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Development of a Visual Attention Game Using Difference Detection Mechanics: Design and Usability Evaluation

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***Abstract*—The increasing use of mobile devices has led to the widespread adoption of digital games as interactive systems. However, most mobile games are primarily designed for entertainment and rarely incorporate structured interaction mechanisms to support cognitive training. This study presents the design and development of a visual attention-based mobile game that uses difference-detection mechanics as its core interaction model. The game, named FindX, was developed using the Game Development Life Cycle (GDLC) framework, including initiation, pre-production, production, and testing stages, and implemented using the Unity engine on the Android platform. The system incorporates structured gameplay elements, including progressive difficulty levels, time constraints, and penalty mechanisms for incorrect interactions, to encourage focused visual processing. Functional testing was conducted using a black-box approach to ensure system reliability. Expert evaluation using the Learning Object Review Instrument (LORI) was performed to assess media quality and content suitability. In addition, usability testing was conducted with 23 participants using the System Usability Scale (SUS). The results indicate that the system achieved a media quality score of 80% and a content feasibility score of 93.3%. The usability evaluation produced an average SUS score of 74.1, categorized as Good and Acceptable. These findings indicate that the proposed system is functional, of good media and content quality, and user-friendly, providing a usable interactive environment designed to support visual attention training through structured game mechanics. Efficacy in improving visual attention was not measured in this study and is identified as future work.**

***Index Terms*—Difference Detection, Interactive System, Mobile Game, Usability Evaluation, Visual Attention**

I. INTRODUCTION

THE rapid development of mobile technology has significantly influenced the daily activities of children, including how they play and learn. Mobile games have become one of the most popular forms of digital entertainment among elementary school students. While digital games are often associated with entertainment purposes, a growing body of research suggests that properly designed games can also support cognitive processing through interactive systems. Educational games have been shown to enhance learning motivation, engagement, and several cognitive skills such as attention, memory, and problem-solving abilities [1]–[2]. This indicates that digital games can potentially serve not only as entertainment media but also as tools for cognitive training.

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In recent years, researchers have increasingly explored the use of game-based learning to improve children's cognitive abilities. Studies have shown that interactive games can help stimulate visual processing and attention in children [3]–[4]. Interactive mobile game systems provide adaptive environments that support cognitive development [2]. Furthermore, digital games have also been utilized as assessment tools to measure cognitive functions such as attention and visual processing in students [3]. These findings highlight the potential of digital games to support both learning and cognitive skill development [5].

Visual attention is an essential component of cognitive development, especially for children in elementary school. The ability to focus on visual details and respond accurately to visual stimuli plays an important role in learning activities, including reading, problem solving, and task completion. Previous studies have demonstrated that game-based interventions can improve attention and visual perception skills in children with developmental conditions such as autism and ADHD [6]–[8]. Interactive serious games have been shown to improve visual-perceptual abilities and attention control through repeated and structured visual tasks. However, most existing studies focus on clinical populations or therapeutic contexts rather than on general elementary school students.

Despite the increasing number of studies on educational games and cognitive training, there is still limited research on games specifically designed to train visual attention and concentration for elementary school children in regular learning contexts. In addition, many of the available digital games used by children are developed primarily for entertainment and rarely incorporate structured cognitive training elements. The availability of locally developed educational games that are relevant to children's developmental needs and cultural context is also still limited. This situation highlights the need for the development of educational games that can both entertain and support cognitive processing through interactive systems.

Another important aspect in educational game development is the design of interaction and usability for young users. Children have different interaction patterns from adults, particularly in attention span, visual perception, and navigation behavior. Therefore, educational games designed for children must consider interface simplicity, intuitive interaction, and engaging visual elements. Previous studies emphasize that usability plays a crucial role in determining whether educational technology can be effectively used by children [9]. If a game is difficult to understand or interact with, children

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may quickly lose interest, and the intended cognitive training benefits may not be achieved.

