Development of a 3D Platformer Game for a Pseudo-Holographic Gaming Console

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Abstract. *T*his work-in-progress paper presents the design and implementation of a 3D platformer game developed for a pseudo-holographic gaming console utilizing a Pepper's Ghost pyramid display. The project applies a Design Science Research (DSR) methodology to address the underexplored potential of holographic projection technologies in gaming contexts. The system integrates custom hardware, including a bespoke cabinet and holographic pyramid, and a software solution built using UPBGE, Blender, and Python. Core game features encompass player navigation across a cubic environment projected holographically, collision detection, and a mobile device interface for control. The artifact was demonstrated through live evaluations and online deployment, revealing key insights into visual design optimization and user interaction constraints unique to the holographic medium. The results underscore the viability of leveraging Pepper's Ghost displays for interactive entertainment and highlight opportunities for further research in novel game mechanics and user experience refinement.

Keywords. computer games, 3D models, Pepper's Ghost pyramid, UPBGE, holographic gaming, design science research

1 Introduction

Gaming consoles are specialized computing devices designed for video gaming. These devices generally fall into two categories: those that require an external display, such as a television, to showcase the game content, and those that are versatile and can function independently with their own display. Gaming consoles which are designed to connect to an external display are usually equipped with high-performance hardware, allowing them to render graphically-intensive games. On the other hand, consoles other consoles are more versatile and have built-in displays, allowing them to function independently, but they can also be connected to an external display for a more immersive gaming experience.

In addition to these dedicated gaming devices, the proliferation of smartphones and tablets has led to an expansion in mobile gaming. These devices feature powerful processors and high-resolution touch-screen displays, allowing them to deliver a compelling gaming experience. Despite their omnipresence, current gaming technology does not utilize holography nor mobile devices as controllers.

Holography, while used in some niche applications and experimental settings, is not a part of standard gaming console technology. The creation of a holographic image is still a complex process that might involve using a panel display as the light source for the holographic image.

A hologram is 3 dimensional visual display that displays objects visible from all angles. At the time of writing there are a number of promising holographic technologies available (Blanche, 2022; Chang et al., 2018; Fadzli et al., 2022; Haleem et al., 2022; Z. Li et al., 2022; Piliar, n.d.; Wang et al., 2022). From a commercial perspective, there are various technologies that will produce a similar effect.

Whilst real holography devices are still an unreached dream for industry (Blanche, 2021), pseudo-holography technologies have matured up to a point in which ready-to-use products are available of the shelf. Technologies like Pepper's Ghost displays (for example Burdekin, 2015), various volumetric displays (see for example Fokides and Kilintari, 2023; Refai, 2009, and others), transparent organic light-emitting diode (OLED) screens for example Tsai et al., 2017, as well as holographic meshes like hologauze (for example Weinel, 2020) are used for in-store marketing, exhibitions, shows and games. artificial intelligence (AI) and holography have the possibility to "*change the nature of the interaction between learners and learning materials*" (X. Li and Taber, 2022).

One such technology are so called Pepper's Ghost images, after the English scientist John Henry Pepper (1821–1900). The basic idea behind this technology is to use a light display that emits an image on a reflective (usually transparent) surface which reflects the image and provides a holographic experience. This technique, has been used for centuries and involves using plate glass, Plexiglas, or plastic film and special lighting techniques to make objects seem to appear or disappear, become transparent, or to make one object morph into another Crowder and Jackson, 2016. An enhancement of the original system is to use a glass or acrylic four sided pyramid instead of just one surface, and place a display above or bellow the pyramid so that the holographic image is visible from all four sides of the pyramid.

Such pyramidal holographic displays have not been widely adopted in gaming technology. Similarly, while mobile devices have been used as controllers in certain contexts, they are not a standard control method for mainstream consoles.

