Effectiveness of Web-Based Digital Library for Elementary School

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***Abstract*—This study investigates the development and evaluation of a web-based digital library tailored for primary education, addressing the critical demand for digital resources that are both accessible and engaging in supporting foundational learning. The initiative aims to bridge the gap in interactive and inclusive educational tools while aligning with curriculum standards. A structured 4D model (Define, Design, Develop, Disseminate) was employed to guide the library's development. The evaluation involved expert validators, teachers, and students, assessing the library's validity, practicality, and effectiveness through structured instruments and user feedback. Results from expert validators indicate high validity, with average scores of 0.92 for material content and 0.91 for media design, signifying strong adherence to educational standards and age-appropriateness. Practicality analysis yielded an average score of 81.2%, classified as "very practical," emphasizing the library's relevance, system reliability, and ability to engage students. The effectiveness evaluation scored an average of 83.6%, categorized as "highly effective," validating the library's role in enhancing digital literacy and fostering active student participation. These findings underline the potential of web-based digital libraries to support primary education by delivering curriculum-aligned, interactive, and inclusive learning experiences. This study contributes to the advancement of technology-enhanced learning tools, presenting empirical evidence of the web-based digital library's impact. It serves as a model for future innovations in digital resources aimed at enriching primary education through engagement and inclusivity.**

***Keywords*—web-based digital library, elementary education, development research**

I. Introduction

In recent years, the integration of digital libraries in education has gained substantial interest as technology becomes increasingly pivotal in enhancing learning experiences [1]. The digitization of educational resources offers significant advantages, particularly in elementary education, where access to diverse and engaging materials is crucial for fostering early literacy and curiosity [2]. However, current digital libraries in elementary schools face notable limitations, including a lack of age-appropriate content, inadequate interactivity, and insufficient alignment with curriculum standards [3]. These shortcomings often lead to limited engagement and fail to meet the specific needs of young learners. Traditional libraries also encounter challenges such as limited physical resources, accessibility constraints, and maintenance costs, which hinder equitable access to information for young students [4]. In this context, a well-designed web-based digital library tailored specifically for primary school students can address these gaps by providing interactive, engaging, and curriculum-compliant resources to create a seamless learning experience that accommodates diverse developmental needs and learning styles [5].

Research by Zhang *et al.* [6] underscores the critical role of primary education as a foundational phase in cognitive and social development, where accessible and high-quality resources can profoundly influence students' academic pathways and skill sets. Aligning with studies by Yuniarti *et al.* [7] and Smith *et al.* [8], a structured and well-curated digital library can facilitate independent exploration, support curriculum objectives, and improve students' digital literacy skills. However, designing and implementing web-based digital libraries for elementary schools presents unique challenges, including developing age-appropriate interfaces, ensuring user-friendly navigation, and curating content that aligns with educational standards and values [9].

Despite the potential advantages, existing research on web-based digital libraries remains limited, particularly for primary education [10]. Most digital libraries are tailored to secondary or higher education audiences, neglecting the specialized needs of younger students and pedagogical approaches best suited to their learning [11]. This gap highlights the urgent need for a structured approach to designing digital libraries that specifically cater to the unique needs of elementary school learners, educators, and curricular demands [12].

To address these challenges, this study seeks to answer the following research questions:

1) How can the development of a web-based digital

library be effectively designed to meet the educational and developmental needs of primary school students?
2) What is the validity of usability and accessibility from the material and media aspects of the web-based digital library?
3) How is the practicality of usability and accessibility based on teachers' responses to the web-based digital library?
4) How can the effectiveness of web-based digital libraries improve engagement and support curriculum-aligned learning outcomes in basic education?

This study aims to develop a web-based digital library platform tailored to elementary schools, emphasizing usability, accessibility, and educational relevance. Employing a systematic development framework, this research contributes to the growing body of literature on digital libraries in elementary education and offers insights into best practices for implementing digital resources in school environments. By integrating technical solutions such as responsive design, offline functionality, and scalable architecture, the platform ensures inclusivity and sustainability across diverse educational settings. By prioritizing design and functionality, the platform aims to provide equitable access to quality resources, fostering both academic achievement and lifelong learning skills among young learners.

II. Literature Review

The development of web-based digital libraries has revolutionized access to information in educational contexts, providing new opportunities to engage students with diverse and interactive resources [13]. In the context of elementary education, digital libraries serve as essential platforms for young learners, offering content aligned with their cognitive and developmental needs [14]. This literature review synthesizes existing research on digital libraries in education, focusing on design principles, usability, and their impacts on elementary education.

Digital libraries, as defined by Rafi *et al.* [15], are organized collections of digital content accessible through online platforms, functioning as educational tools to support learning across disciplines. Research by Yu *et al.* [16] highlights their role in improving literacy, accommodating diverse learning styles, and fostering independent learning behaviors. These benefits are particularly significant in primary education, where students build foundational literacy and digital skills [17]. However, designing digital libraries for young learners requires careful attention to age-appropriate content, intuitive interfaces, and interactive features that engage students while supporting educational objectives [18, 19].

