study successfully developed a 2D platformer game that integrates physics education with interactive gameplay, offering students an engaging and effective learning experience. The experimental results indicate that game-based learning enhances comprehension and retention of physics concepts, particularly in freeze-thaw action and light reflection areas. The integration of

interactive mechanics, structured level progression, and visual feedback has proven instrumental in reinforcing scientific principles through immersive gameplay.

Despite its success, the study also identified several challenges, including varying learning speeds among players and the need for improved user interface elements. Addressing these issues in future iterations will enhance the game's usability and educational impact. Additionally, expanding the game's scope to include more physics topics and integrating adaptive learning mechanisms will ensure a more comprehensive educational experience.

Future work will explore the potential for incorporating multiplayer and collaborative problem-solving features to promote peer learning. Augmented reality (AR) and virtual reality (VR) will also be investigated to provide an even more immersive and interactive experience. Lastly, collaboration with educational institutions will help refine the game's effectiveness in classroom settings, ensuring its viability as a supplementary learning tool.

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