Empowering Young Children in Numeracy through Role-Playing Games Application: Advancing Independent Curriculum Goals

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Abstract: Basic numeracy education is crucial for the development of early childhood as a foundation for logical and analytical thinking. This study aims to develop an educational game application based on the Role-Playing Game (RPG) model, designed to effectively enhance basic numeracy comprehension in early childhood. Aligned with the principles of the Independent Curriculum, which emphasizes child-centered, exploratory, and enjoyable learning, the application was developed using the ADDIE model, structured across five stages: Analysis, Design, Development, Implementation, and Evaluation. The results indicate that this RPG game application, which includes narrative elements, interactive characters, and tiered challenges, significantly improves children's numeracy skills, such as number recognition and basic addition. Furthermore, the application enhances learning motivation through positive feedback features. Integrating local cultural elements in the application's design further enhances its relevance, supporting children in learning within a context that reflects their real-life environment. Consequently, this application is expected to serve as an innovative alternative for effective, interactive numeracy education aligned with the principles of the Independent Curriculum.

Keywords: Basic numeracy; Early childhood; Educational game; Independent curriculum; Role-playing game (RPG)

Introduction

Early childhood numeracy education is crucial in establishing the foundation for developing logical and analytical thinking skills in later years (Wardhani et al., 2021). In Indonesia, *Kurikulum Merdeka* or Independent Curriculum, emphasizes child-centered and exploration-based learning, advocating innovative approaches to foster foundational numeracy skills through developmentally appropriate methods (Nusantara et al., 2024; Salmia et al., 2024; Shvartsman & Shaul, 2024). This approach enables children to learn through concrete experiences and playful activities that align with their developmental characteristics. One innovative method that is gaining popularity is educational games based on Role-Playing Game (RPG) formats, which incorporate narrative and exploration elements to naturally enhance children's motivation to learn (Andika et al., 2019; Ashby et al., 2023; Dale et al., 2020; Huynh et al., 2021; Rakimawati et al., 2020).

Previous studies support the effectiveness of game-based approaches in improving numeracy skills and learning motivation in children (Andika et al., 2019; Novia et al., 2023; Yulianti et al., 2019). For instance, Novia et al. (2023) and Andika et al. (2019) demonstrated that educational games designed for children aged 5–6 significantly improve their literacy and numeracy skills also knowledge about self-concept. Similarly, Aunio et al. (2018) followed by Chen et al. (2023) found that game-based learning fosters critical thinking skills among

students in mathematics. Aunio et al. (2018) further observed that RPG-based educational games help children understand complex concepts through engaging visualizations and interactive contexts. Yulianti et al. (2019) also highlighted the efficacy of role-playing in introducing numeracy literacy to young children, emphasizing the importance of hands-on experience and emotional engagement in learning.

However, although game-based approaches have proven effective, most existing RPG games are designed for school-aged children and emphasize critical thinking skills without considering the developmental characteristics of young children. Many of these games focus solely on cognitive aspects, lacking the holistic, experiential, and exploratory approaches necessary for early childhood education, particularly within the values present in Indonesia (Andika et al., 2019; Aunio & Mononen, 2018; Chen & Wu, 2023; Dale et al., 2020; Graven & Jorgensen, 2024; Huynh et al., 2021; Lee & Choi, 2020; Sukstrienwong, 2018; Yulianti et al., 2019). This has created a gap, particularly in Indonesia, where educational games that are not only enjoyable and educational but also culturally relevant and aligned with the Independent Curriculum are still limited (Ellis et al., 2022). Therefore, developing an RPG-based educational application that aligns with the principles of the Independent Curriculum, like differentiated learning, authentic assessment, and the integration of local cultural values are essential to address this gap.

Based on those studies, this study seeks to examine how the design and effectiveness of an RPG game application can enhance fundamental numeracy comprehension in early childhood and assess its alignment with the principles of the Independent Curriculum. This research is crucial because early childhood numeracy education plays a fundamental role in developing logical and analytical thinking skills, which significantly impact future academic success (Syarfina et al., 2023). In Indonesia, numeracy learning through traditional and digital games has proven effective in enhancing children's motivation and basic skills, such as number recognition, simple addition, and sequencing (Rakhmawati et al., 2020; Samad et al., 2021). However, most existing game-based approaches do not fully consider local cultural relevance or the principles of the Independent Curriculum, which emphasize child-centered and exploration-based learning (Veryawan et al., 2022).

Moreover, the COVID-19 pandemic has caused significant "learning loss," particularly in literacy and numeracy, highlighting an urgent need for effective and engaging learning innovations (Rahmania et al., 2024). This research addresses these gaps by developing an RPG-based educational application that not only enhances early childhood numeracy skills but also aligns with Indonesian cultural values and the principles of the Independent Curriculum (Selvi & Saraswati, 2021; Wulansari & Dwiyanti, 2021). By adopting this approach, the study supports holistic child development through enjoyable and locally relevant methods, while offering an innovative solution to the challenges of 21st-century education.

