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Development of "Stafolding": A Computer-Based Scaffolding Interactive Learning Media to Enhance Students' Mathematical Problem-Solving Ability

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ABSTRACT

The low level of students' mathematical problem-solving ability remains a challenge in the learning process, particularly in statistics topics. One effective approach to address this issue is scaffolding, which provides temporary support that helps students understand problems and find solutions independently. However, in classroom settings, individualized scaffolding is often suboptimal due to the large number of students compared to the limited number of teachers and the relatively short instructional time. This study aims to develop a computer-based scaffolding interactive learning medium that is feasible and practical for enhancing students' mathematical problem-solving ability. The research employed a Research and Development (R&D) design using the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. The media were developed using Canva, Microsoft PowerPoint, and iSpring Suite, and published via GitHub Pages for online accessibility. The validation results showed a feasibility score of 91.11% from material experts and 93.33% from media experts, both categorized as excellent. The practicality tests conducted by teachers and students each obtained a score of 92%, indicating that the media are easy to use and effective in facilitating learning. Therefore, the interactive learning media "Stafolding" are considered feasible and practical to be used as a computer-based scaffolding tool in mathematics learning.

Keywords: interactive learning media; scaffolding; problem-solving ability; computer-based scaffolding

1. Introduction

One of the main objectives of mathematics education in the Indonesian Curriculum is to help students develop their mathematical problem-solving ability. However, in practice, many students continue to experience difficulties in solving mathematical problems,

particularly in statistics topics [1–4]. The main challenges lie in mathematical modeling, which often prevents students from accurately completing problem-solving tasks [3].

Previous studies have demonstrated that scaffolding is an effective approach to assist students in solving problems and to gradually improve their problem-solving abilities [5,6]. Scaffolding may take the form of explanations, step-by-step guidance, or feedback that helps students understand the problem and independently construct solutions [7]. Prior research has shown that scaffolding significantly enhances students' performance in mathematical problem solving by providing assistance tailored to individual needs [8].

However, implementing scaffolding in classroom practice is not an easy task. Time constraints and a high student–teacher ratio often hinder teachers from providing sufficient individual attention. In large classes, it becomes nearly impossible for teachers to deliver personalized scaffolding to every student within the limited instructional time. Although peer scaffolding—where more capable students support their peers—has been attempted, it is not always effective, particularly when the number of students requiring support exceeds those capable of providing it.

Therefore, technology-based interventions are needed to complement the teacher's role in delivering scaffolding. The development of interactive learning media as computer-based scaffolding offers a promising solution.

Research has shown that computer-based scaffolding effectively improves learning outcomes, especially in STEM education, where technology plays a crucial role in supporting flexible and personalized learning [9]. Various studies have reported that digital learning media receive positive responses from students and have a significant impact on mathematics learning outcomes [10–16]. Furthermore, digital media enable interactive visualization that helps students comprehend complex mathematical concepts more easily. However, most digital learning media developed thus far have not explicitly integrated scaffolding principles—particularly in the context of statistics learning at the junior high school level in Indonesia.

Based on these problems and research gaps, this study aims to develop an interactive learning medium based on computer-based scaffolding that is both feasible and practical for mathematics instruction. The developed medium is expected to help students gradually understand statistical concepts, enhance their mathematical problem-solving ability, and serve as an alternative solution to the limitations of conventional scaffolding practices in large classroom settings.

2. Methods

This study employed a Research and Development (R&D) approach using the **ADDIE model**, which consists of five stages: Analyze**, Design, Develop, Implement, and Evaluate**. This model was chosen because it provides a systematic and structured framework suitable for developing learning media that meet both feasibility and practicality criteria in improving students' mathematical problem-solving ability.

The **Analyze stage** aimed to identify the essential needs for developing computer-based scaffolding learning media in the context of statistics learning. This stage involved a comprehensive analysis of learning outcomes, students' problem-solving abilities,

learner characteristics, and available learning facilities. The learning outcomes referred to the Indonesian Curriculum (Phase D), which emphasizes students' ability to determine and interpret statistical measures such as mean, median, mode, and range, and to apply them in real-life contexts. Observations and teacher interviews revealed that many students had difficulties in understanding the context of problems and selecting appropriate strategies for solving them. In addition, the analysis of learner characteristics indicated that students, as digital natives, tend to be more motivated by interactive and visually engaging learning experiences. The analysis of school facilities showed that digital devices and internet access were sufficient to support the implementation of computer-based learning. These findings provided a strong foundation for designing learning media that correspond to students' needs and classroom conditions.

