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INTEGRATION OF DIGITAL LITERACY IN MATHEMATICS DIGITAL BOOK MEDIA

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Abstract

The use of multimedia rich digital books offers an innovative solution in mathematics education, helping both students and teachers adapt to the demands of the digital era. The integration of mathematical digital literacy refers to the skills required to use digital technology to access, evaluate, create, and communicate mathematical information. This study aims to examine the feasibility and practicality of digital book learning media based on the integration of mathematical digital literacy. The research employed Plomp's development model, which consists of three stages: initial investigation, development or prototyping, and assessment. The study was conducted with Grade X students at SMK Taman Siswa Binjai. Data were collected using expert validation questionnaires to assess media and content feasibility, as well as student response questionnaires to evaluate practicality. The digital book was developed using Flip PDF Corporate, a software application for creating interactive e-books. The analysis revealed that the digital book learning media was highly feasible, with a feasibility score of 98%. Additionally, students rated the media as highly practical, with a 94.72% approval rating. This high level of practicality had a positive impact on students' learning behavior by promoting active participation and engagement. The integration of mathematical digital literacy in digital book media represents a meaningful innovation that enhances content delivery through multimedia, interactivity, and student-centered design. Future research should investigate the pedagogical impact of digital learning resources across diverse student populations and educational contexts, providing valuable insights for designing effective, technology-integrated learning environments.

Keywords: digital book; flip pdf; mathematics education; mathematical digital literacy skill.

Abstrak

Penggunaan buku digital berbasis multimedia menawarkan solusi inovatif dalam pendidikan matematika dengan membantu siswa dan guru beradaptasi terhadap tuntutan era digital. Integrasi literasi digital matematis mengacu pada keterampilan dalam menggunakan teknologi digital untuk mengakses, mengevaluasi, menciptakan, dan mengkomunikasikan informasi matematika. Penelitian ini bertujuan untuk mengkaji kelayakan dan kepraktisan media pembelajaran buku digital berbasis integrasi literasi digital matematis. Metode penelitian menggunakan model pengembangan Plomp yang terdiri atas tiga tahap, yaitu investigasi awal, pengembangan atau pembuatan prototipe, dan penilaian. Subjek penelitian adalah siswa kelas X SMK Taman Siswa Binjai. Data dikumpulkan melalui angket validasi ahli untuk menilai kelayakan media dan konten, serta angket respon siswa untuk mengukur kepraktisan. Buku digital dikembangkan menggunakan Flip PDF Corporate, sebuah perangkat lunak untuk membuat e-book interaktif. Hasil analisis menunjukkan bahwa media pembelajaran buku digital sangat layak dengan skor kelayakan 98%. Selain itu, siswa menilai media tersebut sangat praktis dengan tingkat persetujuan 94,72%. Tingkat kepraktisan yang tinggi ini berdampak positif terhadap perilaku belajar siswa karena mendorong partisipasi aktif dan keterlibatan dalam pembelajaran. Integrasi literasi digital matematis dalam buku digital merepresentasikan sebuah inovasi bermakna yang memperkuat penyajian materi melalui multimedia, interaktivitas, serta desain pembelajaran yang berpusat pada siswa. Penelitian selanjutnya perlu mengkaji dampak pedagogis dari penggunaan sumber belajar digital ini pada berbagai populasi siswa dan konteks pendidikan, sehingga dapat memberikan wawasan berharga dalam merancang lingkungan belajar yang efektif dan terintegrasi teknologi.

Kata kunci: *buku digital; flip pdf; keterampilan literasi digital matematis; pendidikan matematika.*

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INTRODUCTION

The integration of digital literacy into mathematics digital book media is a strategic effort to address the challenges of learning in the digital era (Römer, 2024). Mathematical digital literacy encompasses the skills to access, evaluate, create, and communicate mathematical information by effectively utilizing digital technologies (Farida et al., 2023). The implementation of this integration is crucial because well-designed digital learning media can enhance learning interest, motivate students, and foster active participation, while simultaneously strengthening systematic, analytical, creative, and critical thinking skills required in mathematics learning (Wang & Abdullah, 2024).