As part of the O_HAI 4 Games project (*Orchestration of Hybrid Artificial Intelligence Methods for Computer Game* sponsored by the Croatian Science Foundation) one such console has been developed as reported in (Schatten, 2023). Herein we report on the development of a 3D platformer game for this console that has been developed at the Artificial Intelligence Laboratory of the University of Zagreb Faculty of Organization and Informatics.

The rest of this paper is organized as follows: firstly in section 2 we introduce the pseudo-holographic gaming console HoloGameP. In section 3 we discuss the development process of the game in detail. In section 4 we draw our final conclusions and showcase directions of future research.

2 HoloGameP - A Pseudo-Holographic Gaming Console

To build the physical hardware, we first performed preliminary calculations to determine the appropriate dimensions for the plexiglass pyramid. Based on these measurements, we designed the remainder of the cabinet, taking into account available display sizes and ensuring the console would be comfortable for users to view at eye level. A detailed Computer Aided Design (CAD) model was created in FreeCAD[1], which is included in the appendix of this document.

Using this model as a reference, a cabinet combining wooden and metallic elements, as shown in Fig. 1 has been built. The display is installed within the upper metal compartment, with the plexiglass pyramid positioned directly beneath it. The lower wooden section houses all the hardware components, including a gaming PC, a router, and peripheral devices such as a mouse and keyboard.

Figure 1. HoloGameP Cabinet

The software required to operate the HoloGameP console comprises three main components (outlined in Schatten, Peharda, et al., 2022): (1) a streaming system, (2) a game engine with camera transformation capabilities, and (3) an implementation of the controller application programming interface (API). The console can function either by streaming content or running a locally installed game. Testing indicated that the local installation delivers significantly better performance due to network latency constraints. Therefore, in this work, we focus on developing proof-of-concept implementations for the local mode.

[1] Available at https://www.freecad.org/

3 Development Process

To develop a gaming experience based on a Pepper's Ghost pyramid, we employed a design science research (DSR) approach. DSR is a research methodology within information systems and technology that focuses on the development of innovative artifacts such as models, methods, systems and software. These artifacts are intended to help individuals and research teams design, implement, and manage IT solutions (Johannesson and Perjons, 2014). Beyond information systems and technology, design science is also applied across diverse areas of human practice.

Design science methodology (refer to Fig. 2) generally comprises a series of principal stages which are not strictly linear and may be revisited iteratively throughout the course of a DSR project. Below, we describe these stages and outline their application in the development of our holographic gaming system.

3.1 Problem Identification and Motivation

This stage entails recognizing a specific problem or opportunity and establishing its significance. A comprehensive understanding of the problem domain is essen-

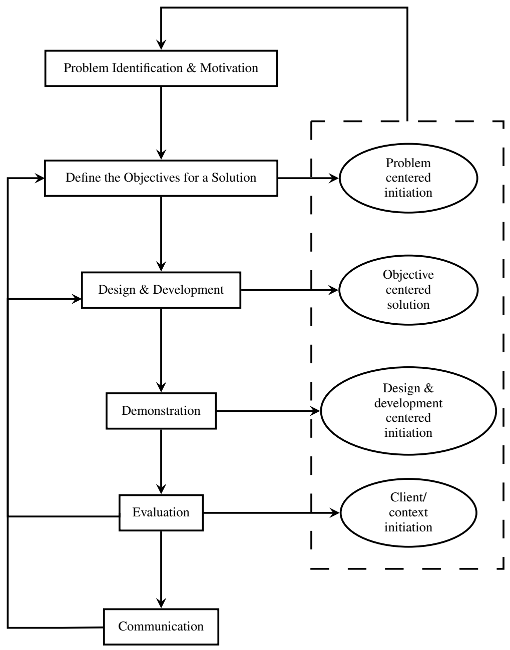

Figure 2. Design science methodology (Azasoo and Boateng, 2015) adapted from (Peffers et al., 2007)

tial, as is the articulation of the motivation for addressing the challenge.

