Integrating Serious Games in Education: Advancing Inclusive Design

Belma Ramic-Brkic[a], Hana Ibric and Bojan Mijatovic[b]
Faculty of Compu *and Herzegovina*
{*belma.ramic, bojan.mijatovic*}*@ssst.edu.ba, hana.ibric@stu.ssst.edu.ba*

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Abstract: Game-based learning is becoming an increasingly valuable tool for enhancing education, especially for young learners. This study explores the usability, engagement, and educational impact of a serious game designed to help children develop skills in math and logic, colors, reading and writing, and shapes through interactive gameplay. The game was tested by both children and adults, with feedback gathered through scaled question responses, open-ended suggestions, and task-related questions. The results show that children found the game intuitive and enjoyable, with particularly high ratings for interface usability and clarity of instructions. While adults provided a different perspective from the target audience, their feedback offered useful insights for improving the game's design. These findings highlight the importance of user-centered design and adaptive learning approaches in creating engaging and effective educational games.

1 INTRODUCTION

Modern education is increasingly exploring innovative methods to enhance learning experiences. With technological advancements reshaping the educational landscape, it has become crucial to integrate these tools effectively into the classroom. The internet has been a constant presence in the lives of Generation Z, making them a highly technologically adept generation. Technology profoundly influences various aspects of their lives, including their approach to studying. Recent studies suggest that children, on average, spend a significant portion of their daily lives online, with some reports indicating over 10 hours of screen time per day. Furthermore, by the age of 20, many will have accumulated more than 30,000 hours of video game play (Anderson and Dill, 2000; Przybylski and Weinstein, 2013; CoderZ, 2024).

The gaming industry is one of the fastest-growing sectors within information technology. Many educators have recognized the potential of game-based learning and educational video games, incorporating these high-tech strategies into teaching practices rather than relying solely on traditional methods. Additionally, such tools are invaluable for parents, as online educational applications and games offer engaging ways to entertain and educate children simultaneously.

[a] https://orcid.org/0000-0002-8205-0137
[b] https://orcid.org/0000-0002-2166-3837

Educational games combine entertainment with learning, making them engaging and effective tools for knowledge acquisition. They are designed to help individuals grasp complex concepts, develop problem-solving abilities, and acquire domain-specific knowledge. While some games are tailored to particular subjects, others provide opportunities to develop a broad range of skills and knowledge. By harnessing the power of serious games, educators can create inclusive learning environments that cater to diverse learner needs and abilities.

However, despite the growing adoption of game-based learning, challenges remain in ensuring inclusivity, accessibility, and effectiveness across diverse learner groups. Particularly, designing educational games for children with disabilities requires careful consideration of pedagogical frameworks and user engagement strategies (Ramic-Brkic and Balik, 2023). This study explores these aspects, focusing on how serious games can enhance learning experiences while addressing key barriers in game-based education.

2 RELATED WORK

Game-based learning is not a new concept, but it has become an increasingly popular medium due to its engaging and interactive nature (Prensky, 2003). As a result, gamification is being incorporated into vari-

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ous areas of training, education and therapy enhancement (Medica Ružić and Dumančić, 2015; Balik and Ramic-Brkic, 2019; Ramic-Brkic et al., 2021). One particularly promising application of gamification and game-based learning is in early childhood and elementary education (Christopoulos and Mystakidis, 2023; Alotaibi, 2024). Various research groups are experimenting with different approaches, highlighting numerous benefits of game-based learning:

- Enhancing hand-eye coordination: The use of a mouse, keyboard, or game controller can significantly improve hand-eye coordination in young learners (Granic et al., 2014; CoderZ, 2024).
- Improving analytic skills: Games teach that problem-solving requires practice, encouraging learners to learn from their mistakes, show persistence, and embrace repeated attempts (Hamari et al., 2014; Play2Health, 2021).
- Expanding memory capacity: Many educational games involve memorization tasks, which strengthen memory skills. Fostering memory development at an early stage can have long-term benefits across various areas of life (Cardoso-Leite et al., 2020; Bediou et al., 2023; CoderZ, 2024).
- Supporting children with attention disorders: Numerous studies indicate that educational video games can improve focus in children with attention challenges, such as those with autism (Green and Bavelier, 2012; Jiménez-Muñoz et al., 2022; CoderZ, 2024).

