

Development of a responsive web-based digital library for geography education students

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Abstract

A responsive web-based digital library is an application built with web technology to allow users to access digital collections via the Internet. Most digital libraries have not adequately addressed the need for self-directed learning for students, so students' access to educational resources is still limited. This study aimed to determine the development of a responsive web-based digital library for geography education students through an analysis of the identification of the planning process for a responsive web-based digital library, a feasibility evaluation by experts, and an assessment of geography education students' responses. The research method used a Research and Development strategy through the 4D model (define, design, develop, and disseminate). The result was that the research plan involved needs analysis for students. The system design used case and activity diagrams and prototype development validated by experts. Expert evaluation on usability, navigation, graphic design, content, and compatibility falls in the 62.50% < score ≤ 81.25% range, indicating feasibility. The study result was a research plan involving needs analysis for geography education students. The system design used case and activity diagrams and the development of a prototype validated by experts. Expert evaluations on usability, navigation, graphic design, content, and compatibility were in the range of 62.50% < score ≤ 81.25%, indicating feasibility. Students' responses showed that the highest percentages were visual communication (80.73%, very good), usability (76.03%, good), and device compatibility (78.18%, good). In conclusion, this study provides significant contributions to supporting self-directed learning by providing easier access to academic resources for geography education students.

Keywords: Digital library; Web responsive; 4D model; Academic library

Pengembangan digital library berbasis web responsive pada mahasiswa pendidikan geografi

Abstrak

Perpustakaan digital berbasis web responsif adalah aplikasi yang dibangun dengan menggunakan teknologi web, di mana pengguna dapat mengakses koleksi file digital melalui internet kapan saja dan di mana saja. Sebagian besar perpustakaan digital belum mampu memenuhi kebutuhan pembelajaran mandiri untuk mahasiswa pendidikan geografi sehingga mahasiswa untuk mengakses sumber daya pendidikan masih terbatas. Penelitian ini bertujuan untuk mengetahui pengembangan digital library berbasis web responsive pada mahasiswa pendidikan geografi melalui analisis proses perencanaan perpustakaan digital berbasis web responsif, evaluasi kelayakan menurut para ahli, dan menilai respons mahasiswa pendidikan geografi. Metode penelitian menggunakan strategi penelitian dan pengembangan (R&D) melalui model 4D (define, design, develop, dan disseminate). Hasil penelitian menunjukkan bahwa perencanaan penelitian mencakup analisis kebutuhan mahasiswa pendidikan geografi. Perancangan sistem menggunakan diagram use case dan activity, dan pengembangan prototipe yang divalidasi oleh ahli. Para ahli mengevaluasi pada aspek usability, navigasi, desain grafis, konten, dan kompatibilitas berada dalam rentang 62,50% < skor ≤ 81,25%, yang menunjukkan kelayakan. Respons mahasiswa menunjukkan persentase tertinggi pada aspek komunikasi visual (80,73%, sangat baik), usability (76,03%, baik), dan kompatibilitas perangkat (78,18%, baik). Simpulan penelitian menyatakan bahwa penelitian ini telah memberikan kontribusi yang signifikan bagi mahasiswa pendidikan geografi dalam mendukung pembelajaran mandiri melalui penyediaan akses yang lebih mudah ke dalam sumber daya akademik.

Kata Kunci: Perpustakaan digital; Web responsif; Model 4D; Perpustakaan perguruan tinggi

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INTRODUCTION

Many sectors around the world are transforming as a result of the Industrial Revolution 4.0, including in Indonesia. This fourth revolution focuses on the application of technology in areas such as information systems, education, and the emergence of modern technology. The use of information technology as a useful means has greatly improved human beings' lives, allowing access to information and knowledge (Belvedere et al., 2013; Tian & Martin, 2011). The development of science and technology also provides more accurate means for information management and sharing (especially important for educational institutions) (Lu et al., 2024). This is proven by the development of information technology in Indonesia, which has experienced rapid growth, resulting in high public expectations for effective, easy, fast, and up-to-date library services.