In this context, problem identification involves discerning a relevant issue and situating it within a broader framework. It is critical to define the motivation not solely in terms of a technical resolution but also with respect to its potential impact and contextual relevance.

In our case, the problem addressed stems from the underutilization and limited public understanding of holographic display technologies, particularly Pepper's Ghost–based systems, in gaming and interactive settings.

While holography has seen increased use in mostly advertising, its integration into proper gaming environments remains rare and underexplored. The motivation behind this project is to bridge that gap by developing an engaging, interactive holographic platformer game specifically designed for a large, custom-built pyramid display installed at our campus building for students and visitors to interact with.

The aim is twofold: to highlight the creative and technical capabilities of Pepper's Ghost holography and to demonstrate how such technology can support innovative forms of digital interaction in the gaming industry, as well as educational settings. By combining game design with holographic projection, the project offers an immersive experience that appeals to a wide range of users from non-gamers trying out new technology, to hardcore players looking for a new challenge, thereby fostering curiosity about both the underlying technology and the possibilities it unlocks for future applications in entertainment, visualization, and other settings.

3.2 Define the Objectives for a Solution

Building upon the previously identified problem, this stage involves formulating clear objectives for the proposed solution. These objectives must be both feasible and explicitly aligned with addressing the identified challenge.

The principal objectives guiding the development of our holographic platformer are as follows:

1. *Demonstrate Entertainment Potential.* The primary goal is to highlight how Pepper's Ghost holography can be used to deliver compelling, interactive gaming experiences. The platformer is designed to entertain and captivate a general audience, demonstrating that holographic displays can be more than passive exhibits. They can support dynamic, responsive digital content. By combining real-time interaction with visual depth and spatial illusion, the game showcases the unique potential of holographic projections to engage users in ways that traditional screens cannot. The use of a pyramid-shaped holographic display allows the game to be experienced from multiple angles, adding a physical presence and novelty factor that enhances immersion. This makes it particularly effective for public installations, exhibitions, or educational environments where grabbing and maintaining audience attention is essential. Through creative design, intuitive gameplay, and responsive mechanics, the project emphasizes that holography is not just a visual trick — it is a viable platform for meaningful and enjoyable digital experiences.

2. *Investigate Novel Game Mechanics Unique to the Medium.* The project aims to explore and evaluate innovative gameplay interactions that are inherently specific to the pseudo-holographic display environment. These mechanics leverage the volumetric appearance, spatial parallax, and multi-angle visibility of the Pepper's Ghost technique to enable experiences that are impractical or unattainable in conventional gaming contexts.

3. *Design for Drop-In Interactivity.* The game is intended to be immediately accessible to walk-by participants, including students, faculty, and visitors. Simple, intuitive controls and quick on boarding make it easy for users to engage with the game without prior instruction or setup.

These objectives guide the design and development process of the game, ensuring that the final product meets all the criteria, works as intended, and, most importantly, sends the right message about the capabilities of this technology.

3.3 Design and Development

During this phase, an artifact is systematically conceived and implemented to fulfill the established objectives. The resulting artifact may take the form of a conceptual model, a methodological framework, or a functional instantiation. The design and development has been conducted by 6 students as part of the Game platforms development course and student internship under the guidance of one university professor.

This phase involves the transformation of initial ideas into a functioning interactive experience tailored to the constraints and opportunities provided by the holographic pyramid display. The development of the game has been started as an intern project and later fully developed during a game development platforms course. The first step was to develop a game development document (GDD) and project plan that will include all phases of the development iteration cycle. The development has been supported by and documented within a Github repository (available at: https://github.com/AILab-FOI/PRRI-HoloGameP2025).

All 3D game assets and models were created using Blender, while the whole game was coded inside Uchronia Project Blender Game Engine (UPBGE), an open-source, 3D game engine deployed using Blender itself, so in a way, this game was developed almost exclusively in Blender, other than the audio and parts of the UI - start and end screens.