The development of a web-based digital library for elementary education involves balancing usability with educational alignment, as emphasized by Kato *et al.* [20]. Polik and Schmidt [21] highlight the importance of intuitive, visually appealing interfaces tailored to younger users with limited reading abilities and technical skills. In addition, Chen *et al.* [9] emphasize that search and navigation tools should be simplified to facilitate independent exploration by young learners. Multimedia integration, such as images, audio, and video, can enhance engagement and accessibility, especially for students with varying literacy levels, as noted by Rafi *et al.* [15]. Content curation is equally critical, with digital libraries needing to align with age-appropriate literacy standards and curriculum guidelines to effectively complement classroom learning [10].

Usability and accessibility are pivotal for the success of digital libraries, particularly in primary school settings. Li and Liu [22] underscore the importance of user-centered design, which prioritizes the needs and preferences of young users in interface design and navigation paths. For primary school students, clear visual cues, large icons, and minimal text reduce cognitive load and enhance usability, enabling smoother interactions with digital resources [23]. Accessibility, as shown by research from [24], requires supporting diverse learners, including those with disabilities or learning difficulties, through features like adjustable font sizes, alternative text for images, and screen reader compatibility. Such measures align with the broader goals of digital equity and universal design for learning, ensuring inclusivity for all students [25].

Empirical studies demonstrate that digital libraries can increase student engagement and improve learning outcomes by offering interactive and student-centered learning environments [26]. For instance, Loh and Sun [27] found that digital libraries motivate students to read more frequently, explore topics of interest, and take ownership of their learning process. These platforms foster active learning by encouraging critical thinking, inquiry-based approaches, and independent resource access [28]. Additionally, research by Blau *et al.* [29] highlights the role of digital libraries in facilitating collaborative learning, enabling students to share resources and work on projects together, thus enhancing social interaction and communication skills.

Despite the well-documented benefits of digital libraries, existing platforms predominantly target secondary and higher education, often focusing on advanced research capabilities rather than the intuitive and engaging formats needed for younger learners. This gap underscores the urgent need for a targeted approach to developing digital libraries that address the specific requirements of elementary school students, emphasizing usability, accessibility, and alignment with primary education curricula.

This literature review emphasizes the potential of digital libraries to enhance access to educational resources and support literacy development, critical thinking, and independent exploration among elementary students. However, challenges persist in adapting digital library features to meet the unique needs of young users. To address these gaps, this study aims to develop a web-based digital library for elementary schools, contributing to the literature by offering insights into the design, usability, and educational impact of digital libraries tailored to young learners.

III. Research Methods

This study used a research and development approach that involved a systematic series of stages to design, develop, and evaluate a web-based digital library specifically designed for elementary school students [30].

A. Research Design

This research development used the 4D model (Define,

Design, Develop, and Disseminate) as a systematic approach to validate a web-based digital library for elementary school students [31]. The 4D model development procedure is presented in Fig. 1 below.

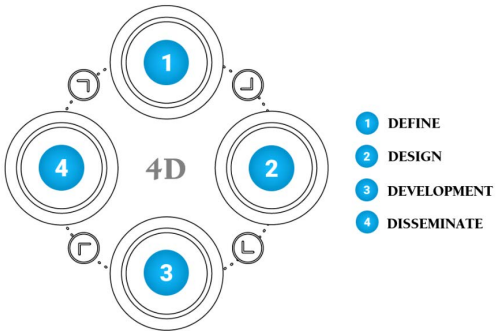

Fig. 1. Development procedure.

The 4D model offers a structured framework for development research, ensuring comprehensive needs analysis, design, development, and dissemination of the digital library.

Define phase: The primary goal was to conduct a thorough needs analysis to identify the requirements of elementary school students and educators for a web-based digital library. Surveys, interviews, and direct observations were conducted with teachers, students, and educational experts at Buah Hati Integrated Islamic Elementary School, Padang, Indonesia, to gain insights into current challenges and gaps in accessing educational resources. This phase emphasized understanding the specific features necessary to make the digital library accessible, user-friendly, and educationally effective. These activities ensured the development process was grounded in a clear understanding of user needs and contextual constraints.

Design phase: This phase translated the outcomes of the needs analysis into a detailed blueprint for the digital library. The system architecture was carefully designed, encompassing the database structure, user interface, and navigation flow to ensure a seamless and engaging user experience. Educational content, including multimedia resources, interactive activities, and adaptive learning paths, was curated to accommodate diverse learning styles and developmental needs. Additionally, prototypes and wireframes of the interface were developed to visualize the design, enabling iterative feedback from stakeholders to refine the platform's functionality and usability.