Furthermore, research has shown that teaching children numeracy through games yields positive results (Nand et al., 2019). Another group developed several serious games based on Montessori pedagogical principles (Plekhanov, 1992), with highly positive outcomes (Lamrani and Abdelwahed, 2020). Designing educational games for younger learners should prioritize simple, colorful visual schemes and intuitive controls, as demonstrated in this project (Oyshi et al., 2018). A research group from the University of Malang conducted several studies on the effectiveness of gamification models for children. Their findings once again confirmed positive outcomes but also highlighted a general limitation: the lack of extensive data in studies involving children (Fadhli et al., 2020).

The trend of game-based learning is also expanding to teenagers, who are acquiring advanced skills through innovative STEM (He et al., 2019) and programming courses (De Kereki et al., 2018). Researchers are investigating whether a correlation exists between teenagers who play games and their performance in STEM courses compared to those who do not (Homen and Juričić, 2023). However, further analysis is necessary to obtain more robust results. Additionally, the integration of new technologies is crucial for incorporating gamification elements. One notable example is the use of VR devices in education, which has been explored in (Guo et al., 2021).

A particularly important and evolving area of game-based learning research involves children with disabilities. A systematic review conducted by researchers (Jadán-Guerrero et al., 2023) highlights "growth in scientific production related to gamification and the education of children with disabilities over the years, although with a decrease in recent years." The development of design frameworks for educational games must be approached with great care when including children with autism. However, research (Mubin and Poh, 2019) has shown that this is rarely the case, further emphasizing the need for greater efforts in this field.

Student-driven innovation plays a significant role in advancing this field. As part of this research, a student-developed game project has been evaluated to demonstrate how learners themselves can contribute to the development of educational tools. Such projects not only showcase the creative potential of students but also highlight their ability to address real-world educational challenges through technology. By involving students in the development process, educators can foster innovation, encourage ownership, and ensure that the resulting games resonate deeply with their intended audience. The work presented here represents our contribution to this field.

3 METHODOLOGY

This study employs a mixed-methods approach to evaluate the effectiveness and inclusivity of a serious game designed to support children. A survey was developed to gather feedback from students who interacted with the game, assessing their experiences from a child's perspective.

3.1 Participants

The survey included a total of 30 participants: 13 children aged 6 to 11 and 17 adults, including college students and employees, aged 16 to 54. This diverse participant pool provided valuable insights into how individuals of varying ages engage with and perceive the designed serious game.

3.2 Survey Design

The survey consists of a structured feedback form that integrates both quantitative and qualitative data collection methods. It includes a mix of scaled questions, open-ended questions, and specific tasks designed to assess various aspects of the game. The primary focus is on how well the game meets the needs of children, particularly in terms of accessibility, engagement, and educational outcomes.

1. Scaled questions: These questions allow participants to rate different aspects of the game (e.g., usability, enjoyment, clarity) on a Likert scale. This provides measurable data on the game's effectiveness in addressing the needs of children.
2. Open-ended questions: These questions offer participants the opportunity to share their insights, suggestions, and any concerns they may have regarding the game. Their feedback will help identify potential areas for improvement and guide future iterations of the game design.
3. Specific tasks: Participants were asked to complete tasks within the game and provide feedback on their experiences. These tasks aim to evaluate the game's ability to engage users and facilitate learning in a way that is accessible to children with disabilities.

3.3 Data Collection

The survey was distributed to adult participants via a Google Forms link. To accommodate linguistic differences, we created two versions of the survey: one in English and one in the local language, as younger children might struggle with answering questions in English. The game session was conducted in the classroom, ensuring a familiar and comfortable environment for the participants. Each session was individual, allowing for personalized attention. After completing the game, the participants were given the survey link, and children completed the questionnaire on-site with the assistance of the experiment leader.

