



GameFlow Model: Evaluating the Enjoyment and Feasibility of a Mobile-Based Story-Listening Game for Preschoolers at Cognitive Risk for Dyslexia

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Abstract

Effective engagement is a critical element for the success of serious gaming interventions, as insufficiently engaging games can result in diminished participation and restricted learning outcomes. The GameFlow model was developed by Sweetser and Wyeth (2005) to guide developers in creating and evaluating enjoyable educational games; however, many language-focused serious games lack comprehensive assessments of both enjoyment and feasibility. This study examines the enjoyment and feasibility of a mobile-based story-listening game designed for preschoolers at cognitive risk for dyslexia, grounded in GameFlow principles. As part of a preventive reading intervention, 53 five- to six-year-old preschoolers identified as cognitively at risk for dyslexia engaged with the game for 12 weeks, four days per week, either in conjunction with a phonics-based intervention or alongside a control game. The story-listening game involved listening to narrated stories and responding to content-related questions. Enjoyment was evaluated using a questionnaire, GameFlow assessments and story appreciation ratings. Feasibility was measured question response accuracy and total training duration. The relationships between enjoyment and feasibility were explored. Data from 53 participants suggested overall positive engagement, though the GameFlow evaluation identified areas for design improvement. Question response accuracy confirmed appropriate difficulty levels, and all participants completed the story-listening game with varying training durations. Greater initial story appreciation correlated with shorter training durations, whereas higher question response accuracy showed no significant relationship with total training time. The tablet-based story-listening game appears to be both feasible and enjoyable, though design refinements could further optimise the user experience.

Keywords: *GameFlow, mobile application, enjoyment, feasibility, early literacy*

1. Introduction

In recent years, there has been a marked increase in the creation of serious digital games tailored to children with special educational needs. This trend reflects both the widespread integration of technology in children's lives and the intrinsic motivation that digital games can foster [1]. Serious games are defined as digital applications that combine entertainment with educational goals, such as improving literacy, numeracy, or language development [2]. To produce measurable learning outcomes, these games typically require frequent and sustained engagement. Therefore, user enjoyment becomes a vital factor in supporting regular gameplay and long-term adherence to the intervention.

This study explores a newly developed serious game designed to deliver story-listening content through a smart device platform, targeting children aged five to six. The game's dual focus is to (1) provide an enjoyable and feasible user experience, and (2) explore its potential to enhance early literacy development. Early literacy, in this context, encompasses a range of foundational skills that support the development of reading and writing, including auditory and phonological processing skills [3]. These skills are critical building blocks for future reading success. Notably, early literacy skills can be cultivated from a young age and once established, tend to remain relatively stable over time [1]. This means that while these skills are initially malleable and responsive to intervention, early gaps that are not addressed during this critical period may become entrenched, potentially leading to long-term challenges in literacy acquisition and broader educational progress.

Children with developmental dyslexia are particularly vulnerable, as they are more likely to experience persistent difficulties in learning to decode words despite receiving adequate instruction and having typical intelligence [3]. These difficulties are often rooted in deficits in phonological processing and can be observed as early as preschool through delayed language milestones and



problems with sound awareness. Without timely and targeted support, early challenges in literacy can lead to long-term reading difficulties that affect academic achievement and self-confidence. Research highlights the importance of early intervention, particularly those that use implicit learning through engaging activities such as storybook listening, to strengthen foundational skills before formal reading instruction begins [4].

Although both traditional and digital story-listening formats have been shown to support vocabulary, grammatical understanding, and narrative skills, only one known study in Belgium [5] has embedded this method within a gamified serious game for Flemish-speaking children at risk of dyslexia. Building on this work, our study replicates and adapts the approach within the Singaporean context, where linguistic diversity, early bilingual exposure, and differing educational practices present unique considerations for early literacy development. In addition to cultural and linguistic localisation, our game design is guided by the GameFlow model [6], which identifies eight dimensions of enjoyable gameplay—concentration, challenge, skills, control, goals, feedback, immersion, and social interaction. This model provides a structured framework to support both the design and evaluation of user enjoyment, an area often underexplored in serious games targeting early literacy.