Experts in early childhood education emphasize the effectiveness of learning through play for young children. Sternberg (2022) stated that intrinsic motivation derived from positive interactions in games plays a significant role in the learning process of young children. Furthermore, Cavas et al. (2020) argued that game-based learning approaches that allow freedom of exploration are proven to support holistic child development.

This study is focused to the development and testing of an RPG game application specifically designed to improve numeracy comprehension in early childhood within the context of the Independent Curriculum. The application focuses solely on basic numeracy aspects, such as number recognition, simple addition, and sequencing, and does not include advanced numeracy or other cognitive skills. Selecting particular institution is also centered to early childhood students in selected early childhood education institutions (ECE) in Indonesia to ensure its cultural and educational relevance within the Indonesian context. Thus, this study aims to bridge the existing gap by offering an RPG-based educational game that supports early childhood numeracy development in an interactive and enjoyable manner, while also aligning with the Independent Curriculum in a way that is culturally relevant to Indonesia.

The novelty of this study lies in its focus on designing and developing an RPG-based educational game specifically tailored to the developmental needs and cultural context of early childhood education in Indonesia. Unlike existing RPG games, which primarily target older children and emphasize cognitive skills without considering the unique developmental characteristics of younger learners, this study incorporates the principles of Indonesia's Independent Curriculum, such as differentiated learning, authentic assessment, and cultural relevance (Ellis et al., 2022; Nusantara et al., 2024). Additionally, it innovates by blending narrative and exploration elements with foundational numeracy skills—such as number recognition, simple addition, and sequencing—within a play-based framework. This approach ensures that the application is not only engaging and developmentally appropriate but also aligns with the cultural and educational values of Indonesia (Andika et al., 2019;

Yulianti et al., 2019). By addressing the gap in culturally sensitive, child-centered learning tools for early numeracy, this study contributes both to educational innovation and the broader discourse on early childhood learning strategies in diverse cultural settings.

Method

This study employed the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The first stage, Analysis, was conducted to identify early childhood numeracy needs through interviews and teacher observations, along with a literature review. The findings from this analysis provided the foundation for designing application features aligned with the principles of the Independent Curriculum, which emphasizes exploration-based and play-centered learning (Fikri et al., 2023; Saidah & Damariswara, 2021). The comprehensive stages in this study shown on Figure 1.
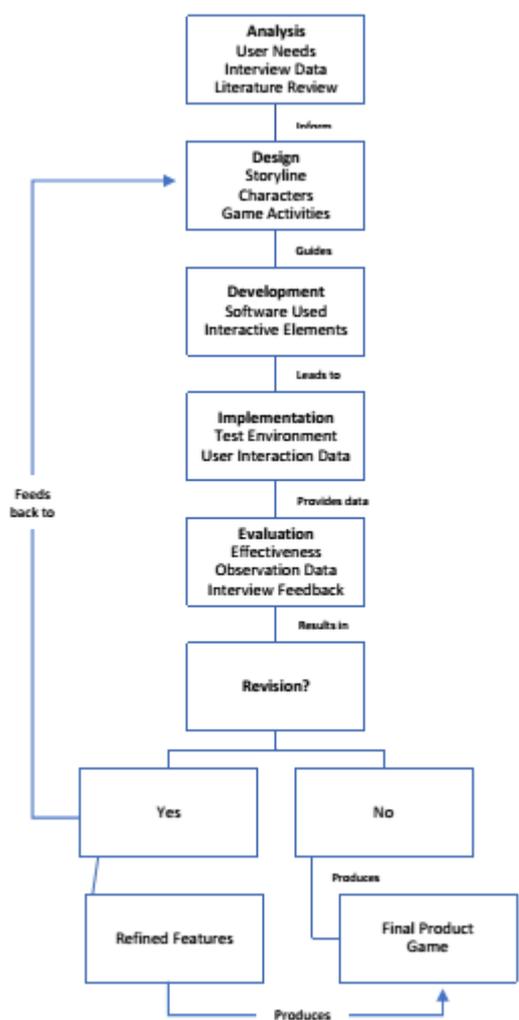

Figure 1. Stages of the ADDIE model in RPG game application development

In the design stage, the main game features were structured, including character creation, storyline, and game-based numeracy activities intended to engage young children. This was followed by the Development stage, where the application was constructed using Unity software. This stage included the creation of visually appealing elements and an intuitive interface, enabling children to learn through interaction within the game. Implementation was conducted through direct testing the application with children in ECE near Universitas Pendidikan Indonesia to observe responses and assess the application's effectiveness in supporting numeracy learning (Gardiner, 2020; Iatrellis et al., 2023).

Evaluation was carried out in two phases: formative, during development, to ensure application quality, and summative, post-implementation, to assess its impact on children's numeracy comprehension. The ADDIE model was selected due to its systematic and flexible approach, allowing adjustments at each stage based on feedback (Huang, 2024). The iterative structure of ADDIE enables the application to be developed responsively and in a way that is relevant to early childhood education, ensuring an optimal final product that meets user needs (Huang, 2024; Maxnun et al., 2024; Song & Sabran, 2024; Stephanidis et al., 2019; Zhao et al., 2023).