In addition to usability considerations, incorporating meaningful learning content into game design is also important. Educational games that integrate visual elements with contextual knowledge can support both cognitive stimulation and knowledge acquisition. For example, incorporating culturally relevant visual content may increase children's engagement and familiarity with the learning material [10]–[12]. This approach allows games not only to function as cognitive training tools but also as media that engagingly introduce educational information.

Based on these considerations, developing an interactive mobile game system that focuses on visual attention training while maintaining an engaging gameplay experience becomes an important research direction. Such a game can provide children with opportunities to practice visual observation, improve attention to detail, and maintain concentration through interactive gameplay activities. By combining cognitive training mechanisms with interactive game elements, the learning experience can become both enjoyable and beneficial for children's cognitive development.

From an engineering perspective, digital games can be viewed as interactive systems that process user input and provide real-time feedback through structured interaction mechanisms [13]–[14]. In the context of visual attention training, the design of interaction mechanics plays a critical role in guiding user focus and maintaining engagement. However, many existing games lack well-defined interaction structures that explicitly support attention-focused tasks. Therefore, designing a system that integrates structured visual tasks with interactive feedback mechanisms becomes an important contribution in game-based system development [15].

Therefore, this study aims to develop and evaluate an interactive mobile game system called FindX, designed to train visual attention and concentration through visual difference detection tasks. The game is developed using the Game Development Life Cycle (GDLC) method and implemented on the Android platform. To evaluate the developed game, this study conducts functional testing, expert validation of media and content quality, and usability testing involving elementary school students using the System Usability Scale (SUS). The results of this study are expected to provide insights into the potential of interactive mobile game systems as tools for supporting children's visual attention and concentration. The main contribution of this study is the design and implementation of a visual attention game system using structured difference detection mechanics combined with usability evaluation.

II. Materials and Methods

A. Research Design

This study employed a development-based research approach aimed at designing and evaluating a mobile interactive game system designed for visual attention training, particularly visual attention and concentration skills. The research focused on the development of a prototype game and the evaluation of its functionality, content feasibility, and usability when used by elementary school students. The developed application, named FindX, was designed as a visual difference detection game where players are required to identify subtle differences between two similar images within a limited time. This type of activity encourages users to observe visual details and maintain attention during gameplay.

The study consisted of two main stages: the development stage and the evaluation stage. During the development stage, the game concept, gameplay mechanics, and interface design were created based on the identified cognitive training objectives. The evaluation stage focused on examining whether the developed game functioned correctly and whether it was appropriate for use by children. Evaluation activities included functional testing, expert validation, and usability testing involving elementary school students.

B. Game Development Method

The development of the FindX game followed the Game Development Life Cycle (GDLC) framework. The stages of the development process are illustrated in Fig. 1. GDLC provides a structured approach for designing and producing digital games through several sequential stages, ensuring that the resulting application meets both functional and user requirements. In this research, the GDLC process consisted of the following stages: initiation, pre-production, production, alpha testing, and beta testing.