The initial vision for the game's visual identity was to create a recognizable and striking steampunk world that would immediately capture players' attention with its characteristic elements (such as gears, pipes, and a small robot). The goal was for every model and environment to clearly reflect that retro-industrial style, while remaining simple and high-contrast enough to display well on the pyramidal hologram platform, where visibility and visual recognition are crucial due to the specific projection method. Inspiration was drawn from classic steampunk motifs, but it was necessary to adapt to gameplay requirements and the technical limitations of the platform, ensuring that every model on the holographic platform contributed to both the atmosphere and the functionality of the game itself.

The unique nature of the pyramidal display using Pepper's Ghost technology demanded particular attention to visual design. We prioritized creating clear, high-contrast elements that remained instantly recognizable from every viewing angle which was a crucial requirement given players physically circle the pyramid during gameplay. To enhance the three-dimensional illusion, a subtle angular offset in level rotation was implemented, allowing players to view approximately one and a half sides simultaneously. This solution effectively overcame the potential flatness of a traditional 2D presentation while maintaining gameplay clarity.

Every detail had to be functional and contribute to clarity, as overly complex or dark elements could hinder gameplay and diminish the player's experience. Additionally, the steampunk theme required carefully selected elements (e.g., gears, pipes, keys, etc.) to create an authentic atmosphere and provide players with a unique visual experience. The final design is featured on Fig. 3.

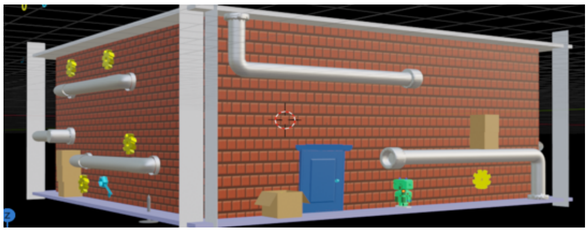

Figure 3. Level design

The main objectives we aimed to achieve with the design of the visual elements were clarity, appeal and uniqueness. Clarity was essential due to the specific display of the game on the pyramidal platform using the Pepper's Ghost effect, where all elements needed to be easily recognizable and visible from different angles. Appeal was achieved through carefully chosen steampunk motifs (gears, pipes, boxes, levers, robot, etc.) that gave the game its distinctive retro-industrial look. Uniqueness was realized by combining classic steampunk elements with our own stylized solutions adapted to the technical limitations of the platform. When deciding on the color palette, shapes, and stylization of characters and environments, the team was guided by the need for high contrast and clear outlines, so that the visuals would remain readable in the hologram display. The color palette included bright, high contrast, metallic tones (brown, bronze, gold, silver, blue, teal), while the shapes were simple and easily recognizable, without unnecessary details that could complicate the display. The robot Mossy and his environment were designed to reflect the steampunk aesthetic, but also to be functional in the context of gameplay. When choosing the visual style, the team kept in mind the target audience: casual players, visitors, steampunk and retro technology enthusiasts, as well as students who would use the game for educational purposes. Therefore, the visual identity was designed to be accessible, interesting, and recognizable to a broad audience, while still specific enough to attract steampunk genre enthusiasts. The high-contrast version employs a vibrant color palette of teal, yellow, orange, and green while preserving the original game elements' design. This enhanced color scheme was specifically developed to maintain visual clarity and gameplay visibility under varying lighting conditions, particularly addressing the challenges posed by different environmental light levels affecting the holographic display. The solution maintains all gameplay functionality while significantly improving the player's ability to distinguish game elements regardless of ambient lighting. Some of the designed assets are shown on figure 4.