Unfortunately, high-tech devices do not solve the problem for some educational institutions in Indonesia. Law Number 14 of 2008 concerning Public Information Disclosure states that public data must be publicly accessible to all by publishing it (Presiden Republik Indonesia, 2008). While this regulation emphasizes the importance of open access to information, the application of this principle in higher education libraries is still not adequately implemented. However, there is already clear guidance on library management with Law No. 43 of 2007 concerning Libraries, including integration with information and communication technology. In accordance with Article 19, paragraph (2) on library development, library development must be tailored to the needs of the community and users and the integration of modernity (Presiden Republik Indonesia, 2007). Although this law has provided a

regulatory basis, its implementation in the field of higher education is still incomplete, especially in the implementation of digital libraries.

Many academic institutions do not yet have a functional and effective digital library system to access academic resources. For instance, data shows that the Geography Education Study Program at Universitas PGRI Pontianak does not yet have a web-based digital library application that can effectively and efficiently convey knowledge and technology that can be used as student references. Consequently, research students cannot access the right materials for their studies. Digital libraries are vital tools in educational environments as they enable independent learning and research (Armen, 2018; Hamad et al., 2024).

Digital libraries bridge the gap by providing users with access to a wealth of materials, regardless of their geographic location and at any time (Rosman et al., 2022; Tella et al., 2023). This system is applied to store, process, and deliver information in digital form, making services more accessible and effective than traditional library systems. Moreover, the increasing use of smartphones and other devices enhances the flexibility of digital libraries, which students may utilize to retrieve information whenever they want and wherever they are (Wang & Ding, 2022; Yaqin, 2022). Studies show that the use of digital libraries via a digital library framework will not just provide better access for students but also improve the quality of education by enabling faster and more accurate information retrieval (Caffrey et al., 2022; Mamabolo & Durodolu, 2023).

However, the absence of a web-based digital library that can respond to users'

needs in the Geography Education Study Program at Universitas PGRI Pontianak indicates that there is still a void. This digital library system will allow students to access academic references and reading materials, thus encouraging them to study independently and improve their academic achievements (Kumaran & Latha, 2023; Ubaidah & Widjaya, 2022). This digital library infrastructure deficiency reflects broader issues in Indonesia's education system, where digital technology adoption in libraries is still not optimal (Anugrah & Kurniadi, 2015; Fitria et al., 2023).

Hence, this study aims to fill this gap by providing a responsive web-based digital library for the Geography Education study program. The context of this development can be found in the regulatory framework outlined in Law No. 14 of 2008, in line with the principles of Law No. 43 of 2007, where one of the focus areas is access to information and education through technology. This digital library will contribute to improving the quality of education that can support the use of independent learning and open access to academic references that lead to broader educational reform goals in Indonesia (Arum & Marfianti, 2021; Listyorini & Iqbal, 2015). Digital libraries must be integrated into educational institutions to address the demands of the digital era and assist students succeed in their studies (Abidin et al., 2021; Sujood et al., 2023).

RESEARCH METHODS

The research method in this study was Research and Development (R&D) to produce a responsive web-based digital library application in the Geography Education study program. The development research aims to connect knowledge to instructional practices and

produce products that are applicable in the field to inform education-seeking learning and research endeavors. This study was conducted from March to July 2023.

The framework used in this study is the 4D model with four stages: (1) definition, (2) design, (3) development (4) dissemination (Fredyana & Dewanto, 2016). This model was selected based on the fact that this model was considered a systematic step-by-step guide to developing technology-based educational products. The 4D model's stages provided a systematic approach that could assist in developing user-centered products that provided validation. Next, the first stage, namely definition, was critical to understanding the problem faced and identifying its solution thoroughly, whereas the design stage focused on planning and creating the application. The model provided sufficient space for testing and validation at all stages, ensuring that the application created was of the best quality.

Although the dissemination step was an integral part of the development workflow to assess the impact of the application in a broader/more heterogeneous setting, we chose not to perform this step due to time and resource constraints. It was also pointed out that if this phase were not carried out, there would not be many users to give feedback, which could potentially provide deeper insights into how the application could be used in different learning contexts. However, this study ensured that expert assessments and informal feedback from a small field trial adequately assessed the application's technical and functional quality at the development stage. So, they wanted to continue their study to the dissemination phase eventually to scale up

the implementation and get user feedback from a larger number.