The **Design stage** focused on constructing a conceptual framework for the learning media. During this stage, a flowchart was created to illustrate the structure and navigation of the learning process, while a storyboard was prepared to guide the layout and content organization. The design process involved the use of Canva and Microsoft PowerPoint for visual development, and iSpring Suite to convert the materials into an interactive HTML5 format. The final product was then published via GitHub Pages, enabling users to access the media online without requiring software installation.

The **Develop stage** consisted of transforming the design into a functional product named "Stafolding." The media incorporated the principles of computer-based scaffolding through features such as step-by-step hints, automated feedback, and interactive visualizations. Once the prototype was completed, validation was conducted by two material experts and two media experts. The material validation focused on the accuracy of content, conceptual correctness, and the integration of scaffolding elements, while media validation assessed the visual design, navigation, interactivity, and compatibility of the media. The results of this stage served as the foundation for designing a learning medium that aligned with students' needs and classroom conditions.

To interpret the validation results, the following feasibility criteria were applied:

Table 1. Feasibility criteria for learning media

Percentage (%)	Category
85–100	Excellent
70–84	Good
55–69	Fair
40–54	Poor
< 40	Very Poor

Feedback from the validators was used to revise and improve the product until it met the criteria for feasibility and readiness for implementation.

The **Implement stage** was carried out through a limited trial at SMP Negeri 1 Tibawa, involving one mathematics teacher and ten students. The purpose of this stage was to determine the practicality of the developed media in a real learning environment. During the implementation, the teacher acted as a facilitator, while students used the media independently via their personal devices. After the learning activities, both teachers and students completed response questionnaires to evaluate the usability, appearance, role of the media as computer-based scaffolding, accessibility, and its influence on learning motivation. The interpretation of practicality results referred to the criteria shown in **Table 2** below.

Table 2. Practicality criteria for learning media

Percentage (%)	Category
85–100	Very Practical
70–84	Practical
55–69	Fairly Practical
40–54	Less Practical
< 40	Not Practical

Finally, the **Evaluate stage** focused on analyzing and interpreting the validation and practicality test results to assess the feasibility and overall quality of the developed media. Data were analyzed using descriptive quantitative techniques by calculating the average percentage for each aspect and interpreting the results according to the established criteria. The findings were used to refine the product, ensuring that the final version of the "Stafolding" interactive learning media met the intended standards of feasibility and practicality for use in mathematics learning. The conceptual framework of the ADDIE development model used in this study is presented in Figure 1.