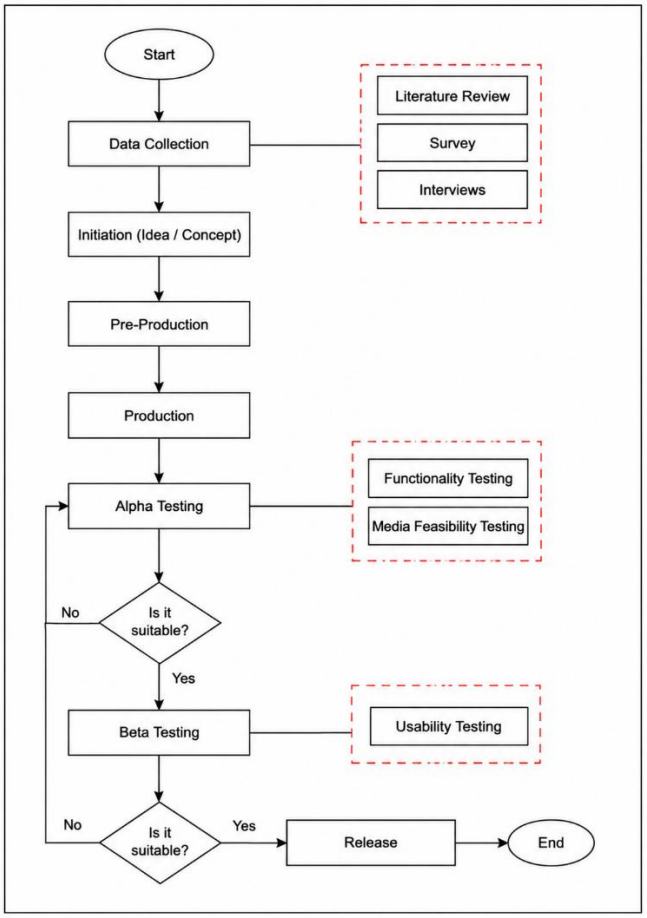


Fig. 1. Game development stages using the GDLC method

The initiation stage involved defining the game concept and identifying the functional and non-functional

requirements of the system. At this stage, the objectives of the game, the target users, and the core gameplay mechanics were determined. The game was designed as a 2D mobile game that runs on the Android platform. Functional requirements included displaying two similar images with several visual differences, providing feedback when a user selects an incorrect area, applying a time penalty for incorrect selections, and implementing progressive difficulty levels.

The pre-production stage focused on designing the structure of the game. This stage included preparing the gameplay flow, storyboard, and interface layout. A flowchart was developed to illustrate the interaction between the player and the game system. The storyboard described the sequence of screens such as the main menu, level selection interface, and gameplay interface.

The production stage involved implementing the game design into a functional application. The FindX game was developed using the Unity game engine with the C# programming language. Various game components were created during this stage, including visual assets, gameplay scripts, level structures, and interaction mechanisms. The game incorporates a timer system and progressive difficulty levels, where the number of visual differences increases as players advance to higher levels.

C. System Design

The FindX game is designed as an interactive system that processes user input in the form of touch interactions and provides immediate visual feedback. The system operates based on a difference detection mechanism, where predefined regions of difference are embedded within two similar images.

When a player selects a point on the screen, the system validates the selected coordinates against the predefined difference regions. If the selected point corresponds to a valid difference area, the system registers it as a correct input and provides positive feedback. Otherwise, the system identifies it as an incorrect input and applies a time penalty.

The system also incorporates a progressive difficulty mechanism, where the number of differences increases across levels. This approach ensures that users are gradually exposed to more complex visual tasks, encouraging sustained attention and interaction. The overall system flow consists of three main components: input processing, validation mechanism, and feedback generation.

D. Data Collection

Data used in this study were collected through several techniques, including observation, expert evaluation, and user testing. Initial observations were conducted to understand children's interaction patterns with digital games and to identify gameplay features that could support visual attention training.

Expert validation was carried out to evaluate the quality of the system as an interactive application. Two aspects were assessed during this stage: media quality and content suitability. Media quality focused on interface design, interaction clarity, accessibility, and technical aspects of the application, while content evaluation focused on the relevance of the learning material and the suitability of the game for elementary school students.

User testing was conducted with 23 children aged between 6 and 12 years. The participants were asked to play the FindX game and then provide feedback through a usability questionnaire. The purpose of this stage was to assess whether the game interface, gameplay mechanics, and interaction design could be easily understood by children.

E. Ethical Considerations

The usability evaluation involved 23 elementary-school children aged between 6 and 12 years. The study was conducted on school premises through official coordination with, and written permission from, the school administration and the responsible class teachers, who supervised the activity and acted in loco parentis for this classroom-based task. Participation was voluntary and anonymous, and any child could stop at any time without consequence.

The activity was non-invasive: participants played the FindX game and completed a short usability questionnaire. No sensitive personal data (such as names, health information, or biometric data) were collected, and all questionnaire responses were recorded and analyzed in anonymized, aggregated form. As this work was scoped as a development and usability study rather than a clinical or efficacy trial, formal approval from an institutional research ethics committee was not obtained; this is acknowledged as a limitation in Section III.F. For the planned efficacy study involving children (see Future Work), the authors will obtain both institutional ethics-committee approval and written informed consent from parents or legal guardians before data collection, in accordance with international research-ethics standards.