Develop phase: The digital library platform was constructed based on the specifications established during the Design phase. Development utilized scalable, secure, and device-agnostic web technologies to ensure accessibility across various devices. The curated educational content was integrated into the platform, enabling effective user interaction and navigation. Initial usability testing was conducted with a representative sample of students and teachers to identify and resolve usability challenges, ensuring the platform's functionality aligned with user expectations.

Disseminate phase: This phase focused on the real-world implementation and evaluation of the digital library. The platform was deployed at Buah Hati Integrated Islamic Elementary School, Padang, Indonesia, where pilot tests were conducted to assess its usability, user satisfaction, and educational impact. Data collection methods included observations, questionnaires, and usage analytics to evaluate student engagement and learning outcomes. Collected data were analysed using qualitative and quantitative methods, providing evidence on the platform's effectiveness in enhancing information literacy and supporting curriculum objectives. Findings were shared through detailed reports, academic publications, and presentations to inform the broader educational community and facilitate knowledge sharing.

In conclusion, the 4D model integrates a robust and systematic approach for conducting needs analysis alongside design, development, and dissemination processes. This ensures that the digital library aligns with the educational needs of primary school students while delivering an engaging and user-friendly learning experience.

B. Research Participants

The sample for this study was carefully selected using a purposive sampling approach to ensure the representativeness and diversity necessary for a comprehensive evaluation of the web-based digital library's effectiveness in elementary education. The study involved 27 elementary school teachers and 194 upper-grade students (Grades 4–6) from multiple schools. Teachers were chosen based on their experience with digital educational tools and their willingness to contribute to the library's development and assessment. Their expertise provided critical insights into the platform's user-friendliness, content relevance, and alignment with the primary school curriculum, which enriched the study's findings on the library's practical implementation in classrooms.

The student sample comprised 194 upper-grade students, selected to reflect a broad range of socio-economic backgrounds. Targeting this age group allowed for an accurate assessment of the digital library's usability and educational value, as these students are at a pivotal stage, transitioning from basic literacy to higher-order cognitive skills. This diversity among student participants supported an evaluation that considers various user needs and abilities, giving the study a strong foundation for generalizability.

All participants were informed about the study objectives, and informed consent was obtained to adhere to ethical standards. The study also ensured the anonymity of student data and minimized disruptions to school routines, maintaining ethical research practices. This sampling technique contributed to a thorough investigation of the digital library's efficacy, providing actionable insights to enhance digital learning resources for elementary education.

C. Research Instruments

In evaluating the validity and suitability of the web-based digital library, two main research instruments were used: a content expert instrument and a media expert instrument. The content expert instrument was designed to assess the educational relevance, accuracy, and alignment of the digital library materials with the curriculum, to ensure that the content meets the required academic standards. Meanwhile, the media expert instrument focused on evaluating the usability, design quality and overall user experience of the digital library, to ensure that the platform is engaging, accessible and appropriate for primary school students. Table 1 and Table 2 present the material and media expert instruments in this study.

Table 1. Material expert validity instrument

No.	Instrument
1	The materials provided in the digital library are relevant to the elementary school curriculum
2	The material provided has sufficient depth for elementary school students
3	The information provided in the digital library is accurate and error-free
4	The material provided supports specific learning objectives
5	The materials presented are easily understood by primary school students
6	The digital library offers a variety of resources that are diverse and appropriate to a range of learning topics
7	The materials provided are appropriate to the learning needs of primary school students.
8	The language used in the digital library materials is appropriate to the level of understanding of primary school students
9	The materials provided support the continuation of learning outside the classroom
10	The materials provided in the digital library are appropriate to the various learning styles of students
11	The materials in the digital library are clearly presented and structured
12	The materials provided are up to date with the latest developments in the field of education
13	Contribution to Students' Skill Development

Table 2. Media expert validity instrument

No.	Instrument
1	The interface design of the digital library is easy to use and suits the needs of elementary school students
2	The digital library can be accessed easily on various devices (computers, tablets, mobile phones) without technical problems
3	Design elements such as colors, icons, and layout are consistent throughout the digital library pages
4	Navigation within the digital library is intuitive and easy for primary school students to understand
5	The page layout in the digital library is neat and supports comfortable reading
6	The digital library has a fast response time without long loading times
7	Instructions for use contained in the digital library are clear and easy to understand
8	The digital library responds well to user interaction
9	The visual design of the digital library is attractive and age-appropriate for elementary school students
10	The digital library provides interactive features that enhance students' learning experience
11	The media used (images, videos, animations) in the digital library support and enrich the learning content
12	The digital library guarantees data security and user privacy
13	The design and features of the digital library support students' various digital learning styles, such as visual, auditory, and kinesthetic

An instrument to assess the practicality, effectiveness, and usability of the digital library platform developed five indicators as follows:

User-friendliness: Measures the ease of navigation, clarity of interface design, and intuitiveness of the digital library system. This indicator assesses whether primary school students and teachers can effectively interact with the platform without extensive training or technical support.