The game also incorporates an Envelope Enhancement (EE) algorithm, which modifies the speech signal to emphasise key acoustic cues such as rise times—shown to support auditory and phonological processing skills, particularly in children at cognitive risk for developmental dyslexia [5]. Unlike earlier modified speech interventions such as Fast ForWord, which primarily used temporally stretched and acoustically enhanced speech to improve rapid auditory processing [6], EE targets the amplitude envelope of speech to enhance rise time salience, a cue critical for syllable and phoneme boundary detection. This study forms part of a larger project that examines the combined effects of EE story listening and a tablet-based phonics program (GraphoGame-English), though only the story game in relation to enjoyment and feasibility are evaluated in this paper. Enjoyment is measured through child and parent questionnaires, in-game behavior, and alignment with GameFlow principles. Feasibility will be examined through usage data and gameplay profiles.

2. Methods

2.1 Participants and Ethical Considerations

From an initial pool of 71 participants, data from 53 preschoolers aged five to six were selected for this study, focusing on those at elevated cognitive risk for dyslexia. These children were recruited for a game-based preventive reading intervention, identified based on their performance in specific cognitive and literacy tests. Participants were considered at risk if they scored above the 10th percentile on the Raven's Progressive Matrices Test – Second Edition (RPM-2; assessing non-verbal intelligence) and the Peabody Picture Vocabulary Test – Fifth Edition (PPVT-5; assessing receptive vocabulary), but fell below the 30th percentile on at least two of the following three early literacy predictors: the Comprehensive Test of Phonological Processing – Second Edition (CTOPP-2), the Test of Word Reading Efficiency – Second Edition (TOWRE-2), and the Wide Range Achievement Test – Fifth Edition (WRAT-5) spelling subtest. Participants were bilingual preschoolers aged 5 to 6 years, each with at least six months of formal education. The sample included 47 English–Mandarin, 4 English–Malay, and 2 English–Tamil bilinguals. Children with behavioral or familial risk factors for neurological conditions such as ADHD or autism were excluded. As formal reading instruction in Singapore begins only in Primary One, all participants were considered prereaders, a status further supported by floor effects observed in the pre-intervention literacy assessments (i.e., CTOPP-2, TOWRE-2 and WRAT-5 spelling subtest). Informed parental consent was obtained, and the study was approved by the ethics committee of Nanyang Technological University, Singapore (Approval No. IRB-2024-009).

2.2 Study Design and Procedure

Participants were randomly assigned to one of three intervention groups:

- PEE Group (n=18; 34%): received phonics-based training via the GraphoGame-English app alongside story listening with envelope-enhanced audio.
- PNE (n=18; 34%): received the same training and stories, but without audio enhancement.
- CNE (n=17; 32%): listened to the same non-enhanced stories and played a non-literacy game (i.e., Lego City).



The 12-week intervention took place during the latter half of the kindergarten year. Smart devices available at the participants' homes, including those running either on Android, iOS, or Microsoft operating systems, were preloaded with the necessary applications. Audio was standardised to 60 dB-A using speech-weighted noise averaged across the narrator's voice.

Families were then provided with Logitech H111 headphones and a parent manual for at-home

use. Children were expected to complete one story game session and a corresponding GraphoGame-English or Lego City session four days per week. Over the 12-week intervention period, this schedule resulted in 48 playing days, with three days off each week. Monthly reward vouchers supported compliance. Post-intervention, both parents and children completed questionnaires assessing motivation, enjoyment, and engagement.

2.3 Story Game Intervention

The story game was developed in Unity 3D and designed to span 24 sessions. Each session featured a five-to-eight-minute story, accompanied by illustrations. After completing the first 24 sessions, the children repeated the set, starting from the beginning for a second round of 24 sessions, to reinforce learning and consolidate the material. The game comprised three interactive environments:

- Story-listening and comprehension tasks: children listened to illustrated stories and answered two multiple-choice comprehension questions and rated each story by selecting either "I like it" or "I don't like it".
- Virtual hub world: visualised session progress via an avatar navigating through cylindrical stages, with stars marking completed sessions—similar in style to Donkey Kong 64.
- Avatar customisation: children used earned coins to purchase new avatars or customise existing ones with accessories.