However, a needs analysis conducted at SMK Taman Siswa Binjai showed that 56% of Grade X students perceived mathematics learning as less engaging and not yet integrated with digital literacy. The survey findings indicated that conventional teaching methods and the limited use of innovative, interactive media reduced students' engagement and motivation. These conditions emphasize the urgency of developing mathematics digital book media integrated with digital literacy skills, aligned with students' learning habits, and capable of making mathematics learning more meaningful and effective.

This problem is caused by the limited use of innovative learning media in mathematics and the lack of teachers' skills in using digital tools effectively (Inganah et al., 2023). Without interactive and attractive media, classes often become monotonous and passive, which lowers students' motivation and participation (Al-Khresheh & Alanazi, 2025). As a result, many students think mathematics is difficult and not relevant (Schoenfeld, 2022). Around 70% of students said they need more engaging learning media, both electronic and non-electronic, to help them understand and enjoy mathematics. One potential solution is using digital books, which can include videos, animations, and interactive quizzes to make learning math more engaging and easier to understand (Yohannes et al., 2023).

Previous studies have demonstrated that the use of digital learning tools, particularly interactive digital books developed with Flip PDF Corporate, provides significant benefits as they incorporate multimedia features such as videos, animations, audio, and hyperlinks that make learning more engaging and dynamic (Karagöz et al., 2023). These features offer a learning experience similar to printed books but with the added advantages of modern technology (Jayaraman & Aane, 2024). In this context, mathematical digital literacy has become an essential skill, as students are required to access, evaluate, and effectively utilize digital mathematical content (Farida et al., 2023). However, the low level of mathematical digital literacy among students and the limited use of digital facilities in schools continue to hinder the optimization of technology-based learning (Zamir & Ali, 2023). Therefore, the integration of digital literacy into mathematics digital book media emerges as a strategic solution to address these challenges while enhancing the effectiveness of mathematics learning.

Although many studies have examined the use of interactive digital books in education (Tlili et al., 2022), only a few have looked at how mathematical digital literacy skills can be integrated into mathematics learning media using Flip PDF Corporate

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(Roemintoyo & Budiarto, 2021). Most past research has focused on the visual and functional features of digital books, not on how they can improve both students' mathematical understanding and digital skills (Zwart et al., 2017). This shows a research gap that needs to be addressed to make the most of digital technology in mathematics education.

This study aims to develop an interactive digital book using Flip PDF Corporate that integrates mathematical digital literacy skills with mathematics content. The digital book will include videos, quizzes, animations, and hyperlinks designed to make learning more engaging and to support students' conceptual understanding. The study seeks to examine the feasibility and practicality of this digital book in improving students' interest, motivation, and learning outcomes, as well as to identify the challenges faced by both teachers and students in its implementation. The findings are expected to provide valuable insights for designing effective learning strategies that integrate digital literacy into mathematics education and to contribute practical implications for improving learning in the digital era.

METHODS

This study uses the research and development (R&D) method, a structured approach to create and test an educational product (Tolla & Jabu, 2022). The product is an interactive digital book for learning mathematics on sequences and series, designed based on mathematical digital literacy. This skill requires understanding math concepts and using technology as a tool for thinking and communicating in learning. the research flow using Plomp Model (Akker et al., 2013) can be seen in figure 1.