Content Relevance and Quality: Evaluates the appropriateness, accuracy, and educational value of the resources available in the digital library. This ensures that the materials are aligned with the curriculum and appropriate for the reading and comprehension levels of primary school students.

Accessibility and Compatibility: Assess the compatibility of the platform across different devices (computers, tablets, mobile phones) and its accessibility features, such as screen readers or language support, to ensure that all users, including people with disabilities, can access the digital library.

Engagement and Interactivity: Measures the extent to which the digital library includes interactive elements, such as multimedia content, quizzes or activities, that encourage student engagement and enhance the learning experience. This indicator also examines features that support collaborative learning among students.

Table 3. Web-based digital library practicality instrument

Indicator	Aspects	Item
User-Friendliness	Ease of navigation	1, 2, 3, 4, 5
	Clarity of interface design	6, 7, 8, 9, 10
	Intuitiveness of the digital library system	11, 12, 13, 14, 15
Content Relevance and Quality	Media suitability	16, 17, 18, 19, 20
	Media accuracy	21, 22, 23, 24, 25
	Available resources	26, 27, 28, 29, 30
Accessibility and Compatibility	Compatibility with various supporting devices	31, 32, 33, 34, 35
	Media accessibility features	36, 37, 38, 39, 40
Engagement and Interactivity	Interactive	41, 42, 43, 44, 45
	Content Appropriateness	46, 47, 48, 49, 50
System Reliability and Performance	Media stability	51, 52, 53, 54, 55
	Speed	56, 57, 58, 59, 60
	Performance	61, 62, 63, 64, 65

Table 4. Web-based digital library effectiveness instrument

Indicator	Item
User-Friendliness	1, 2, 3, 4, 5
Content Relevance and Quality	6, 7, 8, 9, 10
Accessibility and Compatibility	11, 12, 13, 14, 15
Engagement and Interactivity	16, 17, 18, 19, 20
System Reliability and Performance	21, 22, 23, 24, 25

System Reliability and Performance: Examines the stability, loading speed, and technical performance of the web-based platform under various conditions, including high user traffic. This indicator ensures that the platform is dependable and maintains smooth operation during regular use by elementary schools.

These indicators provide a comprehensive framework to evaluate the development and functionality of a web-based digital library tailored to elementary school environments, focusing on usability, accessibility, educational value, and technical robustness. Tables 3 and 4 present the instruments of practicality by teachers and effectiveness by students in using the web-based digital library.

D. Data Analysis Technique

1) Validity analysis technique

Validity data were analyzed using Aiken's V validity coefficient, a formula designed by Aiken to calculate material validity coefficients. This coefficient relies on a panel of n experts' evaluation of an item's representation of the construct being measured [32]. The average score is determined by following these steps: score the answers with numbers between 1 (very invalid), 2 (invalid), 3 (less valid), 4 (valid) to 5 (very valid), Here is the formula used:

$$V = \sum S/[n(c-1)] \quad (1)$$

where, V = validity index; $S = r -$ lowest validity assessment number; c = highest validity assessment number; r = the number given by the validator; n = number of validators.

This study focuses on explaining the validity of mobile learning which includes material and media validation, based on the evaluation from the validators. Data collected through questionnaires were analyzed using descriptive statistics.

2) Practicality analysis technique

Practicality analysis was conducted through a questionnaire distributed to respondents to evaluate the effectiveness of the web-based digital library. In this process, the formula and criteria for practicality are assessed using a Likert scale [33].

$$Practicality = \frac{\sum Score\ obtained}{\sum Maximum\ Score} \times 100\% \quad (2)$$

3) Effectiveness analysis technique

The effectiveness of the web-based digital library for Elementary Schools was assessed using an instrument based on a Likert scale. The data collected through this instrument was comprehensively analyzed using descriptive statistical methods [34].

$$NA = \frac{S}{M} \times 100\% \quad (3)$$

where, NA = final score; S = score obtained; M = maximum score.

IV. Result and Discussion

A. Development

The development of a web-based digital library is a significant advancement in providing easily accessible, high-quality educational resources for primary school students. The initiative aims to harness the power of digital technology to create an engaging, interactive and easy-to-use platform that meets the diverse learning needs of learners. Here is a look at the web-based digital library developed at Buah Hati Integrated Islamic Elementary School, Padang, Indonesia. Fig. 2 displays the Home Page, Fig. 3 displays the Digital Book Menu, Fig. 4 displays the Story Book Menu, Fig. 5 displays Learning Videos that can be used and downloaded by teachers and students as learning resources.

Fig. 2 presents the Home Page of the web-based digital library serves as the central hub for users, providing easy access to a wide array of educational resources and interactive learning tools. Designed with young learners in mind, the Home Page features an intuitive layout that guides students to key sections, including digital books, multimedia content, and personalized learning paths. The user-friendly interface ensures that both students and teachers can navigate the platform effortlessly, making it a welcoming entry point into the digital learning environment.