There are two main sub-stages in the development stage. The first type is expert evaluation, which involves format checking, content analysis, and user needs. It is important to ensure that the application meets the expected quality. The second is development testing, where the application is improved and redefined by experts and users' feedback based on testing. This ensures that the application is technically sound and meets all functional requirements but is also very user-friendly and provides a comfortable user experience. This data is then analyzed using the following formula:

$$P = \frac{\sum x}{\sum x_i} \times 100\%$$

P = percentage of each criterion

X = score of each criterion

X_i = maximum score of each criterion

For the intended expert assessment, six competent IT experts in the fields of systems were employed to assess the system's usability, navigation system, graphic design, content, and compatibility. They consisted of academics from the computer science and information systems discipline from Universitas PGRI Pontianak and Universitas Muhammadiyah informatics study programs, and practitioners who had more than three years of experience in designing and developing websites. They were categorized based on the following score ranges: Score 81.25% < score < 100% highly feasible criteria; Score 62.50% < score < 81.25% moderately feasible criteria; Score 43.75% < score < 62.50% less feasible criteria, and score 25.00% < score < 43.75% not feasible criteria (Sugiyono, 2017).

This study has some limitations in the use of the Likert scale. Despite this, the Likert scale is a common practice that is widely applied and can be the basis for participants to measure intermediate levels like "Agree" or "Strongly Agree" to produce a common agreement that may distort the data and, more importantly, the conclusions drawn in the study. Moreover, the Likert scale fails to capture nuance or context in a response; it only measures the extent to which someone agrees or disagrees with a statement. Hence, the researchers recommended using additional assessment measurements, "e.g., in-depth reviews or open-ended qualitative analysis," to gain a deeper understanding of app quality. Such measures could provide greater insights into experiences and potential areas for improvement.

Additionally, suppose the observation of the idea is not preferred. In that case, qualitative analysis methods (interviews and focus group discussions will provide a better understanding of how the technical and functional aspects of the application can be tested in the prototype development phase, which could not be measured with numbers, at least in this stage, the mind planning phase) could be a good alternative to obtaining detailed feedback from that perspective, the technical perspective. A mix of qualitative and quantitative approaches would provide richer evaluation data and ensure that the developed application met the user's needs.

The researchers also analyzed student response data, targeting the population of Geography Education Undergraduate Students (S1) at IKIP PGRI Pontianak, totaling 218 students. A cluster random sampling method was used to select the sample. First, the population was divided

into clusters according to the academic year; then, a representative cluster sample was randomly selected. The sample size was determined using the Slovin formula (Sugiyono, 2017).

$$n = \frac{N}{1 + Ne^2}$$

N = The total of population

e = The margin of error

Using a 5% margin of error, the sample size was calculated to be:

$$n = \frac{218}{1 + 218(0,05)^2} = 141,11 \approx 141$$

Table 1

Guidelines for assessment scoring used by students

Assessment	Information	Score
SS	Strongly agree	5
S	agree	4
KS	neutral	3
TS	disagree	2
STS	strongly disagree	1

Source: Sugiyono, 2017

Next, all data from the student assessment questionnaire was compiled, and each statement item was calculated using the following formula:

$$p = \frac{\text{total data collection score}}{\text{total criterion score}} \times 100\%$$

P = Percentage of each criterion

The results of the expert evaluations are categorized based on the following score ranges: Excellent interval score category 80-100, Very Good interval score 61-80, Good Interval score 41-60, Fair interval score 21-40, and Very Poor interval score 0-20 (Sugiyono, 2017). Through this analysis, the researchers aimed to determine and conclude the students' responses to the responsive web-based digital library in the Geography Education Study program.

The Likert scale consists of five categories: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Data were obtained through the distribution of the questionnaires, then the responses were analyzed by calculating the average score for each assessment component. This analysis aimed to evaluate students' perceptions of the responsive web-based digital library.

Table 1 shows the assessment scoring guidelines used by students.

RESULTS AND DISCUSSION

Data analysis is the process of interpreting the results obtained from the research and development phase. This analysis served to address research questions, as well as evaluate the usefulness of the web-based digital library platform in the Geography Education program. In this part, the researcher explained the design concept, data collection tools, and evaluation results used by experts and students to complete the questionnaire.

The digital library login page is vital for any website to maintain security and privacy and requires users to enter a username and password to gain access to the system. The login screen is an essential element in the authentication process, being the protected access class of digital assets and library data. After successful

login, the user is presented with the homepage containing several accessible reporting tools. As shown in Figure 1, the page layout includes the user's viewing

history and previously active information. This technique makes the platform more secure and personalized.