Custom 3D assets, textures, and animations were developed in-house or sourced from child-friendly platforms such as the Unity Asset Store and Diesel-X. Visuals featured bold, primary colors and cartoon-style avatars. Coins were awarded based on correct comprehension answers and could be spent in the avatar shop to maintain engagement. Each completed session unlocked a new stage in the hub world, marked by a star. All session data (e.g., progress, response accuracy, timestamps, ratings) were logged and automatically uploaded to a secure research server daily.



Fig. 1. Story game intervention



Fig. 2. Multiple-choice questions



Fig. 3. Reward after each question



Fig. 4. Virtual hub

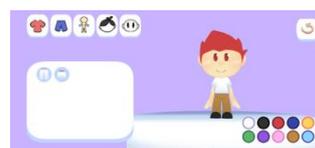


Fig. 5. Avatar customisation

2.4 Postintervention Child and Parental Questionnaires

At the end of the intervention, parents independently completed a brief questionnaire assessing their child's motivation, encouragement, and sustained attention during the story game. Children rated their enjoyment using a simple questionnaire and were also asked if they would be willing to redo the intervention if given the opportunity.

2.5 Statistical Analyses

All analyses for the final sample of 53 children were conducted using R. Enjoyment was evaluated via three approaches: questionnaire responses, GameFlow criteria rated independently by two researchers and story appreciation ratings. Feasibility was examined by computing the question response accuracy (QRA), and training duration (number of days between first and last session). Based on these, children were grouped by completion and schedule adherence.



3. Results

3.1 Enjoyment

3.1.1 Postintervention Questionnaires

Post-intervention responses from the child questionnaire showed that 64% of participants (34 out of 53) reported thoroughly enjoying the game. Additionally, 89% (47 out of 53) expressed willingness to repeat the training. Parental feedback indicated that most children exhibited either high (49%, 26 out of 53) or relatively high (38%, 20 out of 53) motivation to play. Furthermore, the majority of parents noted that their child needed only minimal (43%, 23 out of 53) or occasional (51%, 27 out of 53) encouragement to engage with the game. Notably, 85% (45 out of 53) of parents observed that their child maintained sustained attention during gameplay.

3.1.2 GameFlow Criteria Fulfilment

This section evaluates how the mobile-based story game incorporates Sweetser and Wyeth's [7] eight GameFlow elements—concentration, challenge, player skills, control, clear goals, feedback, immersion, and social interaction—to enhance player engagement and enjoyment among prereaders.

Concentration is essential for keeping players engaged with the game. To achieve this, the game used both auditory and visual stimuli. The main intervention task included audio stories and static illustrations, while the virtual hub world and avatar customisation system incorporated simple tunes and animations. These stimuli were tailored to meet the cognitive and perceptual needs of preschoolers, featuring bright colours, cartoon-like avatars, and cheerful background music. The game removed any unrelated tasks or distractions, allowing players to focus solely on the core activities—listening to stories, answering questions, or spending earned coins. The tasks were designed to engage the players' attention without overwhelming their cognitive capacity, with rewards such as coins for correct answers to maintain their involvement.

Challenge is determined by how well the game content matches the players' abilities. The game ensured that the stories and tasks were developmentally appropriate, focusing on basic comprehension that was suitable for preschoolers. There was no literacy-based content, nor was written text used in the game. Despite introducing a new story each session, the difficulty remained consistent, with no adjustments based on individual performance or progress. Players were presented with the same level of content throughout the game, so the perceived challenge remained relatively constant.