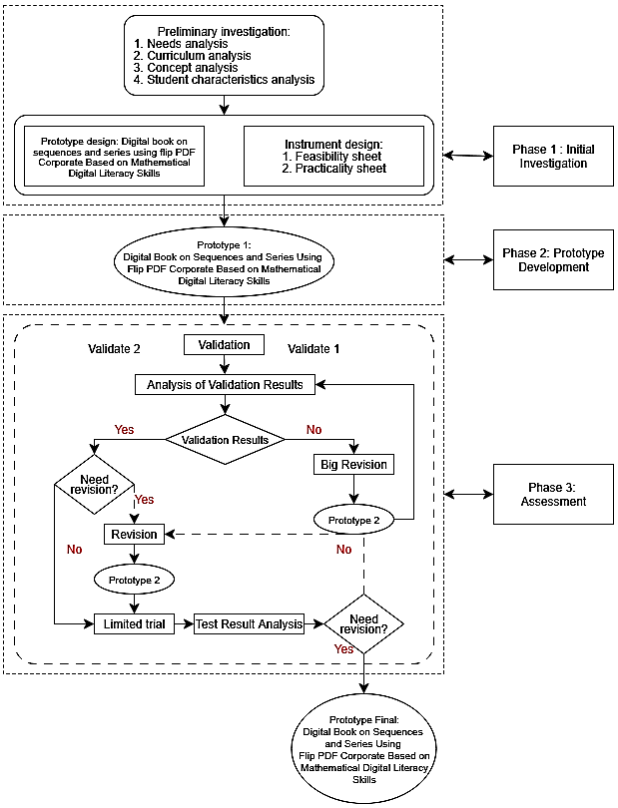

Figure 1. Plomp Model

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The development model in this study uses a simplified version of the Plomp model , which has three main stages: (1) preliminary research, (2) development or prototyping, and (3) assessment (Akker et al., 2013). The first stage identifies the needs of teachers and students, analyzes the curriculum, and studies learner characteristics (Akker et al., 2012). The second stage designs and develops digital media based on mathematical digital literacy principles, then validates it with experts. The final stage conducts a small-scale field trial to see how practical and effective the product is in the classroom. This simplified model was chosen because it is flexible, practical, and suitable for developing educational products within school time and resource limits.

The study took place at SMK Taman Siswa Binjai, North Sumatra. The subjects were 30 Grade X students chosen through purposive sampling, based on their initial abilities and readiness to use digital devices. Four expert validators were also involved: two media experts and two mathematics content experts, to assess the quality and feasibility of the product.

The instruments used in this study consisted of observation sheets, validation questionnaires (media/ learning validation sheets) completed by experts to assess content, language, appearance, and technical aspects, practicality questionnaires given to students and teachers to evaluate ease of use, time efficiency, clarity, and attractiveness (Kothari, 2004).

Data analysis was done quantitatively. Scores from the validation sheets were converted into percentages using the formula 1:

$$\frac{\text{score obtained}}{\text{maximum score}} \times 100 \qquad (1)$$

The product is declared valid or feasible, as presented in Table 1.

Table 1. Interpretation of instrument validity results

Score Range (%)	Category
85 – 100	Very Valid
70 – 84	Valid
55 – 69	Fairly Valid
< 55	Not Valid

(Perroca, 2011)

Practicality data came from the average scores of student and teacher questionnaires and was considered practical if the score was ≥70% (Hasyim et al., 2024).

RESULTS AND DISCUSSION

a) Preliminary Reasearch Phase

The preliminary research phase included four main analyses: needs, curriculum, concept, and student characteristics, which became the basis for developing the digital book using Flip PDF Corporate.

1) Needs Analysis

A Google Form survey showed that 70% of students prefer learning with electronic media, indicating strong readiness to adopt technology-based learning. Flip PDF Corporate was chosen as the platform because it can combine text, images, videos, animations, interactive quizzes, hyperlinks, and other multimedia elements, which can be easily accessed by both teachers and students.

2) Curriculum Analysis

The mathematics content in the digital book was matched with the Learning Outcomes (LO), Learning Objectives, and Learning Achievement Indicators for Grade X students at SMK Taman Siswa Binjai. The Merdeka Curriculum was used as the reference to ensure the material is consistent with and relevant to the latest national education standards.

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3) Concept Analysis

The chosen material was Sequences and Series, organized systematically in the digital book to support gradual understanding. This structure allows students to access explanations, examples, and interactive exercises in a clear and logical order.

4) Student Characteristics Analysis

The questionnaire showed that 56% of students found mathematics "not interesting," and 54% said the teacher did not use any learning media. Interviews confirmed that no mathematics digital book based on digital literacy had been developed for Grade X before. This shows a strong need for innovative, engaging, and curriculum-aligned learning tools.

b) Development or Prototyping Phase

The media was first made in Microsoft Word 2010, then improved using Flip PDF Corporate. This application allowed adding text, images, videos, animations, interactive quizzes, and hyperlinks, with Sequences and Series as the topic (Mahendri et al., 2023). Two media experts checked technical aspects and usability, while two subject experts checked content accuracy and relevance. The aim was to produce a mathematics digital book based on digital literacy that met academic standards and could be used effectively in teaching (İlhan et al., 2025). Expert validation confirmed the product met quality standards for effective learning. This stage includes:

1. Making Learning Media

The digital book was first created in Microsoft Word 2010 and then developed using Flip PDF Corporate with material on Sequences and Series. The steps were: (a) design the material based on the curriculum; (b) leave blank spaces in Word for images or videos; (c) save the file as PDF; (d) import the PDF into Flip PDF Corporate with "New Project"; (e) edit pages to add the cover, content, and tests; (f) insert media in the blank spaces; (g) save changes with "Save and Exit"; (h) choose a background from "Templates"; and (i) publish the project using "Publish."