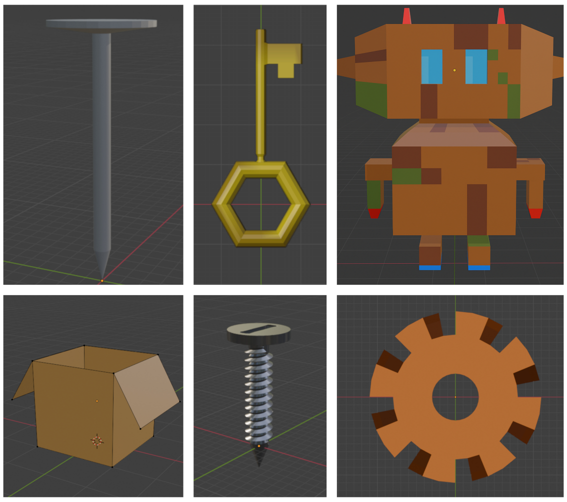

Figure 4. 3D models design

For creating the visual elements in the game, we primarily used Blender, which allowed us to model all key objects (pipes, boxes, and the levels themselves), while basic texture editing was done using simpler tools available in Blender, ensuring that the models were optimized for display on the specific pyramidal platform. The process began with sketching basic shapes and arranging elements within the levels, where we used quick digital sketches and prototypes to test how individual objects would look and function in space, and then turned those concepts into 3D models, focusing on simplicity and readability. During the design process, we closely collaborated with programmers to align the visual elements with the technical requirements of the engine and proper display on the hologram platform, as well as with team members responsible for sound, so that the visual and audio elements would together create a coherent atmosphere. The biggest technical challenges were related to the limitations of displaying on the pyramid, where certain colors and details lost visibility or visuals became overly saturated, so we had to adjust the color palette and simplify shapes to keep elements clear from all angles.

We tackled creative challenges through an iterative process of testing models in actual display conditions and gathering team feedback. This approach allowed us to refine textures, adjust contrasts and modify object sizes until we found an adequate balance between steampunk aesthetics and gameplay functionality. As previously mentioned, to address the transparency issue where players could simultaneously see both sides of the pyramid, we implemented a light gray background in the high contrast model. Key game elements, such as pipes, were given vibrant teal coloring for better visibility. While maintaining authentic steampunk design through predominant use of bronze and gray tones in the player model, collectibles, and some obstacles, we enhanced contrast levels to ensure optimal gameplay visibility in brighter environments. Through this careful balancing, we maintained the artistic vision while overcoming practical display challenges. The contrast adjustments introduced an interesting gameplay element. The obstacles like nails and screws were deliberately colored in darker gray tones to increase the game's difficulty level. This approach solved visibility issues and added an extra layer of challenge to the gameplay experience as shown on Fig. 5

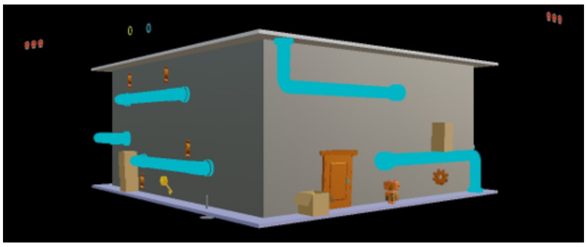

Figure 5. Better contrast level design

The development process consisted mainly of coding and making sure that all 3D models, sound effects, and other assets were properly implemented. The development process had the following phases:

1. *Creation of the Base Game.* As an initial step, it was necessary to develop a prototype serving as a proof of concept. This preliminary implementation comprised only a limited set of box elements to evaluate movement functionality and to configure the scripting responsible for accurately projecting the game onto the display. Establishing correct camera configurations was a critical component, given the specific requirements of the pyramid hologram. Without proper camera alignment, the system would not operate as intended. Four cameras were utilized, each assigned to one of the cardinal directions (north, south, east, west). These cameras were oriented to observe the central game stage from their respective positions, calibrated to ensure that the base platform appeared consistent across all perspectives. Subsequently, the camera outputs were arranged on the display according to the defined script, which positioned each view appropriately. When projected onto the pyramid, the resulting visualization presented a comprehensive overview of the game environment from all four sides. The subsequent objective was to optimize the projection dimensions to achieve the maximum possible height and width on each face of the pyramid, a process that required extensive iterative testing to refine.