Player skills are an important factor in how well a player can progress in the game. To advance in the game, players listen to a story and then answer two related comprehension questions. The game was designed to be intuitive, requiring no external instruction from parents or teachers. While a brief parent manual was available, the game encouraged players to learn by interacting directly with it. No tutorials or online help were included, but support was provided by the research team through email, phone, or home visits. While the development of player skills over time was not a primary focus, repeated play could lead to improvements in accuracy. Players were rewarded with stars and coins based on their effort and performance. Although the range of available actions was limited, the interface was user-friendly and familiar to young children, allowing them to easily understand the controls.

Control in a game often enhances the player's sense of agency. The game allowed players to customise their avatars at the end of each session, with these changes reflected in the virtual hub world. Visual cues such as arrow buttons, footprints, and blue platforms guided players smoothly through the game, helping them understand the actions they were able to take. The interface, though simple, was age-appropriate and easy to navigate. However, during the story game, players did not have control over their avatars' movements, as these were automated.

Clear goals are vital for ensuring that players understand their objectives. The game effectively communicated these goals through simple visual cues and character dialogues. Players knew that they needed to listen to stories, answer questions, and earn rewards, with these objectives being reinforced through both visuals and spoken instructions. The game maintained a consistent structure, so players were able to anticipate the steps involved in each session. If players deviated from the main tasks, they were gently redirected back to the core activities.

Feedback plays a crucial role in keeping players informed about their performance. The game



offered immediate feedback through stars and coins, which were awarded based on the player's responses. Correct answers triggered positive audio feedback, while incorrect ones resulted in neutral responses and a repeat of the question. While detailed explanations for wrong answers were not provided, the feedback mechanisms were designed to be simple and effective, supporting ongoing player participation and learning.

Immersion refers to how deeply players become involved in the game world. The game fostered immersion by embedding the story within a consistent narrative and visual framework. The virtual hub world provided continuity across sessions, and the customisable avatars and interactive elements enhanced emotional engagement. Repetitive game structure and familiar characters allowed players to anticipate what would happen next, reinforcing their sense of being inside the game world. Importantly, the game maintained a steady flow, with no disruptions that could break the immersive experience.

Social interaction enhances the sense of connection and shared experience in a game. Although designed for individual play, the game allowed for social interaction in shared environments like homes. Caregivers could observe or engage with the child and discuss the stories but were not encouraged to assist with the comprehension questions, allowing the child to respond independently. Features like avatar customisation and the reward system encouraged social sharing. However, the game did not incorporate multiplayer or online social components, as the focus was on simplicity and privacy for young users.

3.1.3 Story Appreciation Ratings

All 24 stories were consistently well-received across both listening sessions, with appreciation rates exceeding the 75% threshold (see Figure 6). The mean appreciation rate was identical for both first and second listening sessions ($M = 88\%$ for both sessions), with minimal variation between sessions (mean difference = 0.01). This high level of appreciation remained stable across repeated exposure, suggesting the stories maintained their appeal even when heard for the second time.

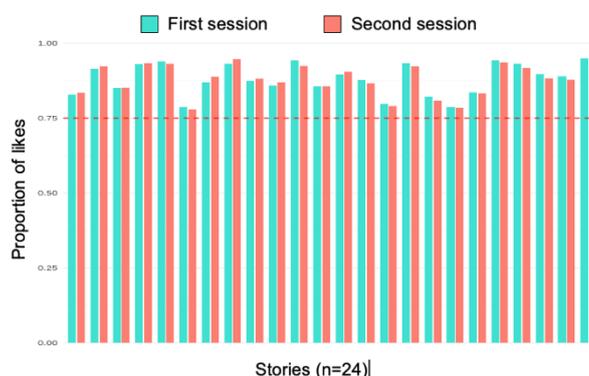


Fig. 6. Story appreciation rates across two listening sessions.

3.2 Feasibility

3.2.1 General QRA

Figure 7 illustrates the QRA across two sessions, showing the proportion of correct responses for 48 unique questions that were each presented twice. In the first session, 44 out of 48 questions (91.7%) achieved accuracy rates above 75%, with a mean accuracy of 84%. When the same questions were presented in the second session, performance slightly improved to a mean of 86%, while maintaining the same number of questions (44/48) above the 75% threshold. This consistent performance across both sessions, with only four questions falling below threshold in each session, indicates an appropriate and consistent level of difficulty for preschoolers.