3.4 Game Development Process

The Computer Graphics group project involved designing and developing an educational first-person (FP) computer game using Unity game engine. Unity Engine stood out as the ideal choice for this project due to its remarkable versatility, robust capabilities, and thriving development community. Students worked in teams to create a stimulating game environment with four distinct educational activities: Math and Logic, Colors, Reading and Writing, and Shapes. The project milestones include:

- Planning and Design (2-3 weeks). During this milestone,
- Development (4-6 weeks)
- Testing and Debugging (2-3 weeks)
- Finalization and Presentation (1 week)
- Deployment

3.5 Educational Goals

This educational game aims to foster learning and engagement by offering interactive activities across four domains:

- Math and Logic: Encourage logical thinking and problem-solving.
- Colors: Teach color recognition and associations.
- Reading and Writing: Promote literacy skills through interactive tasks.
- Shapes: Enhance spatial reasoning and shape identification.

Each activity must include a minimum of four levels, providing progressively challenging tasks that cater to different age groups. To ensure an immersive and educational experience, teams integrated audio and visual feedback throughout the game.

Game mechanics were designed to support learning objectives in the following way:

- Reinforcement through rewards: The game incorporates a reward system in the form of auditory feedback and progress indicators to encourage correct responses. This mechanic supports positive reinforcement, a widely recognized learning strategy, particularly effective for children with Autism in reinforcing desired behaviors and skills. For example, the progress indicator displays the number of components yet to be collected or found, while auditory feedback remains positive even when an incorrect answer is given, using encouraging phrases such as "Please try again."
- Task-based progression: The game structure consists of sequential tasks that ensure players progress from simple to more complex challenges. This scaffolding approach aligns with Bloom's taxonomy, fostering cognitive development by gradually reinforcing skills. This is particularly evident in the math game, where task complexity increases with each new level.

- Repetitive play for skill growth: By incorporating repetitive actions, the game reinforces learning through practice, which is particularly beneficial for motor skills, and pattern recognition. This is especially evident in the sports game, where the player repeatedly shoots a ball into the goal, with only the color of the ball changing.

The game was designed with inclusivity in mind, particularly to accommodate players with Autism Spectrum Disorder. Key elements contributing to its inclusive design include:

- Positive language and feedback: The language used throughout the game is positive and encouraging. Instead of negative indicators or "x" marks when an incorrect answer is given or when a task is not completed on time, the game uses supportive messages such as "Please try again" to promote a growth mindset.
- Clear instructions and guidance: The user interface includes simplified instructions and visual cues, making it easier for players to navigate the game. This support is essential for players with diverse learning needs.
- Bright and clear colors: The game utilizes bright and clear colors to capture attention and maintain engagement. These visual elements are particularly beneficial for players who may need additional stimuli to focus.
- Easy task progression: The game structure allows for straightforward progression through tasks, which helps players easily track their progress and fosters a sense of accomplishment.

3.6 Technical Design

The project involved multiple technical components:

- Game environment - A user-friendly home screen; A visually appealing and immersive environment that motivates exploration.
- Activity development - Each activity is developed as a set of levels within the game, ensuring compatibility with the main environment. Audio and visual feedback enhance the interactive experience.
- Game engine implementation - Unity is used to create game menus, physics, and gameplay mechanics. The design includes clear instructions and help files to guide users through the experience, ensuring accessibility for diverse learners.
- Platform and input methods - The game is designed for PC, allowing for a controlled and scalable learning environment. It supports keyboard and mouse inputs to provide an easy, intuitive and accessible interaction model for players.

4 CASE STUDY: THE SERIOUS GAME

We aimed to create a game that is both fun and engaging for children aged 4 to 8. The goal was to encourage an interest in gaming while promoting physical activities. Players take on the role of explorers in a vibrant park, making decisions and actively participating in their gaming journey. They can choose their preferred sporting activity, learn numbers or colors, and navigate through a beautifully designed park (see Figure 1). These interactions are intended to enhance decision-making skills and foster a sense of independence and engagement. By exploring different pathways and interacting with the environment, players unlock various game modes, encouraging active participation and a personalized gaming experience.

Figure 1: The welcome screen of the game.

4.1 Genre

This game represents an unique blend of adventure, learning, and sports, combining the thrill of exploration with the joy of physical activities. This combination creates an immersive and entertaining experience for young players. By intertwining these genres, the game offers a balance of discovery, movement, and sportsmanship, catering to the natural curiosity and energy of children aged 4 to 8. The genre blend fosters both cognitive and physical development in an engaging and interactive way.