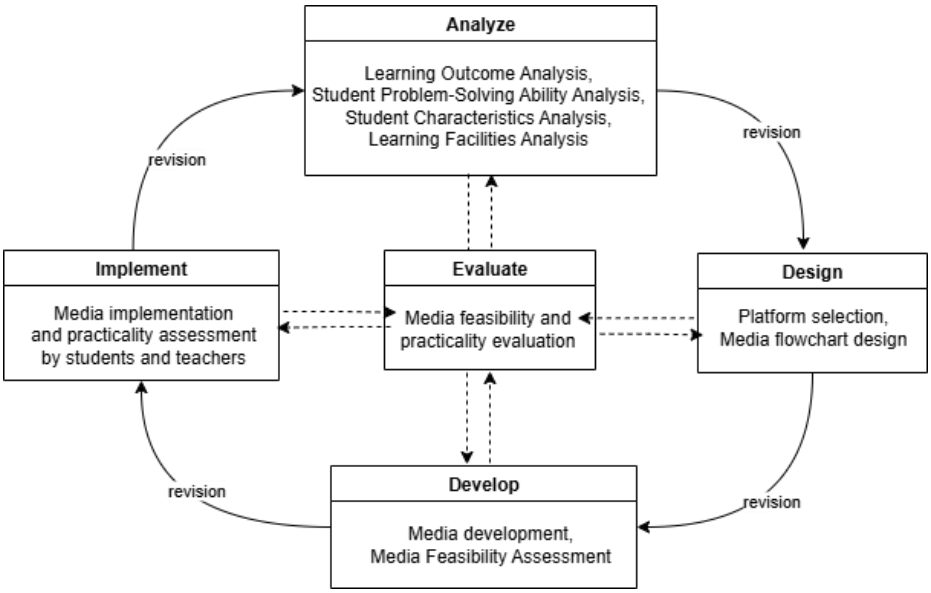


Figure 1. Flowchart of the development procedure based on the ADDIE Model

3. Results and Discussion

3.1. Analyze Stage

The Analyze stage was conducted to identify the fundamental needs in developing computer-based scaffolding interactive learning media for teaching statistics. This stage involved analyzing the learning outcomes, students' problem-solving abilities, learner characteristics, and learning facilities. The analysis of learning outcomes referred to the Indonesian Curriculum (Phase D), particularly the Data Analysis and Probability element, which emphasizes students' ability to determine and interpret the mean, median, mode, and range of data, and to apply these concepts in real-life contexts.

The results of classroom observations and teacher interviews indicated that many students still struggled to comprehend statistical problems, especially in interpreting contextual questions and selecting appropriate strategies for solutions. These difficulties were often caused by limited conceptual understanding and the absence of structured guidance during problem-solving activities. Most students tended to rely on direct instruction from the teacher, which limited opportunities for independent reasoning and exploration.

From the analysis of learner characteristics, it was found that students belong to the generation of digital natives who are familiar with technology and prefer interactive, visually stimulating learning environments. This finding suggests that integrating digital media into learning could enhance students' engagement and motivation. In addition, the analysis of learning facilities revealed that the school environment supports the implementation of digital-based learning. The majority of students had access to laptops or smartphones, and the school provided stable internet connectivity.

Based on these findings, the development of computer-based scaffolding media was deemed highly relevant. The identified problems—students' difficulties in independent problem solving, the need for gradual instructional support, and the availability of digital infrastructure—served as the foundation for designing interactive media that could provide structured assistance in learning statistics.

3.2 Design Stage

The Design stage focused on developing a detailed conceptual and visual blueprint for the interactive learning media based on computer-based scaffolding. This stage aimed to transform the results of the needs analysis into a structured design that would guide the development process in the next phase. The design activities included the creation of a flowchart to visualize the structure and navigation of the learning process, and the development of a storyboard that outlined the organization of content, scaffolding features, and visual components of the media.

The flowchart illustrated the main pathways and interactive elements that would be integrated into the media, including the main menu, learning materials, interactive exercises, and evaluation sections. It also depicted how users would navigate between

components and how scaffolding features—such as hints, feedback, and guidance—would be presented progressively. The structure was designed to ensure that learners could easily move from one activity to another while receiving appropriate levels of support according to their progress. The overall design flow is illustrated in Figure 2.