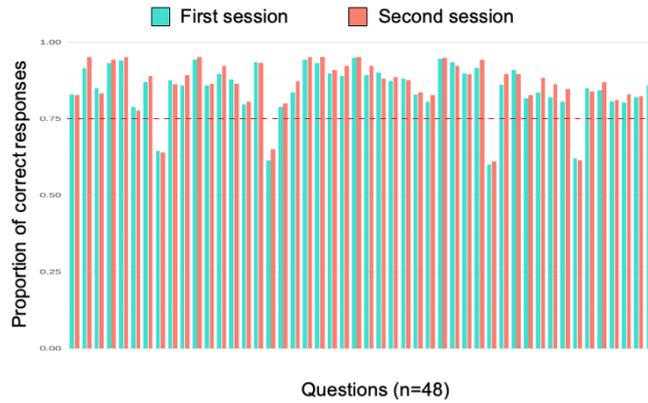


Fig. 7. General question-response accuracy overview. Each vertical bar represents a question, displayed in the sequence they appear during the game.

3.2.2 Final Game Exposure, Training Duration, and Gaming Profiles

Figure 8 presents the individual progress of participants in the story game, including each participant's percentage of the game completed and the corresponding training duration, along with the distribution of these factors. Additionally, Figure 8 shows substantial variation in the training duration for children who completed the game.

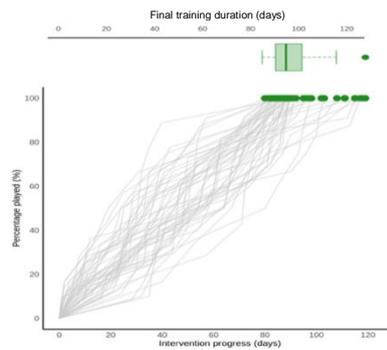


Fig. 8. Individuals' game exposure and training duration and their overall distributions. Bold dots represent the final training duration.

Based on adherence to the intervention schedule, defined as playing the game four times per week over a 12-week period, two gaming profiles were identified: (1) complete and compliant players who met this schedule (37 of 53, 70%; Figure 9A), and (2) complete but noncompliant players who completed the intervention but did not adhere to the prescribed schedule (16 of 53, 30%; Figure 9B).

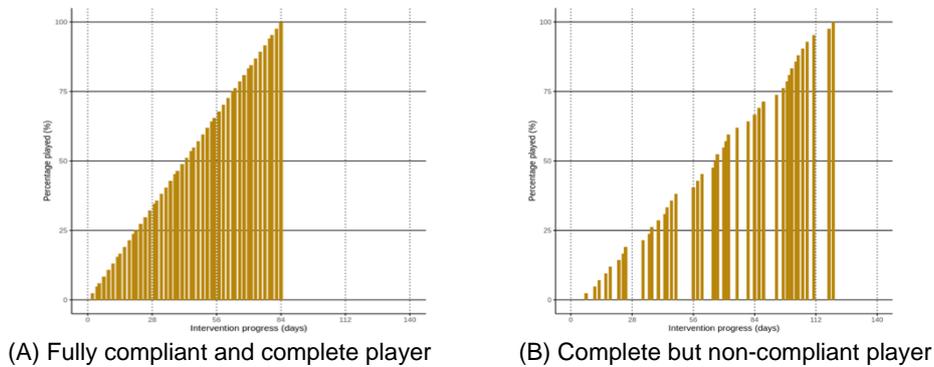


Fig. 9. Illustrations of various gaming profiles within the story game

The Theil–Sen regression analysis revealed a significant negative relationship between mean story appreciation during the first two game phases and the number of training days ($\beta = -0.12$, $p = .007$; Figure 10A). Each “phase” refers to one of the two rounds of 24 game sessions that comprised



the full intervention. Specifically, children who reported higher levels of enjoyment during the initial phases of the game were more likely to complete the training in fewer days, suggesting that greater early engagement with the stories was associated with a shorter overall training duration. In contrast, the Theil–Sen regression analysis revealed that the mean QRA of the first two game phases did not significantly predict the overall progression rate ($\beta = .00$; $p = .72$; Figure 10B), indicating that early accuracy levels had minimal impact on long-term engagement.