4.2 Target Audience

As mentioned earlier, this game is designed specifically for kids aged 4 to 8, offering a user-friendly and enjoyable experience. Special attention has been given to the game's visuals and functionality to ensure it appeals to this age group. The primary ob-

jective is to spark curiosity, support decision-making, and immerse children in a virtual world tailored to their developmental stage. The game promotes learning and fun simultaneously, making it a valuable tool for growth and entertainment.

4.3 Game World Description

The game is set in a carefully designed park filled with lively and appealing elements (Figure 2). The environment features lush greenery, benches, towering trees, and colorful flowers placed thoughtfully throughout the landscape. Winding pathways lead players to various activity zones, such as areas for sports games (Figure 3), math challenges (Figures 4 and 5), reading-writing activities (Figures 6 and 7), and shapes (Figures 8 and 9). A nearby school adds an element of familiarity and community, further enhancing the immersive experience (Figure 10).

While the general story and theme were discussed collaboratively, the UI design and visual style of the game vary across different activities, as each was developed by a different team. After agreeing on the core concept, individual teams had the creative freedom to design their respective sections while keeping the overarching narrative in mind. This approach resulted in diverse stylistic choices across the games, reflecting different artistic interpretations while maintaining a cohesive learning environment.

This carefully crafted world invites exploration and offers a visually stimulating backdrop, making it an ideal setting for young players to embark on their adventures. Furthermore, the bright colors used across all games are visually stimulating and help capture the attention of players. The calming and engaging background sounds, along with generally positive feedback, create an inviting atmosphere. Additionally, the clear and manageable tasks that build upon one another represent key inclusive features that are specifically designed to support a wide range of learning needs and styles.

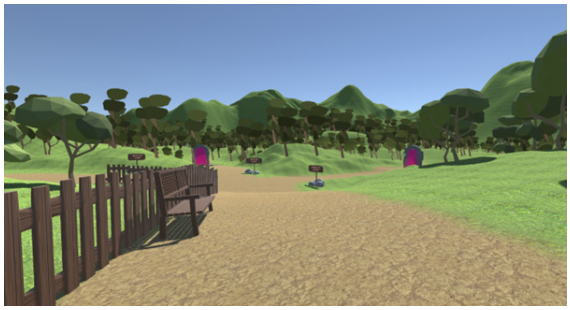

Figure 2: The game environment.

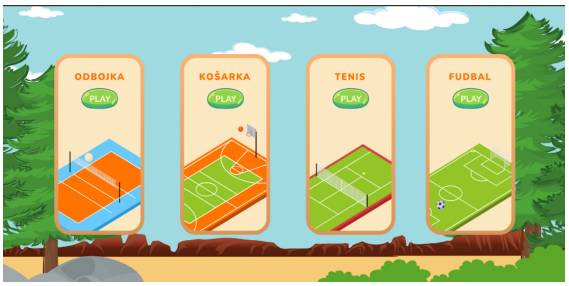

Figure 3: The Color game implemented through various sports.

Figure 4: Math game.

Figure 5: Math game.

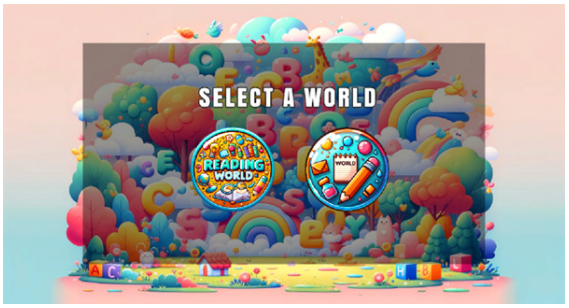

Figure 6: The Reading and Writing game.

Figure 7: The Reading and Writing game.

Figure 8: The Shapes game.

Figure 9: The Shapes game.