Fig. 2. Home page.

Fig. 3. Digital book menu.

Fig. 3 presents the Digital Book Menu in the web-based digital library provides students with access to a diverse collection of e-books, carefully categorized by subject and reading level. This menu is designed to foster a love of reading and support literacy development by offering a wide range of titles, from classic literature to contemporary educational texts. With user-friendly navigation, students can easily browse, select, and read books that align with their interests and academic needs, making it a valuable resource for both independent and guided reading activities.

Fig. 4 illustrates the Story Book Menu, a dedicated section within the web-based digital library that offers a variety of engaging storybooks tailored to different reading levels. This

menu provides an accessible and organized way for students to explore a rich collection of narratives, fostering imagination and literacy skills. The intuitive design of the Story Book Menu allows young learners to easily navigate and select stories that captivate their interests, encouraging a love for reading and enhancing their language development.

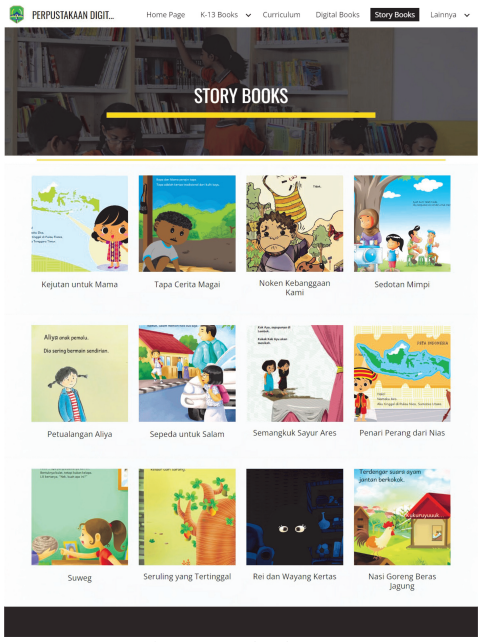

Fig. 4. Story book menu.

Fig. 5 presents the Learning Videos section of the web-based digital library offering a curated collection of educational videos designed to enhance students' understanding of key concepts. These videos are carefully selected to match the curriculum, providing visual and auditory learning experiences that suit different learning styles. The section is organized by subject and grade level, so students can easily find relevant content that supports classroom learning and encourages independent learning.

The development process is guided by a rigorous research methodology, to ensure that the material and media aspects of the digital library meet the highest educational standards. Through expert validation and systematic testing, the web-based digital library is designed to enhance the learning experience, improve information literacy and foster a love for learning among primary school students.

Fig. 5. Learning videos.

B. Research Results

The Research Results section presents the findings of this study, highlighting the validity, practicality and effectiveness of a web-based digital library designed for primary school students.

1) Validity analysis results

This section details the analysis of the data collected from the expert validators, describing the results of the usability analysis and the overall performance of the digital library, demonstrating its potential to enhance the learning experience in the primary education environment.

Validity of the Web-based Digital Library material: Here are the results of the validity of the web-based digital library from material experts, where the validity analysis was tested with 4 expert validators, so that the data was generated according to Table 5.

Table 5. Material validity analysis results

Validator	Score																									
	1	S	2	S	3	S	4	S	5	S	6	S	7	S	8	S	9	S	10	S	11	S	12	S	13	S
1	4	3	4	3	4	3	5	4	4	3	4	3	5	4	5	4	4	3	5	4	5	4	5	4	4	3
2	5	4	5	4	5	4	4	3	5	4	4	3	4	3	4	3	5	4	5	4	4	3	5	4	5	4
3	5	4	5	4	4	3	4	3	4	3	5	4	5	4	4	3	5	4	5	4	5	4	5	4	5	4
4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	3
∑S	15		15		14		14		14		14		15		14		15		16		15		16		14	
V	0.94		0.94		0.88		0.88		0.88		0.88		0.94		0.88		0.94		1.00		0.94		1.00		0.88	
Average (V)	0.92																									

The validity of the web-based digital library material was assessed by four expert validators. The results of this material validity analysis are presented in Table 5. The average score given by the validators was 0.92, indicating that the material is categorized as "valid" and suitable for use. This high validity score suggests that the material of the digital library aligns well with educational standards and effectively meets the learning needs of elementary school students.

Validity of the Web-based Digital Library Media: Here are the results of the validity of the digital library from media experts, where the validity analysis was tested with 4 expert validators, so that the data was generated according to Table 6.