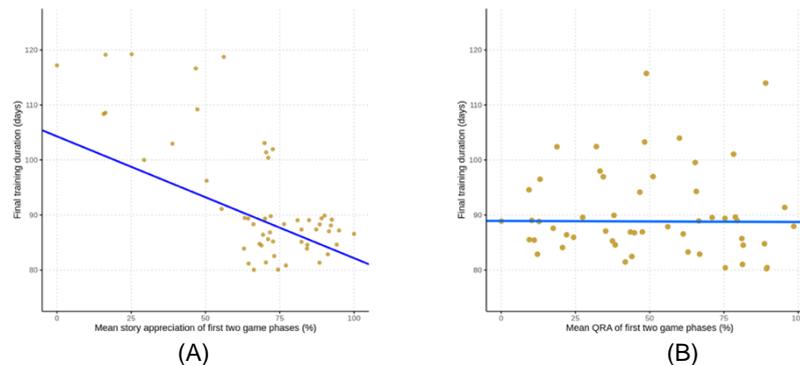


Fig. 10. Theil–Sen regression outcomes. (A) Predictive relationship between initial mean story appreciation and final training duration; and (B) Predictive relationship between initial mean QRA and final training duration.

4. Discussion

This study explored the enjoyment and feasibility of a story-listening game. The findings related to game enjoyment and feasibility are discussed below.

Regarding enjoyment, both child and parent questionnaires, along with in-game enjoyment-related data (such as story appreciation) indicated a very positive experience. The questionnaires revealed that most participants found the game enjoyable, motivating, and capable of holding their attention. The in-game data also suggested that at least 75% of the children enjoyed each story, which suggests that the game content aligned with the interests of preschoolers at cognitive risk for dyslexia, and most players experienced it positively. Despite this, although many elements of the GameFlow model were fully or partially integrated into the game, there was room for improvement in its design. Notably, the concentration principle (i.e., keeping the child's engagement) was the only one fully realised in the game, suggesting that other elements could be further refined to enhance the overall gaming experience.

In terms of feasibility, the results indicated that the game's difficulty level was well-suited to the cognitive abilities of five- to six-year-olds at risk for dyslexia, with most children answering at least 75% questions correctly. This outcome aligned with the goal of creating a game that was neither too easy nor too challenging, ensuring that participants were engaged but required active listening to gather coins. This active engagement was further confirmed by the general QRA results. The fact that only four questions were answered incorrectly twice by more than 25% of the children suggests that the difficulty level was well-balanced. However, in terms of intervention completion, the results revealed significant variability in the duration of the training. While all children were able to complete the game, there was notable variation in how long it took, particularly in relation to the 4-day-per-week schedule that was recommended. These findings suggest that while the game was generally feasible, some children struggled to maintain the recommended intensity, with 70% of participants completing the game as scheduled. Furthermore, analyses showed a negative relationship between initial story appreciation and final training duration, and no significant correlation between initial QRA and the final training duration.

4.1 Limitations

There are two significant considerations regarding the enjoyment of the game. Firstly, although the questionnaire results appeared positive, their interpretation warrants caution. Social desirability bias may have influenced the responses, as children and parents might have provided answers aligning with perceived societal expectations. Additionally, the cognitive limitations inherent in young children could have led to overly positive but less reliable feedback. This issue is corroborated by Borgers et al. [8] who noted that children under seven often struggle to comprehend and reliably use visual analog



scales, thereby raising concerns about the dependability of self-reported measures in this demographic. These findings underscore the necessity for refining methodologies to assess enjoyment in young children. Future research might consider integrating observational methods or combining self-reports with behavioural metrics to offer a more robust and nuanced understanding of children's engagement.