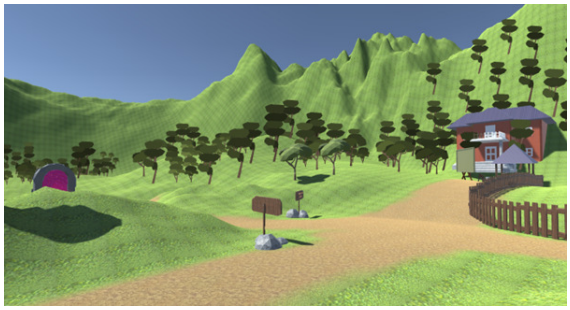

Figure 10: The nearby school environment within the game world.

5 RESULTS AND EVALUATION

The study involved 13 children (8 males, 5 females) who evaluated the serious game using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Notably, participants only provided ratings of 3, 4, or 5, indicating generally highly positive perceptions (Figure 11).

We used the Likert scale to cover six key aspects: clarity of instructions, level complexity, engagement of visuals and sounds, educational effectiveness, level progression, and interface usability. The percentage distribution of responses is as follows:

- Game Instructions Clarity: 85% of participants strongly agreed (5) that the instructions were clear and easy to understand, while 15% provided an agree rating (4).
- Level Complexity: 46% of participants strongly agreed (5) that the levels were appropriately complex, while 38% rated them as 4, and 15% were neutral (3).
- Engagement of Visuals and Sounds: The visuals and sounds were well received, with 85% rating them as highly engaging (5), 8% as 4, while 8% remained neutral (3).
- Educational Effectiveness: 77% of children strongly agreed (5) that the game effectively teaches math, logic, colors, and shapes, while 15% rated it as 4, and 8% as neutral (3).
- Level Progression: 69% of participants found the level progression natural and intuitive (5), while 31% rated it as 4.
- Interface Usability: The interface was highly rated, with 92% of children strongly agreeing (5) that it was simple to navigate without frustration, while only 8% rated it as 4.

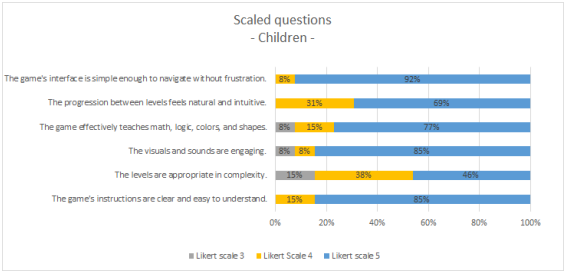

Figure 11: The results of scaled questions for Children group of participants.

Within Open-Ended questions, children highlighted the elements of the game that they found most engaging. The responses indicate a strong preference for sports and mathematics. The inclusion of colors

and education-related features also stands out, suggesting that the combination of playful elements and educational content is appealing.

Children didn't find any elements confusing or frustrating, which suggests that the game design is intuitive and engaging for them. This aligns with the results from the previous distribution of the Likert scale.

The children's feedback highlighted a strong preference for more sports, particularly football, in the game's educational content, suggesting that the integration of sports-themed learning activities was well-received. They also enjoyed the visual aspects of the game, especially nature settings and the use of colors, which enhanced their overall experience. In addition to sports, children appreciated the educational value of math-related content, particularly activities involving addition and subtraction.

In the "Specific Tasks" section of the questionnaire, three task-related questions were asked: whether the "Shapes and puzzle" level was intuitive, whether the difficulty progression in the "Math & logic" section was logical, and whether the navigation in the main environment was straightforward. All participants responded positively, with 100% answering "Yes" to each question. This indicates that the children found the level intuitive, the difficulty progression logical, and the navigation straightforward, with no additional comments provided. These results suggest that these aspects of the game were well-received and functioned as intended.

Within the adult group, the study involved 17 participants, including 9 males and 8 females. Their results for the scaled questions are presented below in Figure 12:

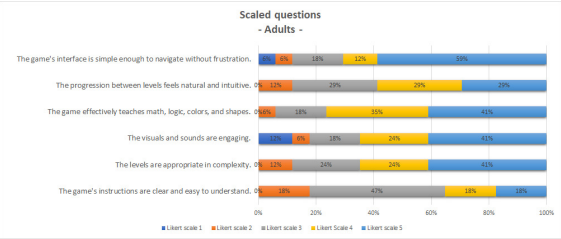

Figure 12: The results of scaled questions for Adults group of participants.