Table 6. Media validity analysis results

Validator	Score																									
	1	S	2	S	3	S	4	S	5	S	6	S	7	S	8	S	9	S	10	S	11	S	12	S	13	S
1	5	4	5	4	4	3	5	4	4	3	5	4	5	4	4	3	5	4	5	4	5	4	4	3	5	4
2	5	4	5	4	5	4	4	3	4	3	4	3	4	3	5	4	5	4	5	4	4	3	5	4	5	4
3	5	4	5	4	5	4	5	4	4	3	4	3	4	3	5	4	5	4	4	3	5	4	5	4	5	4
4	4	3	4	3	5	4	5	4	4	3	5	4	5	4	4	3	4	3	4	3	5	4	5	4	5	4
∑S	15		15		15		15		12		14		14		14		15		14		15		15		16	
V	0.94		0.94		0.94		0.94		0.75		0.88		0.88		0.88		0.94		0.88		0.94		0.94		1.00	
Average (V)	0.91																									

The validity of the web-based digital library media was also evaluated by four expert validators. The results of this media validity analysis are shown in Table 6. The average score given by the validators was 0.91, indicating that the media is categorized as "valid" and suitable for use. This score reflects that the digital library's design and functionality meet the required standards for usability and engagement, ensuring that the platform is user-friendly and educationally effective.

2) Practicality analysis results

The results of the analysis of the practicality of web-based digital libraries on teacher responses as media users, the data are presented in Table 7.

Table 7. Practicality analysis results of web-based digital library

Indicator	Aspects	Total Score	Average
User Friendliness	Ease of navigation	81%	79%
	Clarity of interface design	77%	
	Intuitiveness of the digital library system	80%	
Content Relevance and Quality	Media suitability	82%	83%
	Media accuracy	85%	
	Available resources	82%	
Accessibility and Compatibility	Compatibility with various supporting devices	73%	75%
	Media accessibility features	77%	
Engagement and Interactivity	Interactive	87%	86%
	Content Appropriateness	85%	
System Reliability and Performance	Media stability	85%	84%
	Speed	83%	
	Performance	84%	

The practicality analysis for the Web-Based Digital Library Development for Elementary Schools, based on teacher responses, reveals the platform's effectiveness in meeting essential educational needs. The analysis, summarized in Table 7, covers five primary indicators: User-Friendliness, Content Relevance and Quality, Accessibility and Compatibility, Engagement and Interactivity, and System Reliability and Performance. Each indicator is evaluated based on specific aspects, with scores reflecting the average percentage across teachers' responses.

User-Friendliness: This indicator assessed the ease of navigation, clarity of the interface design, and the system's intuitiveness. The individual scores were 81% for ease of navigation, 77% for clarity of interface design, and 80% for intuitiveness, resulting in an overall average of 79%. These results suggest that teachers found the platform to be user-friendly, with a design that is both clear and easy to navigate, facilitating smooth user experiences for educators and students alike.

Content Relevance and Quality: Evaluating the suitability, accuracy, and availability of resources, this indicator scored high, with 82% for media suitability, 85% for media accuracy, and 82% for resource availability, yielding an overall average of 83%. The high scores across these aspects underscore the digital library's alignment with educational objectives and its effectiveness in providing relevant, high-quality content that supports elementary learning outcomes.

Accessibility and Compatibility: This indicator focused on the platform's compatibility across different devices and the accessibility of its features. The scores were 73% for compatibility with various devices and 77% for accessibility features, with an overall average of 75%. While accessibility features were reasonably effective, the results highlight potential areas for improvement in compatibility, particularly for ensuring consistent performance across all devices used in elementary classrooms.

Engagement and Interactivity: Measuring the level of interactivity and the engagement quality of the content, this indicator scored 87% for interactive elements and 85% for content appropriateness, with a high overall average of 86%. These results indicate that the digital library successfully engages students, offering interactive and age-appropriate content that maintains interest and encourages active learning.

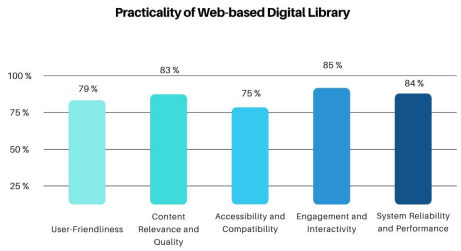

Fig. 6. Practicality analysis results.

System Reliability and Performance: This indicator evaluated platform stability, speed, and overall performance. Scores were 85% for stability, 83% for speed, and 84% for performance, resulting in an average of 84%. These high scores reflect the digital library's reliability, meeting standards for stable and efficient operation, thus supporting consistent access to resources without technical interruptions.

The average results of the practicality analysis from the teacher's response are presented in Fig. 6 below.

The average result of the practicality analysis obtained a score of 81.2% in the "very practical" category, indicating that the Web-Based Digital Library for Primary Schools is a complete educational tool, especially excelling in content relevance, student engagement, and system reliability. While it is generally accessible, an area for improvement is to improve compatibility across devices to ensure wider accessibility. Overall, the findings support the effectiveness of this platform as a valuable and practical resource for primary education, fostering a positive digital learning environment for teachers and students.