The final product can be exported as HTML, ZIP, EXE, Mac application, mobile version, or burned to CD. For this book, the EXE format was used for laptops and desktops, and HTML for Android devices. The design includes the cover, main menu, preface, table of contents, plus images, videos, animations, and interactive quizzes to make learning more engaging, build curiosity, and help students understand the Sequences and Series topic, as shown in Figure 2 until Figure 9.

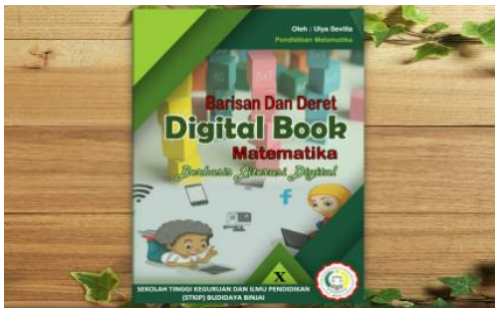

Figure 2. Digital book cover


Figure 3. Learning experiences and sparking questions

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Figure 4. Inside cover and main menu

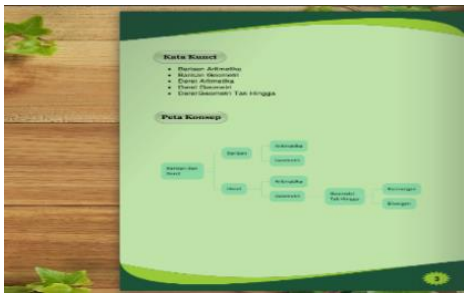

Figure 5. Key words and concept maps

Figure 6. Preface

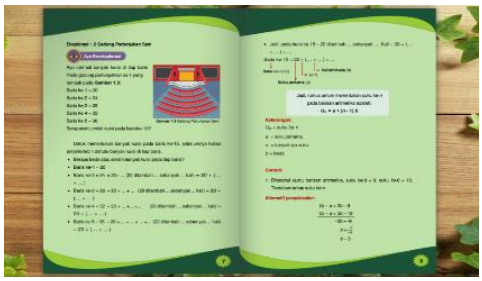

Figure 7. Contents of rows and sequences

Figure 8. Table of contents and instructions

Figure 9. Competency test and bibliography

2. Validation

Validation is done by consulting the developed learning media with experts, such as lecturers and teachers, especially in mathematics (Ulandari et al., 2019). This process uses an instrument sheet filled out by each validator according to their expertise, using a Likert scale (Daryanes et al., 2023). Next, each validator completes a questionnaire provided earlier to assess the feasibility of the digital book designed by the researchers.

a. Analysis of Data from Media Expert Validation Results

The expert validation results for the developed digital learning media are shown in Table 2. This validation assessed content feasibility, language quality, presentation, and media design to ensure the product meets academic and technical standards.

Table 2. Expert Validation Results

Aspect	Mean	SD	Category
Content Feasibility	4.75	0.28	Very Valid
Language	4.67	0.33	Very Valid
Presentation	4.70	0.30	Very Valid
Media Design	4.80	0.25	Very Valid
Overall	**4.73**	**0.29**	**Very Valid**

The Cronbach's Alpha reliability coefficient was 0.91, showing excellent internal consistency. This means the

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validators' assessments were consistent and reliable for all evaluation items. Students' responses to the developed learning media are shown in Table 2. This evaluation collected direct feedback from users about the media's attractiveness, ease of use, clarity of content, and effectiveness in increasing learning motivation (Mohamed, 2025).