The evaluation by adults group reveals largely positive feedback:

- The majority of respondents found the game's instructions clear and easy to understand, with 36% rating them at the highest levels (Likert 4 and 5) and no participants selecting the lowest rating.
- Regarding level complexity, while most users (65%) rated it positively (Likert 3-5), a small portion (12%) found the difficulty less appropriate (Likert 2).
- The visual and auditory elements of the game received generally favorable feedback, with 65% of participants giving high ratings (Likert 4 and 5). However, 12% of respondents expressed dissatisfaction (Likert 1), indicating room for improvement in engagement.
- In terms of educational effectiveness, 76% of participants rated the game highly (Likert 4 and 5) for teaching math, logic, colors, and shapes, while a small portion (6%) felt it was ineffective.
- The progression between levels was perceived as natural and intuitive by most participants (76% rated it Likert 3-5). However, 12% of users found the progression less satisfactory (Likert 2), suggesting that some adjustments may be beneficial.
- Finally, the game's interface was one of its strongest aspects, with 71% of participants giving the highest rating (Likert 5). This suggests that navigation was smooth and user-friendly, with only a minimal percentage (6%) experiencing frustration.

The analysis of open-ended responses from the adult participant group revealed the following key findings:

- They found the game's visuals, colors, and 3D models highly appealing, with some comparing the design to Minecraft; they also appreciated the ease of navigation and smooth gameplay, while a few emphasized the game's educational value and potential to help children.
- The most commonly reported frustration among adult participants was the lack of clear instructions, with multiple respondents noting that some games had unclear goals or missing guidance, leading to confusion. Additionally, some found specific UI elements, navigation between minigames, and inconsistent visual/audio cues to be challenging. Other concerns included technical issues such as frame rate drops and bugs, as well as confusion regarding specific mechanics, like losing a heart after scoring in the basketball game. While some participants reported no issues, these responses suggest that improving instructions, UI clarity, and game consistency could enhance the overall user experience.
- While some participants felt the educational content was already effective, others suggested clearer instructions, more games and levels, adaptive difficulty, and randomized tasks to enhance engagement. One response emphasized adding communication skill activities like role-playing

and interactive storytelling, while others recommended refining math challenges and improving responsiveness for a better learning experience.

- Participants noted that children would likely enjoy the game's vibrant colors, sports-themed games like basketball, and the cartoon-like environment.
- To make the game more engaging, participants suggested adding clearer instructions, more animations, and sound effects. Other ideas included introducing a running feature, making the games slightly more challenging, and improving game navigation (e.g., not starting from the beginning after exiting a portal).

In the "Specific Tasks" section of the questionnaire, adult participants were given the same tasks as the child participants. As expected, the results differ, as shown in Figure 13:

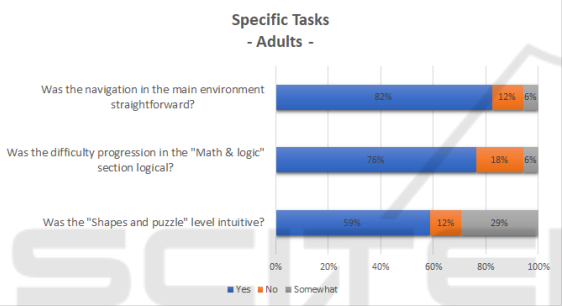

Figure 13: The results of "Specific tasks" questions for Adults group of participants.

The results indicate generally positive feedback regarding the intuitiveness of the game's elements, but also some room for improvement in specific areas.