2. *Development of Movement Mechanics.* The player character navigates each face of the pyramid in a manner analogous to a traditional 2D platformer, while in the game engine it traverses the surfaces of a virtual cube, with each face

projected onto a corresponding side of the holographic display. To maintain consistent directional orientation, the character must rotate 90 degrees upon reaching the boundary of a cube face. This transition was facilitated by designing invisible colliders at each edge, which triggered the rotational adjustment to align the character with the next face. The implementation of core movement functions—lateral motion and jumping—was comparatively straightforward, utilizing the engine's built-in logic brick system, which provides a node-based programming interface. To handle jumping, an invisible platform was added directly beneath the player character. This platform is used to detect collisions with the ground. When a collision between this invisible platform and the ground occurs, the player is allowed to jump again. This prevents unwanted situations where the player could jump, hit the ceiling or another platform from below, and immediately jump again mid-air before reaching the floor. Additionally, a lever mechanism was implemented which, once activated, triggers the movement of an obstacle (in our case, a nail), allowing the player to progress and reach the key. A start screen was also created, along with a game-over screen and a victory screen that congratulates the player upon winning.

3. *Implementation of Game Elements.* The final major phase of development entailed integrating all game assets and implementing essential mechanics, including the collection of coins and keys, activation of levers, progression between levels, health point management, and user interface components.

   Visual elements were incorporated into the game environment by exporting 3D models created in Blender into file formats compatible with UPBGE. These assets were subsequently positioned within the levels in accordance with the design specifications and gameplay requirements. During the integration phase, it was necessary to modify certain aspects of the visual design to address the constraints imposed by the engine and the hardware configuration, particularly with respect to the holographic display. This process involved optimizing the models to reduce polygon counts, employing simplified textures, and restricting the color palette and contrast levels, as excessively detailed or dark elements exhibited diminished clarity when projected onto the pyramidal display surface.

   Each visual component required empirical validation under real operating conditions to ensure appropriate scaling and positioning, thereby maintaining visibility and functionality from all viewing angles. This iterative refinement necessitated continuous collaboration between the 3D modeling team and the programming team to reconcile technical limitations with the intended visual identity of the game.

   Finally, a mobile device interface was integrated with the host computer's controller API to function as the primary game controller. This interface was implemented using a Flask server developed in the Python programming language. The mobile device connected to the web server via a standard web browser and transmitted controller input data through this web socket interface. To accommodate variable ambient lighting conditions and enhance usability, a toggle button was incorporated to enable users to switch between the standard and high-contrast display modes, thereby improving visibility and user experience.

   The completed project has been published on a dedicated itch.io webpage, accessible at https://ailab-foi.itch.io/prri-hologamep2025.

3.4 Demonstration

In the context of Design Science Research, the demonstration phase entails the application of the developed artifact to illustrate its efficacy in addressing one or more instances of the identified problem within a relevant environment. This process serves to validate the artifact's functional utility and to collect empirical evidence of its performance under realistic conditions. Demonstration activities may include experimental deployment, simulation, controlled experiments, or observational studies conducted with representative users.

In this project, the game was subjected to live demonstrations utilizing both the Pepper's Ghost pyramid console and a conventional computer monitor. Students and developers engaged with multiple levels to assess gameplay mechanics, detect software defects, and identify areas requiring refinement (see Fig. 6). This evaluation process yielded critical insights regarding 3D model scaling, color contrast optimization, and other display characteristics that substantially influenced the overall user experience.

For the final presentation, the game was exhibited exclusively on the holographic pyramid, incorporating two display configurations: a standard mode optimized for controlled lighting conditions and a high-contrast mode designed to improve visibility in environments with elevated ambient brightness. This dual-mode approach effectively demonstrated the system's adaptability and underscored the impact of environmental factors on the perceptual quality of holographic projections.