III. Results and Discussion

A. Game Implementation

The main outcome of this research is a mobile game system named FindX, designed to train visual attention and concentration skills in elementary school children. The game was implemented as a 2D mobile application that runs on the Android platform. The gameplay mechanism is based on a visual difference detection task, where players are required to identify differences between two similar images within a limited time.

The gameplay begins with a **main menu interface** that provides several options, including play, settings, and exit. When the player selects the play option, the system displays the **level selection interface** where available levels can be chosen. The main interface of the FindX game is shown in Fig. 2. Each level presents two nearly identical images that contain several subtle differences. Players must carefully observe the images and identify the differences by tapping on the correct locations. An example of the gameplay interface used in the FindX game is presented in Fig. 3.

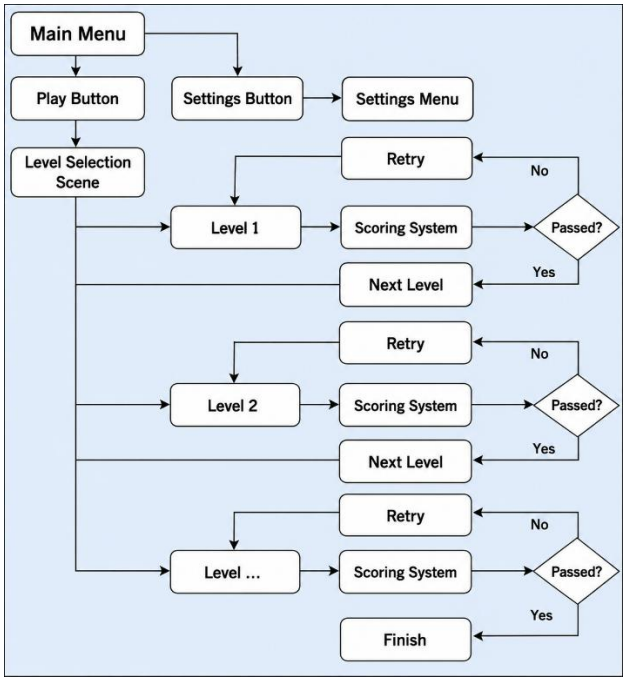


Fig. 2. Main menu interface of the FindX mobile game

To encourage careful observation and sustained attention, the game incorporates several gameplay elements. A timer mechanism limits the time available for completing each level. If the player selects an incorrect area, the system applies a time penalty, which reduces the remaining time. The number of differences increases progressively across levels, providing a gradual increase in difficulty. In addition to its cognitive training purpose, the images used in the game feature Indonesian national monuments, allowing the game to also introduce educational visual content to players.



Fig. 3. Gameplay interface showing the visual difference detection task

From a system perspective, the gameplay interaction follows an input-process-output model. User input is captured through touch interactions on the screen, which are then processed by the system to determine whether the selected area corresponds to a predefined difference region. The system then generates appropriate feedback in the form of visual indicators and time adjustments. This structured interaction model ensures consistent system behavior and enhances user engagement.

B. Functional Testing

Functional testing was conducted to ensure that all game features operated according to the predefined system requirements. The testing process used a black-box testing approach, which focuses on examining system outputs based on user inputs without analyzing the internal program code.

Several key functions were evaluated during the testing stage, including navigation between menus, audio control settings, gameplay interaction, timer functionality, and level progression. The results of the testing indicated that all tested features functioned correctly. The system successfully displayed the main menu interface, allowed users to navigate between levels, detected correct and incorrect selections during gameplay, and applied timer penalties when incorrect answers were chosen.

The testing also confirmed that the system correctly implemented the level progression mechanism. Players who achieved sufficient scores were allowed to continue to the next level, while players with lower scores were prompted to retry the level. These results indicate that the developed application meets the functional requirements defined during the system design stage.