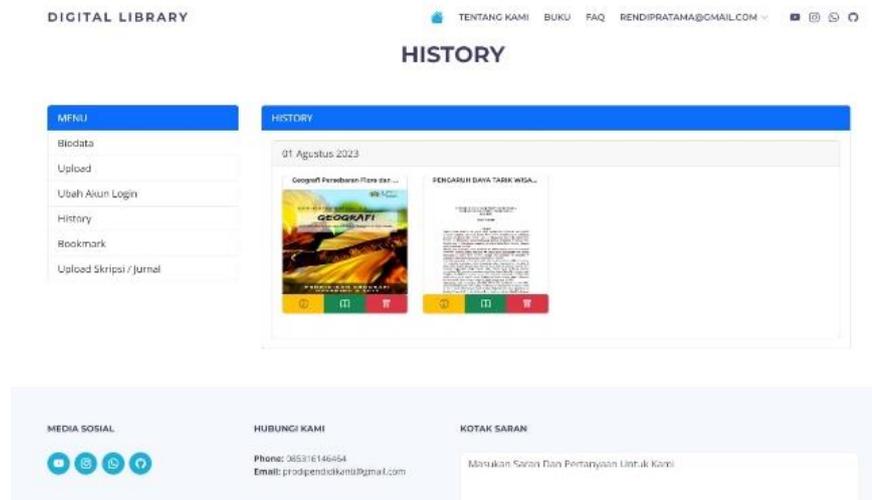


Figure 1. Digital library history page

Source: Layout Responsive Web-based Digital Library from localhost, 2023

As illustrated in Figure 1, the history page allows users to see what materials they have browsed and review previously accessed material. This page consists of a

couple of lines in CSS, but it is necessary to track its usage and allow users to access previous content easily.

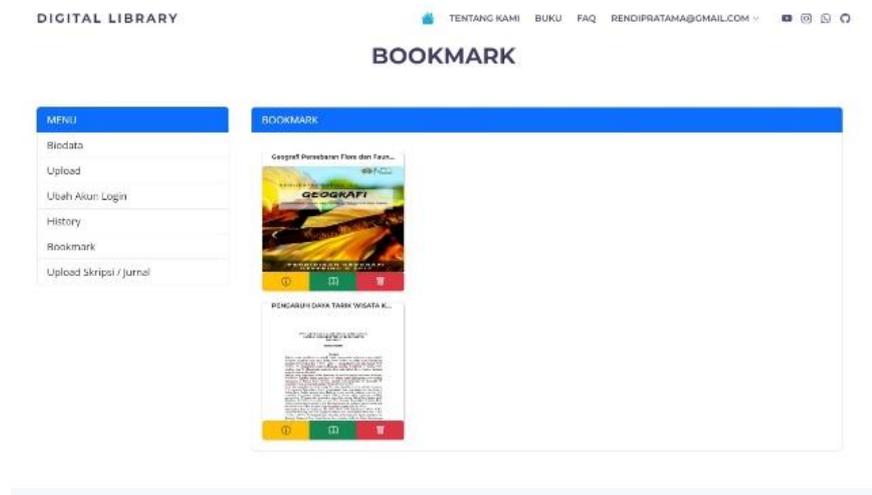


Figure 2. Digital library bookmark page

Source: Layout Responsive Web-based Digital Library from localhost, 2023

Another handy feature is bookmarks, which allow users to save often-used pages or resources. This functionality allows

users easy access to important parts of the digital library without the need to rediscover them, as evidenced in Figure 2.



Figure 3. Digital library file upload page

Source: Layout Responsive Web-based Digital Library from localhost, 2023

The file upload feature allows the administrator to add new content, such as e-books and research papers, to the library, ensuring that the resource base is continually updated with materials relevant to students and faculty. Analysis of input from media experts provides valuable insights into the quality of the web-based digital library. Experts from the fields of information technology,

including representatives from Universitas Muhammadiyah Pontianak and IKIP PGRI Pontianak, assessed various aspects of the digital library's design and functionality. These aspects were evaluated based on usability, navigation system, graphic design, content, and compatibility. Table 2 summarizes the findings of the experts' assessments.