3) Effectiveness analysis results

The results of the analysis of the effectiveness of the web-based digital library from student responses as media users, the data is presented in Fig. 7.

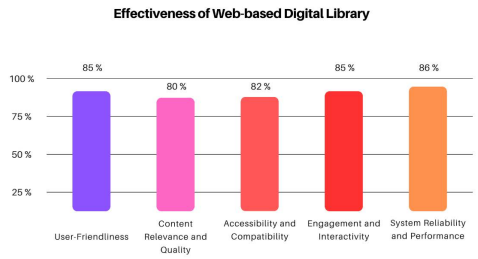

Fig. 7. Effectiveness analysis results.

Fig. 7 presents, the results of the effectiveness analysis of the web-based digital library for Primary Schools, based on student responses, demonstrates its substantial impact as an educational tool, with high scores across critical indicators: user-friendliness, content relevance and quality, accessibility and compatibility, engagement and interactivity, and system reliability and performance.

User-Friendliness: This indicator, with a score of 85%, reflects the students' satisfaction with the platform's ease of navigation and intuitive design. Students found the digital library straightforward to use, with an interface that supports independent exploration and promotes a seamless learning experience. This high score underlines the effectiveness of the user-centered design in enhancing usability for young learners.

Content Relevance and Quality: Scoring an average of 80%, this indicator assessed the alignment of digital content with primary educational goals. Students responded positively to the relevance and appropriateness of the resources, indicating that the content was engaging and aligned well with their learning needs. This score suggests that the digital library effectively supports curriculum objectives, providing valuable resources for foundational learning.

Accessibility and Compatibility: The platform's Accessibility and Compatibility scored slightly lower at 82%, with some students noting issues with device compatibility. While the library is generally accessible across various devices, this score points to potential improvements in ensuring consistent functionality across all platforms commonly used in elementary settings. Enhanced device compatibility would broaden access and ensure a smoother user experience for all students.

Engagement and Interactivity: With a strong score of 85%, this indicator demonstrates the platform's ability to engage students through interactive features and age-appropriate content. Students responded well to the interactive elements, which promote active learning and stimulate curiosity. This score underscores the platform's effectiveness in maintaining student interest and supporting interactive, hands-on learning activities.

System Reliability and Performance: Scoring 86%, this indicator reflects the platform's stability and responsiveness, with students experiencing minimal technical issues. The high level of system reliability ensures that students can access resources consistently, without disruptions, allowing for a continuous and effective learning process.

In conclusion, the average effectiveness analysis result for all indicators is 83.6% with a category of "highly effective" this confirms the role of the digital library as a valuable educational resource for primary school students. High scores in terms of user-friendliness, engagement and system reliability emphasize the platform's capacity to provide a positive and engaging digital learning experience. Although effective overall, improved device compatibility is recommended to optimize accessibility across all student devices. These findings suggest that web-based digital libraries are well-equipped to support primary education, improve digital literacy and encourage student engagement in meaningful ways.

C. Discussion

The development of a web-based digital library for elementary schools addresses the growing demand for digital resources that are both engaging and accessible for diverse student populations. This study evaluated the library's validity, practicality, and effectiveness, providing valuable insights into its potential as a learning tool for primary education while identifying opportunities for further enhancement. Unlike conventional digital libraries that predominantly focus on static resources such as PDFs and text-based materials [35, 36], this platform incorporates interactive multimedia, adaptive learning paths, and gamified elements tailored to the needs of primary education. These innovative features distinguish it by accommodating diverse learning styles and actively engaging young learners, aligning with contemporary pedagogical theories that emphasize interactivity and adaptability in digital education.

A key differentiator of this platform is its user-centered design, ensuring intuitive navigation for both teachers and students. Research by Huda [37] highlights that many digital libraries face challenges related to accessibility and compatibility across multiple devices. This digital library addresses these issues with a device-agnostic interface; however, further efforts are needed to improve compatibility with older or less common devices. Such adaptability is particularly critical in low-resource settings where technological infrastructure varies significantly.

1) Validity results

The validity analysis revealed high scores for content and media design, with averages of 0.92 and 0.91, respectively, categorizing them as "valid." These findings confirm the library's alignment with educational standards and its capacity to support basic learning in a developmentally appropriate manner [38–40]. This alignment is essential, as emphasized by Suwarto *et al.* [41] and Kyva *et al.* [42], who

stress the importance of digital content that adheres to curricular objectives and cognitive benchmarks in primary education. The high validation scores suggest that the platform provides age-appropriate and curriculum-aligned content, significantly contributing to the learning experiences of elementary students.