In addition to in-person demonstrations, the game was made publicly accessible via the itch.io platform, thereby enabling a broader audience to engage with and evaluate the artifact in diverse settings.

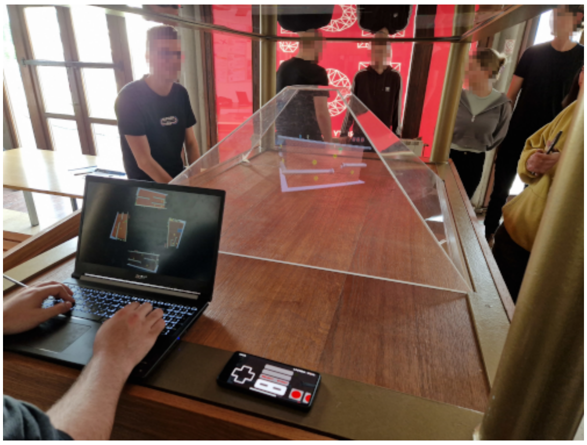

Figure 6. Final demonstration

3.5 Evaluation

The feedback received during testing was carefully analyzed and used to improve the game's implementation. Several key suggestions were implemented, including (1) adjusting color contrast to maintain visibility in different lighting conditions around the pyramid, (2) adding a quick-switch button between display modes to accommodate environmental changes, and (3) implementing clear end screens to provide players with immediate feedback on their game outcome. These changes directly addressed usability issues and enhanced the overall player experience, demonstrating how user testing can effectively guide development. The adjustments proved particularly valuable for ensuring optimal performance of the holographic display under varying real-world conditions.

3.6 Communication

The communication phase in the DSR process involves disseminating the artifact, the underlying design principles, and the associated research findings to both academic and practitioner audiences. Effective communication serves multiple purposes: (1) it validates the work through peer review, (2) facilitates knowledge transfer, (3) encourages adoption and further refinement, and (4) contributes to the broader body of knowledge within the discipline.

In this project, dissemination efforts have included the preparation of this publication, which documents the design rationale, implementation process, and empirical evaluation of the holographic gaming system. Beyond scholarly reporting, the game has been made publicly accessible for free use and testing through multiple distribution channels. Specifically, the complete source code, assets, and technical documentation are hosted on a dedicated GitHub repository to support transparency, reproducibility, and potential reuse by other researchers and developers.

Additionally, a packaged version of the game has been published on a dedicated itch.io page, enabling a wider audience - including educators, students, and independent developers - to experience the system in practice. This dual-platform strategy ensures that both technical stakeholders and the general public can engage with the artifact, provide feedback, and explore its potential applications.

4 Conclusion and Future Research

This work has presented the development of a functional 3D platformer game specifically designed for a pseudo-holographic console based on the Pepper's Ghost projection technique. Employing a DSR approach, the project demonstrated how holographic displays, traditionally confined to advertising or exhibitions, can be adapted to support engaging, interactive digital experiences in gaming contexts. The iterative design and testing process illuminated critical challenges associated with content clarity, visual consistency across perspectives, and the influence of environmental lighting on display performance. Feedback gathered during demonstrations informed refinements in visual presentation, user interface design, and controller integration, resulting in a system capable of delivering a distinctive and accessible gaming experience.

Future research will focus on extending the evaluation phase through sustained deployment of the game in real-world settings. Specifically, the game will be installed for an extended period on campus to facilitate longitudinal studies of user interaction patterns, engagement levels, and overall reception. Data collection will include systematic gathering of player feedback and analysis of gameplay log files to identify usage trends, recurring issues, and opportunities for further enhancement. Additionally, forthcoming development efforts will explore the design and implementation of innovative game mechanics uniquely enabled by the pseudo-holographic display environment, with the aim of expanding the expressive potential of this medium beyond conventional 2D and 3D gaming paradigms.

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