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Development of Digital Learning Media to Strengthen Literacy and Numeracy in SDN 015 Rambah

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Abstrak

Penelitian ini bertujuan mengembangkan media pembelajaran digital untuk memperkuat literasi dan numerasi siswa kelas IV SDN 015 Rambah serta menguji kelayakan dan efektivitasnya. Penelitian menggunakan metode *Research and Development* (R&D) dengan model *ADDIE* yang meliputi tahap *analysis*, *design*, *development*, *implementation*, dan *evaluation*, serta uji efektivitas menggunakan desain *one-group pretest-posttest*. Subjek uji terbatas berjumlah 20 siswa kelas IV, sedangkan validasi produk melibatkan empat validator, yaitu dua ahli materi dan dua ahli media. Data dikumpulkan melalui observasi, wawancara, lembar validasi, serta tes *pre-test* dan *post-test* literasi-numerasi yang memuat indikator pemahaman informasi, penalaran numerik, pemecahan masalah kontekstual, dan interpretasi data sederhana. Data dianalisis secara deskriptif dan menggunakan *N-Gain*. Hasil penelitian menunjukkan bahwa media yang dikembangkan berbentuk aplikasi *game* edukasi berbasis *Progressive Web App* (*PWA*) yang ringan, interaktif, dapat digunakan pada berbagai perangkat, dan mendukung pemanfaatan pada kondisi koneksi terbatas. Validasi ahli materi memperoleh rata-rata 4,60 dan ahli media 4,40, dengan rata-rata keseluruhan 4,50 dalam kategori sangat layak. Uji efektivitas menunjukkan rata-rata nilai siswa meningkat dari 57,45 menjadi 82,55 dengan rata-rata *N-Gain* 0,59 berkategori sedang, sehingga media dinyatakan efektif. Kebaruan penelitian ini terletak pada pengembangan media literasi dan numerasi berbasis *PWA* tanpa *backend server* yang memadukan materi singkat, latihan interaktif, umpan balik langsung, gamifikasi, dan penyimpanan progres lokal untuk konteks sekolah dasar dengan keterbatasan infrastruktur. Dengan demikian, media yang dikembangkan sangat layak dan efektif digunakan sebagai pendukung pembelajaran literasi dan numerasi di sekolah dasar.

Kata Kunci: Literasi; Media digital; Numerasi; PWA; Sekolah dasar;

Abstract

This study aimed to develop digital learning media to strengthen literacy and numeracy among fourth-grade students at SDN 015 Rambah and to examine its feasibility and effectiveness. The study employed a Research and Development (R&D) method using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages, while the effectiveness test used a one-group pretest-posttest design. The limited trial involved 20 fourth-grade students, and product validation involved four validators, consisting of two material experts and two media experts. Data were collected through observation, interviews, validation sheets, and literacy-numeracy pre-test and post-test instruments covering information comprehension, numerical reasoning, contextual problem solving, and simple data interpretation. The data were analyzed descriptively and using the N-Gain index. The results showed that the developed media took the form of a lightweight, interactive, multi-device educational game application based on Progressive Web App (PWA) technology and was suitable for use under limited internet connectivity. The material expert validation score was 4.60 and the media expert validation score was 4.40, with an overall mean of 4.50 categorized as very feasible. The effectiveness test showed that students' mean score increased from 57.45 to 82.55, with an average N-Gain of 0.59 in the moderate category, indicating that the media was effective. The novelty of this study lies in the development of a PWA-based literacy and numeracy medium without a backend server that integrates concise materials, interactive exercises, immediate feedback, gamification, and local progress storage for elementary school settings with limited infrastructure. Therefore, the developed media is highly feasible and effective as a supporting tool for literacy and numeracy learning in elementary schools.