Table 3. Student Response Results

Indicator	Mean	SD	Category
Attractiveness of the Media	4.65	0.35	Very Positive
Ease of Use	4.70	0.32	Very Positive
Content Clarity	4.60	0.38	Very Positive
Learning Motivation Improvement	4.75	0.29	Very Positive
Overall	**4.68**	**0.34**	**Very Positive**

The Cronbach's Alpha for the student response instrument was 0.88, showing good reliability. The highest score was for Learning Motivation Improvement (4.75), indicating that the multimedia features increased students' interest in learning mathematics. The lowest score was for Content Clarity (4.60), which is still high but suggests small improvements, such as simplifying explanations and adding more varied examples. These results match the studies of Waang (2023) and Tugtekin & Dursun (2022), which found that interactive, multimedia-rich media can improve engagement and motivation. However, this study offers a more complete integration of text, images, animations, and interactive quizzes compared to earlier research, making it a unique contribution to mathematics education. The digital book has several strengths, including high validity and reliability from both experts and students, effective multimedia integration, and alignment with the national curriculum. Still, minor weaknesses remain, such as improving language clarity and adding more examples for better understanding. Overall, this digital book is an engaging, interactive, and curriculum-aligned resource for vocational high school mathematics that effectively boosts student motivation and understanding.

Media experts assessed the digital book based on key indicators, namely visual display, sound, and ease of use (Afwan et al., 2020). The validation results indicate that the digital book developed in this study is highly feasible. The detailed assessment results from the experts are presented in Table 4 Media experts assessed the digital book using key indicators such as visual appearance, sound, and ease of use (Afwan et al., 2020). The validation results show that the digital book developed in this study has a high level of feasibility (can be seen in Table 4).

Table 4. Feasibility Analysis of the Digital Book by Media Experts

No	Assessment Indicators	Total Score Which is Obtained	Amount Score Maximum	Number Percentage	Criteria
1	Visual Display	58	60	96.66%	Very Feasible
2	Sound	4	4	100%	Very Feasible
3	Ease of use	8	8	100%	Very Feasible
4	Overall	70	72	97.22%	Very Feasible

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The validation results show that the Visual Display aspect scored 58 out of 60 (96.66%). According to Borg & Gall (1983), a score of ≥85% is in the highly feasible category. This means the book's design, layout, color choice, and readability meet high standards. However, because it is not 100%, improvements can still be made, such as improving illustration quality or making typography more consistent for better comfort and visual appeal. The Voice and Ease of Use indicators both scored a perfect 100%, showing that audio quality and usability are already optimal with no major revisions needed. The overall score of 97.22% confirms that the digital book is highly feasible, with only small improvements needed, mainly to optimize the visuals to match the perfect scores of other indicators.

b. Analysis of Data from Material Expert Validation Results

The assessment of the digital book by material experts was based on several key indicators: presentation, content, language, and overall quality (Yusmar et al., 2024). The validation results show that the digital book developed in this research is suitable for use. As shown in Table 5, all indicators meet the criteria for high feasibility

Table 5. Feasibility Analysis of the Digital Book by Material Experts

No.	Assessment Indicators	Total Score Which is Obtained	Amount Score Maximum	Number Percentage	Criteria
1	Presentation	16	16	100%	Very Feasible
2	Head	39	44	88.63%	Very Feasible
3	Language	25	28	89.28%	Very Feasible
4	Overall	80	88	90.90%	Very Feasible

The feasibility analysis of the digital book by material experts shows very feasible results. As shown in Table 5, the presentation indicator scored 100%, indicating the book is highly suitable for use. The content indicator scored 88.63%, and the language indicator scored 89.28%, both in the "very feasible" category. Overall, the material aspect scored 90.90%, also in the "very feasible" category. These results show that the digital learning media for Sequences and Series, developed with Flip PDF Corporate and based on digital literacy, meets the "very feasible" criteria. However, as shown in Table 6, validators still provided comments and suggestions, meaning some improve-ments are needed. The next section presents these comments and suggestions.