C. Expert Evaluation

Following functional testing, the game was evaluated by experts to assess its suitability as an interactive system. The evaluation focused on two main aspects: media quality and content feasibility. The assessment used the Learning Object Review Instrument (LORI) framework, which evaluates digital learning media based on several indicators such as presentation design, interaction usability, accessibility, and technology compliance.

The results of the media evaluation show that the FindX game achieved a score of 48 out of 60, corresponding to 80% of the maximum score. This result indicates that the overall quality of the game interface, visual design, and interaction features is considered suitable for intended application use. The visual elements, including color selection, icon design, and layout arrangement, were considered appropriate for children. In addition, the navigation structure of the game was evaluated as relatively easy to understand.

Content feasibility evaluation was also conducted to determine whether the visual materials used in the game were appropriate for elementary school students. The results show that the game achieved a score of 42 out of 45, corresponding to 93.3%, which indicates a very high level of content suitability. The experts noted that the gradual increase in difficulty across levels allows the game to provide appropriate cognitive challenges for children. In addition, the use of national monument images was considered beneficial in introducing basic cultural knowledge while maintaining player engagement.

D. Usability Evaluation

To evaluate the usability of the developed game, testing was conducted with 23 children aged between 6 and 12 years. The participants were asked to play the FindX game and then respond to a usability questionnaire based on the System Usability Scale (SUS).

The SUS questionnaire consists of ten statements designed to measure users' perceptions of system usability. Each response was scored according to the SUS calculation method, and the final score for each respondent was obtained by multiplying the total score by 2.5. After calculating all responses, the average usability score of the game was found to be 74.1, which falls into the Good and

Acceptable usability category. The distribution of SUS scores obtained from the respondents is illustrated in Fig. 4.

Beyond the mean, descriptive statistics were computed to characterize the spread and reliability of the usability ratings across the 23 respondents. The individual SUS scores ranged from 47.5 to 90.0, with a median of 80.0 and a standard deviation of 14.39. Assuming an approximately normal sampling distribution, the 95% confidence interval for the mean SUS score is 74.13 ± 5.88, i.e., approximately 68.25–80.01. The score distribution, summarized in Fig. 4, shows that the majority of respondents rated the system within the Good-to-Excellent range, with only a small number of lower ratings. The complete anonymized item-level response data are provided as supplementary material.

According to standard SUS interpretation guidelines, a score within the range of 70–80 is categorized as Good and falls within the Acceptable usability range. This indicates that the FindX game is generally easy for children to understand and use. During the testing session, most participants were able to navigate the game interface and complete the gameplay tasks without significant difficulty. According to SUS interpretation guidelines, this score indicates that the system usability is considered good for the target users. The position of the obtained SUS score within the usability acceptability range is illustrated in Fig. 5.

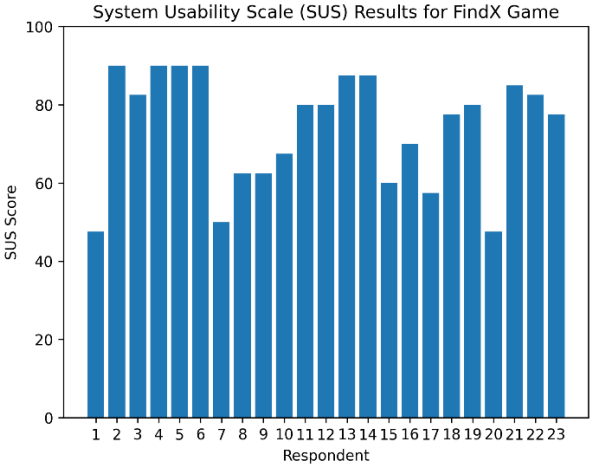


Fig. 4. System Usability Scale (SUS) results obtained from 23 respondents

The results suggest that the interface design, gameplay structure, and interaction mechanisms are suitable for the target users. The timer-based gameplay and visual search tasks encouraged players to maintain attention while interacting with the game. Overall, the usability evaluation demonstrates that the developed application is easy for the target users to operate and provides a user-friendly environment designed to support visual attention and concentration tasks. Whether such use produces measurable gains in visual attention was not tested here and is addressed as future work.