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Keywords: Digital media; Elementary school; Literacy; Numeracy; PWA;

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INTRODUCTION

Digital transformation has changed the way information is accessed, distributed, and used in educational settings. In basic education, this change is important because students increasingly interact with digital devices in daily learning activities, while schools are expected to provide meaningful learning experiences that support foundational competencies. Literacy and numeracy are foundational competencies because literacy enables students to understand, evaluate, and use information, whereas numeracy enables students to reason with numbers, interpret data, and solve contextual problems (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2021; National Council of Teachers of Mathematics [NCTM], 2000; OECD, 2018, 2023). Previous studies indicate that technology-assisted learning can improve student engagement and strengthen understanding of mathematical and language-related concepts when the learning design is interactive, structured, and supported by feedback (Crompton et al., 2017; Hillmayr et al., 2020; Kusumah et al., 2020; Sailer & Homner, 2020; Zainuddin et al., 2020). Digital learning resources, visual media, mobile learning, and gamified instructional designs have shown positive contributions to students' learning motivation and learning outcomes (Bond et al., 2020; Rahmawati Suwanto & Wijaya, 2021; Sung et al., 2016; Sundayana et al., 2017; Triana et al., 2019). Likewise, contextual and realistic learning approaches have been reported to support students' mathematical reasoning, communication, and problem-solving ability more effectively (Palinussa et al., 2021; Rohid & Rusmawati, 2019).

Strengthening literacy and numeracy is particularly important at SDN 015 Rambah because the preliminary observation and teacher interview showed that fourth-grade students still needed more guided practice in reading short information, identifying key ideas, understanding vocabulary in context, performing basic numerical operations, reading simple data, and solving daily-life problems. Classroom learning was still largely supported by textbooks and oral explanation, whereas students tended to respond more actively when learning materials were presented visually, interactively, and in the form of simple challenges. At the same time, the school context indicated that smartphones and laptops were more realistic learning devices than a dedicated computer laboratory, while internet connectivity was not always stable. These conditions created a gap between the need for interactive literacy-numeracy learning and the availability of practical digital media that can operate with limited infrastructure.

Based on this gap, this study offers a digital learning medium designed as an educational game application based on Progressive Web App (PWA) technology. PWA was selected because it allows web-based learning media to be installable, responsive across devices, cacheable for limited connectivity, and easier to maintain than fully server-dependent applications (Biørn-Hansen et al., 2017; Fortunato & Bernardino, 2018; Majchrzak et al., 2018). The novelty of this research lies in the development of a literacy and numeracy learning medium that combines concise materials, interactive practice, immediate feedback, gamification, and local progress storage without relying on a backend server, making it relevant for elementary schools with limited infrastructure. Therefore, this study aimed to develop digital learning media for strengthening literacy and numeracy among fourth-grade students at SDN 015 Rambah and to examine its feasibility and effectiveness in classroom use.

METHOD

This study employed Research and Development (R&D) using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation (Branch, 2009). The ADDIE model was selected because it provides a systematic procedure for developing instructional products, beginning with needs identification and ending with evaluation of product feasibility and effectiveness. In this study, the analysis stage identified students' literacy-numeracy needs, teacher expectations, and school infrastructure conditions. The design stage produced the learning flow, interface structure, content map, assessment blueprint, and PWA architecture. The development stage produced the digital learning media prototype. The implementation stage involved expert validation and a limited classroom trial. The evaluation stage was conducted through revision based on expert suggestions and analysis of students' pre-test and post-test results.

The research was conducted at SDN 015 Rambah. The subjects of the limited trial were 20 fourth-grade students selected based on the class involved in the preliminary needs analysis, while the object of

the research was the PWA-based literacy and numeracy digital learning media. Product feasibility was assessed by four validators, consisting of two material experts and two media experts. The material experts assessed content accuracy, relevance to fourth-grade learning needs, language suitability, literacy indicators, numeracy indicators, and clarity of examples. The media experts assessed display quality, readability, navigation, interactivity, consistency, accessibility across devices, offline-friendly use, and technical performance.

The instruments consisted of observation guidelines, semi-structured interview notes, expert validation sheets, and literacy-numeracy learning outcome tests. The literacy-numeracy test was constructed as a pre-test and post-test with 20 multiple-choice items consisting of 10 literacy items and 10 numeracy items. The literacy items measured the ability to understand short texts, identify main ideas, interpret explicit information, and use vocabulary in context. The numeracy items measured number operations, comparison of quantities, interpretation of simple tables or pictures, and contextual problem solving. Before being used in the limited trial, the test blueprint and item relevance were reviewed by the material validators to ensure content validity and alignment with fourth-grade competencies.