Result and Discussion

This study produced an RPG game application specifically designed to improve basic numeracy comprehension in early childhood through an engaging and interactive learning approach. The application design incorporates RPG elements, such as an engaging storyline, interactive characters, and progressive challenges, aimed at attracting children's interest in learning. Each stage within the game is structured to introduce fundamental numeracy concepts, such as number recognition, basic addition, and sequencing. For instance, children are encouraged to collect coins with specific values to unlock subsequent levels, which requires the use of counting skills. This approach aligns with the findings of Aunio et al. (2018) and Krath et al. (2021), who emphasized that gaming elements enhance children's understanding of complex concepts through interactive visualizations and contextualized gameplay situations.

The application was developed using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), where the design stage focused on creating numeracy content and learning activities that align with the principles of the Independent Curriculum, which emphasizes child-centered learning. During the analysis stage,

observations and interviews were conducted to identify the needs of the target users, i.e., young children, ensuring that the developed application meets their interests and requirements for learning numeracy (Hooshyar et al., 2021; Huang, 2024; Krath et al., 2021; Rakimawati et al., 2020). Furthermore, the application includes an automated feedback feature, providing positive reinforcement for correct or incorrect actions, thereby fostering children's intrinsic motivation in the numeracy learning process.

Effectiveness of the Application in Enhancing Basic Numeracy Comprehension

Testing results indicate that this RPG game application has a positive impact on enhancing basic numeracy comprehension in early childhood. During the implementation stage, the application was trialed with several groups of children at ECE centers with varied levels of basic numeracy skills. Observations and pre- and post-testing results demonstrated a significant improvement in children's numeracy understanding, such as their ability to recognize numbers, perform simple additions, and follow some instructions on the application. These findings are consistent with those of who demonstrated that game-based learning media effectively enhances counting abilities in early childhood, as children were more engaged and actively involved in enjoyable learning experiences (Nurfatanah et al., 2021; Shvartsman & Shaul, 2024).

Additionally, observations on children's learning motivation revealed that children using this game application displayed higher enthusiasm for learning numeracy compared to traditional learning methods. As noted by Sternberg (2022), intrinsic motivation, fostered through positive interactions within the game, plays a critical role in learning, especially for young children who learn more effectively through direct experiences and engaging visual stimulation (Andika et al., 2019; Cahyana et al., 2023; Huynh et al., 2021; Lee & Choi, 2020; Tsai et al., 2021).

Alignment of the Application with the Principles of the Independent Curriculum

This RPG game application was designed with careful attention to the principles of the Independent Curriculum, namely child-centered, experience-based learning that accommodates diverse learning needs. In the game, children are free to explore various features, make decisions, and complete challenges that increase in difficulty progressively. As stated by Cavas et al. (2020), game-based learning approaches that allow for exploration are effective in fostering developmentally oriented learning, enabling children to learn in an environment that supports creativity and discovery.

The holistic learning approach is also applied within this application by integrating local cultural elements into character designs and storyline, enabling children to learn within a context familiar to their daily lives (Lee-Hammond & McConney, 2017; Nusantara et al., 2024; Saidah & Damariswara, 2021; Salmia et al., 2024). The inclusion of cultural elements is considered crucial for establishing an emotional connection between children and the learning content, as suggested by Ellis et al. (2022), Saidah et al. (2021), and Salmia et al. (2024), who found that culturally relevant applications can increase children's engagement in learning through relatable experiences.

Discussion

The findings of this study reinforce previous research on the benefits of using RPG-based games in early childhood education. Game-based approaches are not only effective in enhancing numeracy comprehension but also in building learning motivation through interactive elements and direct experiences. The application design, which emphasizes the principles of the Independent Curriculum, successfully creates a child-friendly learning environment, enabling children to learn independently according to their individual abilities and interests.

This study contributes to the field by presenting an RPG game application that integrates local cultural values, a feature rarely found in similar educational games. However, further implementation requires adjustments in the variation of difficulty levels to accommodate a broader range of children with diverse numeracy skills. Additionally, a long-term evaluation is recommended to assess the application's impact on children's numeracy development over an extended period.

Conclusion

The findings indicate that the RPG-based educational game application profoundly enhances early childhood numeracy comprehension by embedding foundational concepts, such as number recognition, sequencing, and simple addition, within a narrative-driven and exploration-based framework. Aligned with the principles of Indonesia's Independent Curriculum, the application emphasizes child-centered, experiential, and enjoyable learning, fostering intrinsic motivation through interactive gameplay and positive feedback features. The inclusion of local cultural elements enhances its contextual relevance, allowing children to connect their learning with familiar real-life environments. This innovative and developmentally appropriate approach addresses the need for culturally

relevant, play-based learning tools, providing an effective solution for supporting holistic child development and advancing numeracy education.

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