Table 2
Digital library feasibility calculation results

No	Assessment Aspects	Number of Values	Percentage	Category
1	Usability	70	77.78	Feasible
2	Navigation System	47	78.33	Feasible
3	Graphic design	38	76	Feasible
4	Content	23	76.67	Feasible
5	Compatibility	21	70	Feasible

Source: Data analysis, 2023

According to Table 2, the usability, navigation, graphic design, content, and compatibility of the library received feasibility scores above 70%, indicating that the digital library is user-friendly, well-organized, and visually exciting and offers relevant content for students and faculty. Usability, for example, scored 77.78%, indicating that it encompasses usability,

meaning that users can use the platform and obtain the required information easily. Navigation System at 78.33% indicates that the layout and design of the platform allow users to find the resources they need quickly and efficiently, resulting in a better user experience.

Graphic Design scored 76% suggesting an aesthetic and functional

design that is non-distracting toward the learning experience. Another aspect, namely Content based on the score obtained of 76.67%, indicates that the digital library contains a collection of relevant and quality materials tailored to the needs of Geography Education students. On the higher side, this 70% Compatibility scores indicate that the platform works well regardless of any device, although consistency in platform usage across platforms could be better.

However, when we compare the results of this study with current digital library platforms, some points of comparison can be made. User-centered design and intuitive navigation are essential for user engagement and learning, which is why many digital libraries, such as Google Scholar and JSTOR, focus heavily on these aspects (Gonçalves et al., 2007). Similar to these platforms, the web-based digital library developed through this study also reported high usability and navigation scores. In contrast, this study's focus on the specific content of Geography

Education sets it apart from more general databases like JSTOR, which serve a larger academic audience.

A significant advantage of this web-based library is the integration of features such as user authentication and content management (file uploads), which are key to ensuring the security and accessibility of resources, features also emphasized by leading academic libraries such as Elsevier's ScienceDirect. While these platforms offer vast content repositories, the specific focus on geography education in this study makes the digital library more targeted and relevant to the needs of students in this field.

In addition to expert evaluation, student responses were collected through a small group test involving 141 students from the geography education study program. The purpose of this analysis was to gauge the usability and effectiveness of the digital library in meeting students' educational needs. As shown in Table 3, student responses revealed positive feedback on various aspects of the digital library.

Table 3

Student response to the digital library

No	Variable	Question indicator (%)							Mean
		1	2	3	4	5	6	7	
1	Visual Communication	84.98	82.12	80	78.45	78.12	-	-	80.73
2	Usability	74.69	74.12	74.61	76.08	78.45	77.31	77.14	76.06
3	Device	74.86	82.61	79.35	78.69	77.63	75.92	-	78.18

Source: Data analysis, 2023

For Visual Communication, a score of 80.73% indicated that students found the platform's layout and visual elements helpful when learning. This is in line with Wen and Zhang (2015), who emphasize the role of visual design in user engagement and interface design for e-learning platforms. With this goal, design plays a vital role in making learning better, as well

as improving the user experience by making information more accessible and understandable.

The Usability aspect had an average score of 77.78%, indicating that the platform is mostly convenient with increased visibility. It aligns well with Nielsen's (2012) case on Usability as an integral component to helping ensure

digital tools are correct, fast and user-friendly. A high usability score indicates that the platform is successful in providing a smooth user experience to accomplish the task easily and quickly.

The Navigation System scored 78.33%, indicating that the system was intuitive and easy to use. According to Schall (2014), intuitive navigation is a key aspect of platform effectiveness, as it minimizes the cognitive load on users and frees them to focus on content rather than platform mechanics. The high navigation score highlights the need to design systems that are user-focused and aligned with user needs and behaviors.

Graphic Design – 76%: This segment received a positive score, suggesting that the platform's visual appeal was favorable, though it could be improved. According to Park et al. (2009), visually appealing designs can play a significant role in increasing user engagement and motivation to complete tasks, especially in the content learning areas. Thus, improving graphic designs can make the platform more engaging and functional.

As for the Content category, it scored 76.67% since it can provide relevant and quality educational content. This is consistent with Horton et al. (2021), who argue that well-curated and pedagogically relevant content is the core of a strong digital learning platform. Furthermore, the capacity to offer relevant and timely resources fits into a range of needs, especially in a post-pandemic context.

With a Compatibility score of 70%, the platform was able to perform well across devices but could do better in terms of compatibility. Yan et al. (2014) underline that building applications that are available across multiple platforms increases both accessibility and user engagement.

Improving compatibility helps ensure that the system remains inclusive and operable across an assorted number of devices and work systems.