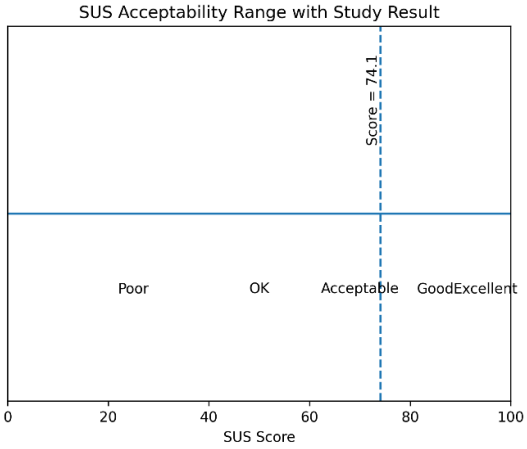


Fig. 5. SUS acceptability range with the obtained usability score (74.1)

From an interaction perspective, the obtained SUS score indicates that the system successfully supports intuitive user interaction. The combination of simple interface design, clear visual feedback, and structured gameplay contributes to the overall usability of the system. The timer and penalty mechanisms also play an important role in maintaining user attention during interaction.

TABLE 1. COMPARISON OF FINDX WITH REPRESENTATIVE PRIOR VISUAL-ATTENTION AND SERIOUS-GAME SYSTEMS

Aspect	**FindX (this study)**	**Ref. [7] VR/serious game**	**Ref. [8] ADHD serious games**	**Ref. [3] cognitive assessment game**	**Ref. [16] reading game**
Core mechanic	Difference detection (spot-the-difference)	Motion / VR interaction	Varied training tasks	Timed cognitive tasks	Phonics/reading tasks
Cognitive objective	Visual attention & concentration	Visual-perceptual skills	Attention control (ADHD)	Attention measurement	Early reading
Target population	General primary-school children	Children with disability	Children with ADHD	General students	Kindergarten students
Platform	Android mobile (2D, Unity)	VR / motion system	Various	Web-based	Mobile
Development method	GDLC	Not specified	N/A (review)	Not specified	ADDIE/other
Evaluation	Black-box + LORI + SUS	RCT (efficacy)	Systematic review	Validity study	Usability/learning
Cultural content	Indonesian national monuments	None reported	None	None	Local language
Efficacy tested	No (usability only; future work)	Yes	Yes (reviewed)	Yes	Partial

To clarify the specific contribution of FindX relative to existing systems, Table 1 compares it with representative prior work across game mechanics, cognitive objective, target population, platform, development methodology, evaluation approach, cultural content, and whether cognitive efficacy was empirically tested. The comparison shows that, while difference-detection and serious-game mechanics are individually well established, FindX occupies a distinct niche: a lightweight, non-adaptive, culturally contextualized mobile system aimed at the general primary-school population and evaluated through a combined functional, expert (LORI), and usability (SUS) protocol [17]. It deliberately trades the computational

complexity of adaptive or VR-based systems for simplicity and accessibility on standard Android devices.

As Table 1 indicates, most prior systems that report cognitive efficacy do so for clinical or special-needs populations and rely on more resource-intensive platforms. FindX contributes an accessible design point for mainstream classrooms, at the cost of not yet having efficacy evidence—a gap addressed in the Limitations and Future Work below.

E. Discussion

The results of this study highlight the importance of structured interaction design in developing game-based systems for visual attention training. The difference detection mechanism used in this study provides a simple yet effective approach to guiding user focus through repetitive visual tasks.

Compared to more complex systems that rely on advanced computational models or adaptive algorithms, the proposed approach demonstrates that effective interaction design can be achieved through well-structured gameplay mechanics. The use of progressive difficulty and penalty-based feedback allows the system to maintain user engagement while encouraging careful observation.

In addition, the usability results indicate that the system design is suitable for the target users, suggesting that simplicity and clarity are key factors in designing interactive systems for children. These findings contribute to the development of lightweight game-based systems that do not require complex algorithms but still provide meaningful interaction experiences.