2) Practicality analysis

Teacher responses in the practicality analysis resulted in an average score of 81.2%, categorizing the library as "very practical." High scores were observed in engagement and interactivity (86%) and content relevance and quality (83%), validating the library's effectiveness in achieving instructional goals and engaging students. These findings align with research by Raza *et al.* [5], Waterman *et al.* [23], and Beširević [40], who emphasize that user-centered design enhances usability, allowing teachers to integrate digital tools seamlessly into their classrooms. Moreover, the platform's ability to reduce teacher preparation time is consistent with findings from Rafi *et al.* [15] and Haq *et al.* [43], demonstrating that practical tools promote the adoption of technology in education.

However, the moderate score in accessibility and compatibility (75%) highlights a need for improvement, particularly in diverse technology environments where classrooms may utilize different devices. This finding corroborates studies by Rafi *et al.* [10] and Zan *et al.* [44], which emphasize the importance of adaptable digital designs to enhance accessibility in educational technology.

3) Effectiveness feedback

Student feedback further confirmed the library's effectiveness, with an average score of 83.6% in the "highly effective" category. User-friendliness and engagement and interactivity both scored 85%, reflecting the platform's ability to enhance student engagement. These results align with theories that underscore interactivity as a critical driver of learning [40, 43]. Interactive elements are particularly valuable in primary education, where digital tools can reinforce foundational skills and foster curiosity.

While accessibility and compatibility scored moderately at 82%, ongoing improvements in cross-platform functionality could enhance the platform's inclusivity, providing equitable access for students using a variety of devices [41, 45, 46].

4) Generalizability and limitations

While this study demonstrates the potential of a web-based digital library to enhance primary education in the observed school environment, its generalizability to other educational settings with diverse technological infrastructures warrants further investigation. For instance, schools in rural or underserved regions with limited access to devices or reliable internet connectivity may encounter challenges in implementing similar platforms. Addressing these disparities requires adaptive solutions, such as offline functionality, modular deployment, and partnerships with local stakeholders to ensure equitable access.

This study is limited to a single primary school environment with relatively stable technological infrastructure. The findings may not fully capture the challenges faced in regions with limited access to devices, internet connectivity, or supportive policies for digital learning. Additionally, cultural and policy differences, such as restrictions on device usage for minors in certain countries, may affect the applicability of the platform in such contexts.

5) Future development and research

Future studies should explore the implementation of web-based digital libraries in diverse educational contexts, particularly in areas with limited technological infrastructure. Investigating the effectiveness of alternative deployment strategies, such as offline or hybrid platforms, can provide valuable insights into ensuring accessibility. Additionally, longitudinal research on the impact of policy changes, such as device usage regulations, on the adoption and effectiveness of digital libraries will help guide the development of adaptable and compliant educational tools.

Overall, this web-based digital library demonstrates substantial potential as an accessible, engaging educational resource tailored to the needs of primary education. Its strengths in content alignment, engagement, and reliability position it as a valuable tool for both students and teachers. Nevertheless, targeted improvements in device compatibility and accessibility are necessary to maximize its impact. This study contributes to the growing body of research on digital resource integration in primary education, positioning the platform as a model for future innovations aimed at fostering inclusive and curriculum-aligned learning environments.

V. Conclusion

The development of a web-based digital library for primary schools demonstrates significant potential as an innovative tool to enhance primary education. By offering a curriculum-aligned, easily accessible, and engaging learning platform, this digital library addresses key challenges in modern education. The comprehensive analysis of validity, practicality, and effectiveness, supported by data from expert validators, teachers, and students, confirms its educational relevance, usability, and ability to engage young learners effectively. Key contributions of this study include the library's customized design, interactive features, and alignment with basic education standards. These attributes position the platform as a meaningful resource for fostering student engagement and improving learning outcomes. However, certain areas require further attention, particularly in enhancing device compatibility to accommodate diverse technological environments. Additionally, the absence of longitudinal studies limits the understanding of its impact on long-term educational outcomes. Future research should prioritize extending the platform's adaptability to diverse educational contexts, ensuring equitable access for all learners. Moreover, studies should investigate its sustainability and impact on specific learning outcomes, such as digital literacy and foundational subject skills, over extended periods. This research highlights the transformative potential of digital libraries in primary education, offering a model for inclusive, interactive, and curriculum-aligned digital resources. By addressing the evolving needs of early education, this study marks an essential step toward creating sustainable and effective digital learning tools.

Conflict of Interest

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Halomoan: Conceptualization; data curation; methodology; investigation; supervision; writing-original draft. Muhammad Hakiki: Conceptualization; data curation; methodology; formal analysis; software; writing-original draft; writing-review & editing. Rido Putra: Investigation; supervision, writing-original draft. Desty Endrawati Subroto: Data curation; writing-review & editing. Khusnul Khotimah: Validation; software. Indra Bulan: Formal analysis. Misra Nofrita: Formal analysis. Rita Arianti: Data curation; writing-review & editing. Kurniati Rahmadani: Validation; software. Resti Utami: Validation; software. Abdulnassir Yassin: Validation; software. All authors had approved the final version.

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