- "Shapes and puzzle" level intuitiveness: A majority of participants (59%) found the "Shapes and puzzle" level intuitive, with an additional 29% expressing a somewhat positive opinion. However, 12% of respondents found it not intuitive, suggesting that some users may have encountered challenges or confusion with this level's design or instructions. Participants who selected "Somewhat" mentioned a few issues that impacted intuitiveness, such as the lack of clear instructions, an incorrect image for selecting a circle, and the sequential popping up of objects instead of displaying them all at once. These issues may have caused confusion and made the level less intuitive for some users.
- Difficulty progression in the "Math & logic" section: The majority (76%) of participants found the difficulty progression in the "Math & logic" section logical, indicating effective challenge escalation. However, 18% felt the progression could be better calibrated, which may be linked to specific usability concerns. For instance, the "Somewhat" response regarding the inability to change incorrect answers suggests that while the difficulty itself is generally appropriate, some aspects of user interaction — such as not being able to correct mistakes — may hinder the flow and adaptability of the experience. This minor frustration could be contributing to the 18% who found the progression less logical, pointing to the need for more flexible mechanics that allow for error correction and a smoother learning process.
- Navigation in the main environment: While the majority (82%) of participants found the navigation in the main environment straightforward, the "Somewhat" response highlights a specific frustration related to the portal feature. The participant mentioned that the environment feels open world, offering a sense of freedom, but the portal resets the player to the beginning, which can be frustrating. This indicates that while the overall navigation is user-friendly, minor adjustments to the portal system — such as allowing players to maintain progress or continue from their last location — could improve the experience and reduce frustration for some users.

6 DISCUSSION

The results of scaled questions for children group of participants demonstrate that none of the participants rated any aspect below 3, suggesting that the game was mostly well-received. The most positively rated aspects were interface usability (92% strongly agreeing) and clarity of instructions (85% strongly agreeing), indicating that the game was intuitive and easy to use.

While the level complexity received the most varied responses (46% strongly agreeing, 38% agreeing, and 15% neutral), this suggests that some participants may have found the difficulty level either too easy or too challenging. Future iterations of the game could consider adaptive difficulty to better match different skill levels.

Children feedback suggested that expanding the variety of sports, emphasizing football, and continuing to focus on visually engaging environments and math challenges would further enhance the game's appeal and educational effectiveness.

The children's feedback on features that could make the game more engaging included suggestions like adding a *kicking the ball* feature. They also suggested incorporating a *drawing feature*, allowing for

more creativity within the game. Some responses indicated no changes were needed, while others suggested improving the game's start or adding more math challenges, such as multiplication and division. Additionally, there was a request for better lighting of objects that need to glow, highlighting an opportunity to enhance the visual effects for clarity and impact.

The analysis of adult participants' feedback reveals a generally positive reception of the game, particularly its visuals, 3D models, and smooth gameplay. Many adults appreciated the game's educational potential and ease of navigation, with some comparing it to Minecraft. However, a key frustration was the lack of clear instructions, which led to confusion, especially regarding game goals and mechanics. While their feedback provides valuable insights into usability, design, and educational effectiveness, the results (see Figure 12) indicate that their perceptions may differ from those of the actual target audience. Adults might have higher expectations regarding complexity, engagement, and progression, which could explain some of the mixed ratings, particularly in aspects such as visuals and level design. Additionally, while they can objectively assess clarity and navigation, their ability to gauge how engaging or intuitive the game would be for children remains limited.

Adult participants also provided valuable suggestions for improving the game's engagement and educational content. While the majority found the difficulty progression in the Math & logic section effective, some felt it could be better calibrated, particularly through adaptive difficulty and the ability to correct mistakes. Additionally, features like more animations, sound effects, and a running feature were recommended to increase engagement. In terms of navigation, although most participants found it straightforward, a few expressed frustration with the portal system, which resets progress, suggesting that allowing players to continue from their last location could reduce frustration. Overall, these insights point to several opportunities for refining the game, particularly in the areas of instructions, UI consistency, and user flexibility.

7 CONCLUSION AND FUTURE WORK

The results of this study demonstrate that the game was well-received by children, particularly in terms of usability and clarity of instructions. The high ratings suggest that the game successfully provides an intuitive and engaging learning experience. However, the varied responses regarding difficulty level highlight the need for adaptive gameplay to accommodate different skill levels. Expanding content variety, especially in sports-related themes, and enhancing interactive elements could further improve the game's appeal.

Future work should focus on refining adaptive difficulty mechanisms and testing long-term learning outcomes. By continuously iterating based on user feedback, serious games like the one presented here can become more effective tools for education, offering engaging, personalized, and inclusive learning experiences for diverse learners.

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