The obtained mean SUS score of 74.1 is consistent with usability levels reported for other children-oriented educational applications [18]–[19], which commonly fall in the high-60s to high-70s range and are interpreted as "Good" and above the acceptability threshold. Compared with adaptive or VR-based serious games for visual perception and attention [7], [20]–[21], which report efficacy through randomized designs but require specialized hardware or more complex computational models, FindX achieves comparable usability using only a standard 2D Android touch interface. This supports the view that, for the general primary-school population, interface simplicity and clear feedback may matter as much as algorithmic sophistication for user acceptance.

In relation to prior serious-game reviews for ADHD and neurodiverse children [8], [22]–[23], which emphasize structured, repetitive, and progressively challenging tasks as key design ingredients, the FindX difference-detection loop with progressive difficulty and penalty-based feedback embodies the same principles in a non-clinical, culturally contextualized form. Unlike reading- or vocabulary-oriented educational games [16], [24]–[25], which target linguistic skills, FindX focuses specifically on sustained visual search and selective attention, positioning it as a complementary rather than overlapping tool in the educational-game landscape. Nonetheless, in contrast to those efficacy-focused studies, the present work evaluates only functionality, media/content quality, and usability, and therefore cannot make claims about measured cognitive gains.

F. Limitations and Future Work

This study has several limitations that should be considered when interpreting the results. First, and most importantly, the evaluation addressed system functionality, media and content quality (LORI), and usability (SUS), but did not empirically measure whether playing FindX improves children's visual attention or concentration. Consequently, no causal claim about cognitive efficacy can be made from the present data. Second, the usability sample consisted of 23 participants from a single school, which limits the statistical power and the generalizability of the findings to other age groups, regions, and settings. Third, expert evaluation was based on a limited number of reviewers, and the content was restricted to a specific set of images (national monuments).

To address these limitations, future work will focus on a controlled efficacy study using a pre-test/post-test design with a comparison (control) group and a validated instrument for visual attention and concentration, so that any change attributable to the game can be measured rather than assumed. Such a study will be conducted with a larger and more diverse participant pool, and will be preceded by institutional research-ethics approval and written informed consent from parents or legal guardians, with due attention to the potential risks of digital and immersive technologies for children [26]. Additional directions include incorporating adaptive difficulty based on player performance, expanding the content library, and logging in-game interaction data (e.g., reaction time and error rate) as objective behavioral indicators of attention.

V. CONCLUSION

This study presents the development and evaluation of an interactive mobile game system designed for visual attention training using difference detection mechanics. The system integrates structured interaction mechanisms, including progressive difficulty levels, input validation, and feedback responses, to support focused visual processing during gameplay.

The evaluation results demonstrate that the system performs effectively in terms of functionality, quality, and usability. Functional testing confirmed that all core system features operate as intended. Expert evaluation using the Learning Object Review Instrument (LORI) indicated that the system achieved a media quality score of 80% and a content feasibility score of 93.3%, reflecting good system quality and suitability. In addition, usability testing produced an average System Usability Scale (SUS) score of 74.1, indicating that the system provides an intuitive and user-friendly interaction experience.

Overall, the findings indicate that the proposed system provides a functional, good-quality, and user-friendly platform designed to support visual attention training through structured game mechanics. It should be emphasized that this study did not measure whether the game actually improves users' visual attention or concentration; establishing such cognitive efficacy requires a controlled pre-test/post-test study, which we identify as essential future work. This study nonetheless demonstrates that well-designed, lightweight interaction mechanisms can deliver a usable and engaging

environment for children without relying on complex computational models, providing a validated basis for the efficacy evaluation to follow.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study—including the complete Learning Object Review Instrument (LORI) evaluation form with per-indicator scores, the full ten-item System Usability Scale (SUS) questionnaire, and the anonymized, summarized participant response data—are provided as supplementary material accompanying this article. Additional implementation details (system architecture and representative game assets) are available from the corresponding author upon reasonable request.

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