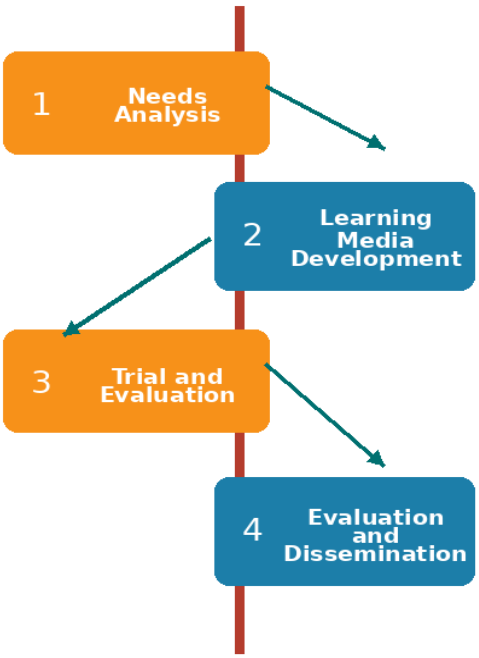

Figure 1. ADDIE-based stages of digital learning media development

Data were analyzed descriptively and quantitatively. Expert validation scores used a Likert scale of 1-5 and were converted into feasibility categories: very feasible (4.21-5.00), feasible (3.41-4.20), fairly feasible (2.61-3.40), less feasible (1.81-2.60), and not feasible (1.00-1.80). The improvement in students' learning outcomes was analyzed using the normalized gain (N-Gain) formula: g = (post-test score - pre-test score) / (maximum score - pre-test score) (Hake, 1998). The N-Gain criteria were high (g >= 0.70), moderate (0.30 <= g < 0.70), fair (0.10 <= g < 0.30), and low (g < 0.10). This design enabled the study to evaluate both product feasibility and the extent to which the media contributed to strengthening students' literacy and numeracy.

RESULT AND DISCUSSION

A. Needs Analysis and Product Characteristics

The needs analysis showed that fourth-grade students required learning media that could translate literacy and numeracy tasks into concrete, visual, and interactive activities. In literacy learning, students needed support in reading short information, identifying important ideas, understanding vocabulary, and answering questions based on textual clues. In numeracy learning, students needed repeated practice in number operations, comparing quantities, interpreting simple data, and solving contextual problems related to daily situations. Teachers needed a medium that was simple, practical, and easy to operate without requiring complex technical preparation. The school context also indicated that smartphones and laptops were more realistic than specialized computer laboratories, while internet connectivity was not always stable. These findings directed the development toward a front-end-only PWA architecture that could function without a backend server and store students' progress locally.

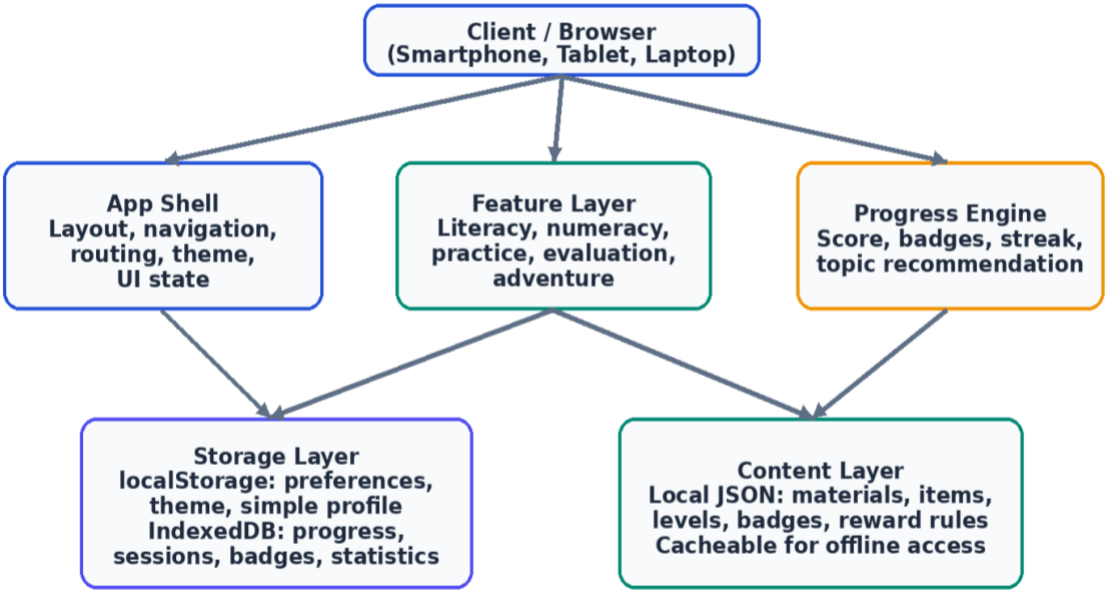

Figure 2. PWA-based digital learning media system architecture

Figure 2 shows that the developed media uses a front-end-only architecture. Learning content, practice features, feedback, scoring, badges, and progress storage are managed locally in the browser through cacheable content, localStorage, and IndexedDB. This architecture makes the application lightweight and suitable for elementary schools with limited infrastructure because students can access learning activities on different devices and continue practice even when internet connectivity is unstable.