Secondly, the GameFlow-based evaluation was conducted by two researchers involved in the game's design, which introduces potential subjectivity into the findings. While the assumption that the game's design successfully fostered enjoyment among most children appears plausible, this premise requires empirical validation. Sweetser and Wyeth [7] underscore the importance of incorporating external evaluations to mitigate bias. Future studies could address this limitation by involving independent evaluators or parents uninvolved in the game's development process, thereby enhancing the objectivity and reliability of the assessments.

Two critical aspects of feasibility merit discussion. The variability in training intensity among participants presents another noteworthy challenge. Treatment fidelity by ensuring consistent quality and quantity of intervention is widely recognised as crucial for achieving effective outcomes [9]. Nonetheless, research by Katzir et al. [10] indicates that interventions extended over longer periods can still yield positive outcomes, suggesting that the variability in training durations observed in this study might not have substantially undermined its effectiveness. Future interventions could explore adaptive pacing strategies that cater to individual differences while preserving fidelity to the intervention protocol.

Finally, the observed relationship between initial story appreciation, QRA scores, and training duration highlights several avenues for enhancing game design. Allowing participants to use the save and pause functions during the story game may enhance control, initial engagement, and encourage adherence to the intervention schedule. Moreover, implementing a session-specific progress tracking system could help children monitor their achievements and maintain a sense of progression across multiple sessions. Additionally, integrating adaptive question difficulty tailored to individual cognitive abilities, as suggested by Gee could help sustain motivation by ensuring the game remains both challenging and accessible [1].

5. Conclusions

In conclusion, the story game developed for this study appears to be both feasible and enjoyable for five- to six-year-old preschoolers at cognitive risk for dyslexia. Further research with a more refined design is needed. Future studies should aim to confirm the game's efficacy in children with actual language comprehension difficulties and to optimise the design based on the insights gained from this study.

REFERENCES

- [1] Gee, James Paul, "What video games have to teach us about learning and literacy", *Computers in Entertainment (CIE)* 1, no. 1 (2003): 20-20.
- [2] Hamari, Juho, Jonna Koivisto, and Harri Sarsa. "Does gamification work?--a literature review of empirical studies on gamification." In *2014 47th Hawaii International Conference on System Sciences*, pp. 3025-3034. IEEE, 2014.
- [3] Snowling, Margaret J. "From language to reading and dyslexia 1." *Dyslexia* 7, no. 1 (2001): 37-46.
- [4] Richardson, Ulla, Jennifer M. Thomson, Sophie K. Scott, and Usha Goswami. "Auditory processing skills and phonological representation in dyslexic children." *Dyslexia* 10, no. 3 (2004): 215-233.
- [5] Van Herck, Shauni, Femke Vanden Bempt, Maria Economou, Jolijn Vanderauwera, Toivo Glatz, Benjamin Dieudonné, Maaïke Vandermosten, Pol Ghesquière, and Jan Wouters. "Ahead of maturation: Enhanced speech envelope training boosts rise time discrimination in pre-readers at cognitive risk for dyslexia." *Developmental Science* 25, no. 3 (2022): e13186.
- [6] Tallal, Paula. "Fast ForWord®: the birth of the neurocognitive training revolution." *Progress in Brain Research* 207 (2013): 175-207.
- [7] Sweetser, Penelope, and Peta Wyeth. "GameFlow: a model for evaluating player enjoyment in games." *Computers in Entertainment* 3, no. 3 (2005): 3-3.



- [8] Borgers, Natacha, Edith De Leeuw, and Joop Hox. "Children as respondents in survey research: Cognitive development and response quality 1." *Bulletin of Sociological Methodology/Bulletin de méthodologie sociologique* 66, no. 1 (2000): 60-75.
- [9] O'Donnell, Carol L. "Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research." *Review of Educational Research* 78, no. 1 (2008): 33-84.
- [10] Katzir, Tami, Nonie K. Lesaux, and Young-Suk Kim. "The role of reading self-concept and home literacy practices in fourth grade reading comprehension." *Reading and Writing* 22 (2009): 261-276.

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