Table 6. Digital book revisions based on validation results and expert suggestions

No	Expert	Criticism and Suggestions	Improvement results
1	Expert 1	Show book source non-digital into digital book	Book source non-digital has been displayed inside digital book
2	Expert 2	There isn't any	There isn't any
3	Expert 3	The video explaining the material should be deleted	The video is changed to a video explaining example questions
		The number of questions has been increased	Questions have been added in the form of a quiz
4	Expert 4	There isn't any	There isn't any

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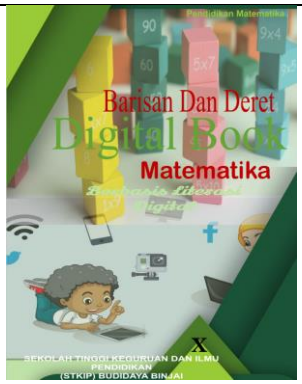
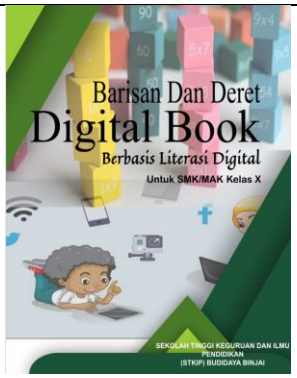
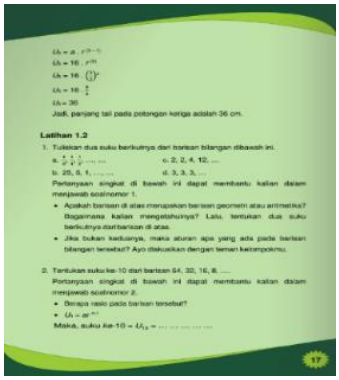
Based on Table 6, the digital book was revised according to validation results and expert feedback. Expert 1 suggested adding non-digital book sources, which was done in the revised version. Expert 3 advised replacing the material explanation video with one that explains example questions, and this was applied. The number of practice questions was also increased as quizzes to improve student engagement. Expert 2 and Expert 4 did not give suggestions because the aspects they assessed already met feasibility standards. Overall, all feedback was used to improve the quality, interactivity, and effectiveness of the digital book. After validation by media and material experts, further improvements were made to the language, content, and design based on their feedback. Based on Table 7, which shows the suggestions from media and material expert validators .

Table 7. Improvements Suggested by Media Expert Validators and Material Experts

No	Before Revision	After Revision	Information
1			Fixed adding book source non-digital This needs to be done so that readers know where the content of the material presented in it comes from the digital book.
2			The video explaining the material was deleted and replaced with a video explaining example questions to understand the content of the material digital book not excessive.
3			The questions are increased so that students better understand the material of the rows and series.

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The questionnaire results show that most students gave positive responses to the revised Sequences and Series digital book. About 92% of students were satisfied with the design, content, and interactive features, showing that the visual and content improvements increased satisfaction. Around 89% found the material easier to understand after the explanatory video was replaced with an example-based video and more practice exercises were added, helping them connect concepts to real applications. The media's attractiveness received the highest rating, 94%, meaning the colors, illustrations, and layouts successfully increased learning interest. Ease of use was rated positively by 91% of students because of simple navigation, clear interactive buttons, and well-structured content that supported independent learning. In addition, 90% of students said the extra exercises helped them better understand sequences and series. Overall, these results show that the revisions improved both the appearance and the effectiveness of the media in helping students understand the material.

c. Assessment Phase

After the product passed the validation stage, the next step was to conduct a trial involving students in a large group. This trial was carried out in Grade X of SMK Taman Siswa Binjai with 30 enthusiastic students. At this stage, the digital book was used as the main tool to measure the practicality and effectiveness of the product. Validation had previously been conducted by experts using media and material validation questionnaires to ensure product quality. The practicality of the digital book was measured through student responses collected via a questionnaire. Its effectiveness was assessed based on students' achievement of learning outcomes through post-test scores. This step was important to ensure that the developed product was not only of high quality but also practical and effective for teaching and learning. By directly involving students, the researchers aimed to provide a better and deeper learning experience.

The findings of this study reveal several important points, as follows :

1. Feasibility of Learning Media *Digital Book* Based on Digital Literacy

The results of this study indicate that the development of learning media for sequences and series using the Plomp model (Akker et al., 2013), integrated with digital literacy, produced a learning product with a very high level of feasibility, as evidenced by validation scores of 100% from media experts and 96% from content experts. The developed media demonstrates strong visual appeal, interactivity, intuitive navigation, and well-integrated multimedia elements, which are consistent with the principles of the cognitive theory of multimedia learning and cognitive load theory in reducing extraneous cognitive load and enhancing students' conceptual understanding (Twabu, 2025). These findings reinforce previous studies reporting that interactive digital media increases learning motivation and fosters positive perceptions of mathematics (Jayaraman & Aane, 2024; Karagöz et al., 2023; Maspul, 2024; Parveen et al., 2024).