Table 1. Main Features of the Developed Learning Media

Feature	Function	Expected Output
Onboarding	Introduces the application, nickname, and avatar.	Students start learning with a simple identity.
Learning	Presents concise materials and examples.	Students gain conceptual understanding before practice.
Practice	Provides topic-based questions with immediate feedback.	Students learn while answering and reviewing mistakes.
Adventure and Evaluation	Packages learning into missions, levels, and mixed-question tests.	Motivation and learning outcomes improve.
Progress	Stores statistics, badges, and learning history locally.	Students and teachers can monitor development.

The developed product integrated concise learning materials, literacy and numeracy practice, immediate feedback, gamification, and local storage using localStorage and IndexedDB. The literacy component was strengthened through short reading texts, contextual questions, vocabulary practice, and feedback that helped students review the reason behind each answer. The numeracy component was strengthened through number-based tasks, visual representations, simple data interpretation, and contextual problem-solving missions. This design is consistent with constructivist learning because students build understanding through active interaction, repeated practice, and reflection on feedback (Vygotsky, 1978). It is also aligned with multimedia learning principles, which emphasize that combining words, visuals, and organized interactions can help learners process information more effectively (Clark & Mayer, 2016; Mayer, 2021). Figure 3 presents several main interfaces of the developed learning media, including onboarding, practice exercise, and progress tracking screens. These interfaces reflect the child-friendly design of the PWA-based application through simple navigation, concise content presentation, and immediate feedback features that support independent and engaging learning.

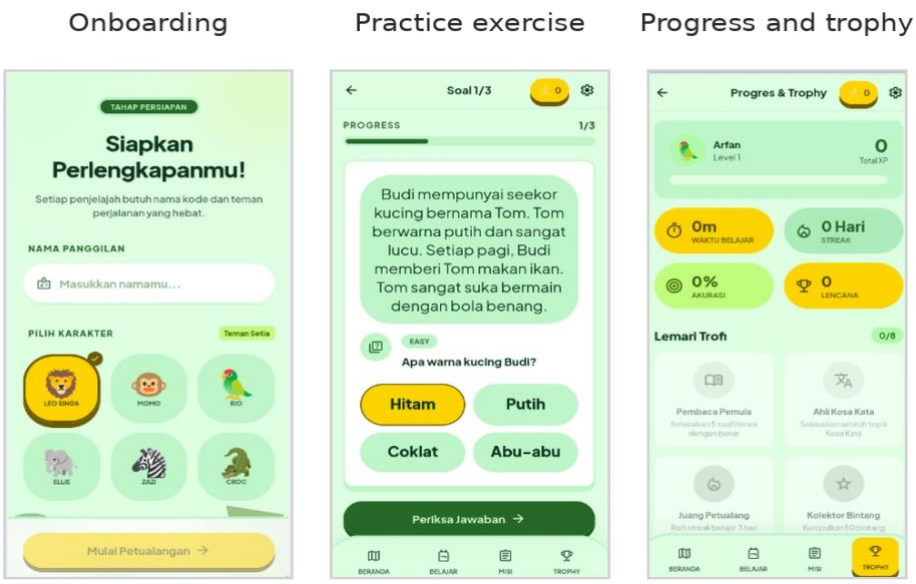

Figure 3. Interfaces of the developed learning media

1. Expert Validation

The feasibility of the developed media was assessed by two material experts and two media experts. The material experts examined the alignment of content with fourth-grade literacy and numeracy needs, concept accuracy, language suitability, clarity of examples, and relevance of evaluation items. The media experts assessed display quality, readability, color suitability, navigation, interactivity, consistency, accessibility across devices, offline-friendly use, and technical quality.