Similar trends were also noted in other digital library platforms, which were increasingly becoming important partners in supporting higher education, especially during the post-pandemic era. A study by Brewer et al. stated that digital libraries have emerged as a vital component of education in virtual environments, providing access to a wide range of academic resources and enabling distant learning facilities (Brewer et al., 2017). This trend has further redefined higher education, highlighting the critical role of digital tools and inequitable access to learning materials. In this regard, the high scores with respect to innate satisfaction and navigation aspects for the current study (77.78% and 78.33%, respectively) highlight how user-centered design elements help create a more holistic experience when retrieving interesting materials on the digital platform. This is consistent with Nooji et al. (2023), who stated that a user-friendly and easy-to-navigate platform affects user experience and learning effectiveness. The fact that the platform is able to meet these metrics signifies its efficacy in making the learning process easier and more effective when everything occurs at a rapid pace in the digital world.

Furthermore, the highest scores in the compatibility and content dimensions illustrate that this platform is highly accessible on multiple devices with relevant content. According to previous research conducted by Sunu (2022), an effective and efficient digital content management system is highly significant across all digital platforms, as it helps

provide easy access to requested materials quickly, particularly when the pandemic severely restricts access to physical libraries. Also, students can learn anywhere, at any time, thanks to seamless access to materials across devices. However, there are a number of challenges in developing and maintaining digital platforms. One of the challenges faced, according to a study relevant to digital libraries in higher education, is that, as with digital libraries, the investment required to set up digital library infrastructure: technology, content and licensing fees burden limited budgets (Brewer et al., 2017). Moreover, internet connectivity issues, especially in remote areas, remain a major challenge for students and education institutes.

In addition, this platform may also facilitate collaboration among students through digital technology. Digital platforms are key players in enriching the lives of children, particularly in Arab societies (Youssef & Khalifa, 2024), for example, the Digital Library of Arab Children's Culture for Sustainable Development (DLACSD). By creating a digital library that connects the past, present, and future (and empowers children to write their own stories), educators can have a stronger sense of ownership and creativity in educational materials. This is consistent with the findings of this study, which showed that combining collaborative and/or creative aspects could increase user engagement and create richer learning experiences. Hence, the continued growth of these platforms should include things like interactivity that allows students to engage and enrich their learning. Besides, the study also underlined that students and faculty must be trained to use the

platforms as they must be aware of the digital systems in order to benefit from them (Sunu, 2022).

A major influence on the development of the idea is Mestre (2024), who cited the transition from traditional library resources to digital platforms, especially for fields such as architecture. They consult material through digital devices, websites, and others rather than through local libraries, Lomelí adds, saying that this change is also universal. This trend transformed the way students access educational resources, making digital compatibility and integration essential for learning. This study describes the integrated nature of these platforms that can accommodate comprehensive information in the form of text, images, audio or video to create an impression in the student's mind to produce many things.

Although the platform performs well, there are compatibility issues across devices. According to Youssef and Khalifa (2024) addressing these compatibility issues with library resources is a fundamental solution to providing terminology access to students across all devices. As students are introduced to different platforms, platforms must ensure compatibility across devices to maintain accessibility. Further testing to confirm compatibility on additional devices should be conducted to help ensure more users are happy and able to use the utility. There are also data security and privacy issues (Brewer et al., 2017) and additional concerns because critical information needs to be protected, and strong cybersecurity must be implemented to avoid misuse of sensitive student information and prevent it from falling into the wrong hands.

CONCLUSION

The development of a web-based digital library in the Geography Education Study Program is feasible and beneficial for both the study program and students. Research planning includes needs analysis, system design using use case diagrams and activity diagrams, and prototype development validated by experts. Overall, the mean response of students to the use of web-based digital libraries was 78.31% in the good category. The login page is an important aspect of digital security, ensuring that only authorized users can access certain information or services. The research and development process uses a combination of qualitative and quantitative data analysis techniques, including data collection from validators and the use of descriptive data to calculate average scores. The web-based digital library assessment is carried out using a Likert scale. The development of a web-based digital library aims to improve learning independence and enrich student knowledge, providing unlimited access to resources regardless of time and distance. Future research includes the development of a comprehensive web-based digital library system to meet the needs of the Geography Education Study Program and the academic community of Universitas PGRI Pontianak. Further development of this platform to accommodate various educational needs can be achieved through user feedback, additional integrations such as interactive devices and collaborative learning resources, as well as integration with other academic programs. In consequence, this evolution can offer a more inclusive, organized, and versatile virtual learning space for current and future learning needs.

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