The novelty of this study lies in positioning mathematical digital literacy as a core design principle of the learning media, rather than merely a by-product of technology use. Unlike prior studies that primarily focused on visual design, interactivity, and technical

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functionality of digital learning media (Tlili et al., 2022; Zwart et al., 2017), this study explicitly integrates competencies related to accessing, evaluating, and utilizing digital mathematical information, as conceptualized by Farida et al. (2023). Consequently, the feasibility of digital learning media is determined not only by usability and aesthetic aspects but also by its capacity to support the systematic development of students' digital literacy competencies, despite persistent challenges related to infrastructure readiness and heteroge-neous levels of digital literacy among users (Dobson & Willinsky, 2009; Zamir & Ali, 2023).

2. Practicality of Learning Media *Digital Book* Based on Digital Literacy

The practicality test of the digital literacy based mathematics digital book on sequences and series, conducted with 30 students at SMK Taman Siswa Binjai, resulted in a score of 94.72%, which is categorized as highly practical. This finding indicates that the developed product is easy to use, well accepted by students, and capable of supporting their learning needs. The high level of practicality was reflected in ease of access across devices, time efficiency, clear and concise content presentation, and visually appealing design, all of which facilitated students' understanding of abstract mathematical concepts. The integration of digital literacy played a crucial role in enhancing the practicality of the media, as students were not only able to use the digital book efficiently but were also encouraged to independently access, manage, and interpret digital mathematical information, thereby reducing cognitive load and improving conceptual comprehension.

These findings are consistent with the expert validation results, which reported scores of 100% from media experts and 96% from content experts, confirming that the digital book is both technically feasible and pedagogically relevant. The results also align with previous studies indicating that digital based mathematics learning media enhance student engagement and provide more flexible and inclusive learning access (Alam et al., 2025; Mandala et al., 2025). Furthermore, the findings reinforce prior evidence that interactive digital media increase learning motivation and foster more positive student perceptions of mathematics learning (Maspul, 2024; Parveen et al., 2024). However, unlike earlier studies that generally interpret practicality as a direct outcome of technical ease alone, this study demonstrates that the integration of digital literacy significantly strengthens media practicality by actively involving students in managing digital mathematical information.

On the other hand, this study also confirms limitations previously identified by Dobson and Willinsky (2009), namely that the practicality of digital learning media is strongly influenced by external factors such as device availability and quality, internet stability, and variations in students' levels of digital literacy. In contrast to studies that have examined the effectiveness of digital media in improving learning outcomes (Stohl & Confrey, 2004), this research remains limited to the stages of feasibility and practicality. Consequently, the findings provide a foundation for future research to investigate the effectiveness of digital literacy–based digital books in enhancing students' mathematical understanding more comprehensively, particularly

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within vocational education contexts that align with the demands of 21st-century learning (Zou et al., 2025).

CONCLUSIONS

This study concludes that the development of a digital literacy-based digital book on sequences and series using the Plomp model meets the criteria of feasibility and practicality. The media was found to be highly feasible, with validation scores of 100% from media experts and 96% from material experts, and highly practical, with a student response score of 94.72%. The product is engaging, accessible, and supports students' understanding through interactive features, clear content, and appealing visuals. Although limitations remain regarding infrastructure and varying levels of digital literacy, the digital book shows strong potential to support mathematics learning under the Merdeka Curriculum and to strengthen students' digital competencies for 21st-century education.

Based on the research results, discussion, and conclusions, several suggestions are given. Educators and researchers are advised to develop digital book learning media for more topics, using the same approach applied to sequences and series with the Flip PDF Corporate application and guided by digital literacy principles. Since this study only used Flip PDF Corporate, future research can create other innovative learning media to improve teaching and learning. For those developping digital book learning media, it is important to explore and improve its strengths, especially by making full use of Flip PDF Corporate features. With ongoing creativity and commitment, this digital tool can be optimized to produce more effective and engaging educational resources.

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