Table 2. Expert Validation Results

Validator	Total Score	Mean	Category
Material experts (n=2)	46	4.60	Very feasible
Media experts (n=2)	44	4.40	Very feasible
Overall	90	4.50	Very feasible

The overall mean score of 4.50 indicates that the product was very feasible for classroom use. These results suggest that the developed media met both pedagogical and technological criteria. Pedagogically, the content, examples, and practice items were considered appropriate for fourth-grade students' literacy and numeracy needs. Technologically, the PWA design was considered practical because it provided simple navigation, responsive display, and local progress storage. The findings reinforce previous studies showing that structured, interactive, and technology-supported media can support students' conceptual understanding and learning outcomes more effectively (Hillmayr et al., 2020; Kusumah et al., 2020; Palinussa et al., 2021).

2. Effectiveness of the Developed Media

After the product was declared feasible, a limited trial was conducted to examine its effectiveness in strengthening students' literacy and numeracy. In this study, literacy was operationally defined as students' ability to understand short texts, identify key information, interpret explicit meaning, and answer questions based on the information provided. Numeracy was operationally defined as students' ability to use basic number operations, compare quantities, interpret simple data, and solve contextual numerical problems. The effectiveness test was based on pre-test and post-test scores and was summarized using N-Gain.

Table 3. Summary of Pre-test, Post-test, and N-Gain Results

Indicator	Value
Number of students	20
Mean pre-test score	57.45
Mean post-test score	82.55
Mean improvement	25.10
Mean N-Gain	0.59
N-Gain category	Moderate
Conclusion	Effective

The results show a substantial increase from a mean pre-test score of 57.45 to a mean post-test score of 82.55, with a mean improvement of 25.10 points. The mean N-Gain of 0.59 falls into the moderate category, indicating that the developed media was effective but still had room for improvement. The moderate category can be interpreted from several conditions. First, the limited trial was conducted with a relatively small number of students and within a limited implementation period, so students did not yet have sufficient time to experience long-term repeated practice. Second, students' initial literacy and numeracy abilities were varied, which may have influenced the magnitude of improvement. Third, the current version of the media still used a fixed set of exercises and had not yet provided fully adaptive remediation for each student's specific difficulty.

The effectiveness of the PWA-based media can be explained through its ability to provide accessible, interactive, and repeatable learning experiences. Because the application is lightweight, installable, and supported by local progress storage, students can access materials and exercises more flexibly on available devices without depending fully on stable internet connection. This condition supports the principles of constructivism, in which students actively construct understanding through interaction with tasks, feedback, and repeated problem solving (Vygotsky, 1978). It also reflects multimedia learning theory because the media combines text, visuals, structured questions, feedback, and game elements to reduce abstractness and support meaningful processing (Clark & Mayer, 2016; Mayer, 2021). These results are in line with studies reporting that interactive learning media, mobile learning, and gamified instructional support can improve students' motivation and learning outcomes (Crompton et al., 2017; Sailer & Homner, 2020; Sung et al., 2016; Zainuddin et al., 2020).

However, this study has several limitations. The limited trial involved only 20 students in one school, so the results cannot yet be generalized to broader elementary school contexts. The effectiveness test used a one-group pretest-posttest design without a control group, so improvement cannot be attributed solely to the media without considering other classroom factors. In addition, the learning outcome test focused on selected literacy and numeracy indicators and had not yet been expanded to cover all dimensions of the national literacy-numeracy framework. Future development should involve a larger sample, comparison classes, longer implementation time, more varied item banks, adaptive feedback, teacher dashboards, and broader testing across schools with different infrastructure conditions.

CONCLUSION

The study concludes that the digital learning media developed for fourth-grade students at SDN 015 Rambah was highly feasible and effective in strengthening literacy and numeracy. The product was designed as a lightweight, interactive, and multi-device educational game based on PWA technology and adapted to school conditions with limited infrastructure. Expert validation involving two material experts and two media experts showed a very feasible category, while the effectiveness test demonstrated meaningful improvement in students' learning outcomes with a moderate N-Gain. The main contribution of this study is the development of a front-end-only PWA learning medium that integrates concise materials, literacy-numeracy practice, instant feedback, gamification, and local progress storage for elementary school use. Nevertheless, this study was limited to a small-scale trial in one school and used a one-group pretest-posttest design without a control group. Future research is recommended to test the media with larger samples, comparison groups, longer implementation periods, adaptive feedback mechanisms, and teacher-monitoring features so that its effectiveness for literacy and numeracy learning can be examined more comprehensively.

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