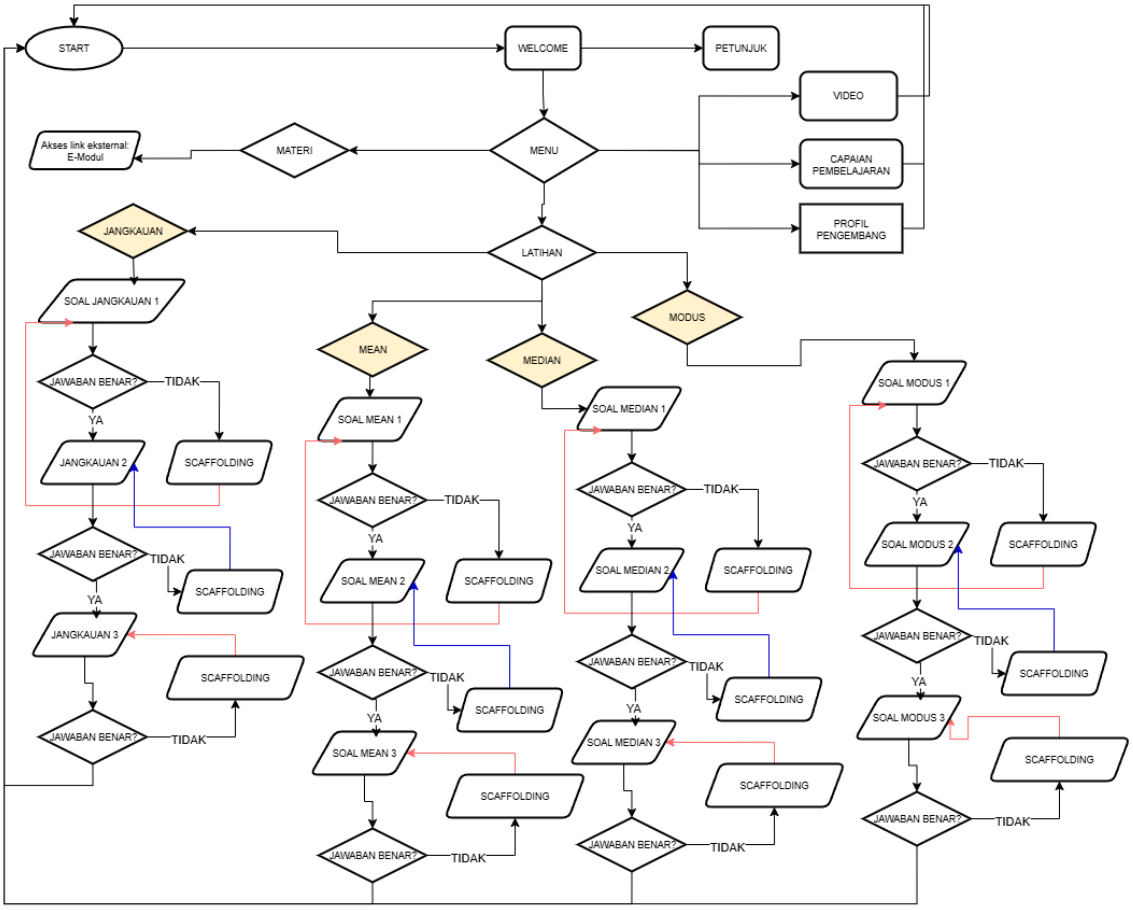


Figure 2. Flowchart of the interactive learning media as computer-based scaffolding

3.3 Develop Stage

The Develop stage focused on transforming the conceptual design into a fully functional digital product. The interactive learning media, named "Stafolding", were developed by integrating the principles of computer-based scaffolding into the instructional flow. These principles were operationalized through three key features: step-by-step guidance, which assists students in breaking down complex problems into manageable parts; automated feedback, which provides immediate responses and explanations to student actions; and interactive visualization, which facilitates the comprehension of abstract statistical concepts through engaging multimedia elements.

Once the initial prototype was completed, it was subjected to expert validation to ensure its quality and relevance. The validation process involved two material experts and two media experts, each evaluating different dimensions of the product. The material experts assessed the content alignment with curriculum objectives, the accuracy of statistical concepts, and the implementation of scaffolding principles within the instructional

sequence. Meanwhile, the media experts evaluated the visual presentation, navigation system, level of interactivity, and technical compatibility of the learning media across devices and platforms.

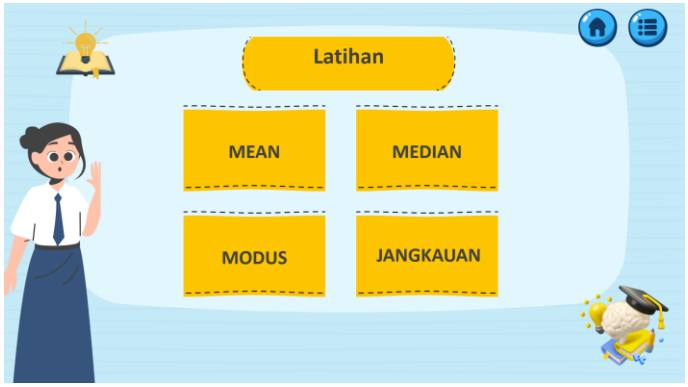
The feedback obtained from validators was used to revise and refine the product. Improvements included adjustments to the **layout**, **font size**, and **text arrangement** to enhance readability and communication clarity. The validation results indicated that the developed media met the expected quality standards and were ready to proceed to the implementation phase.

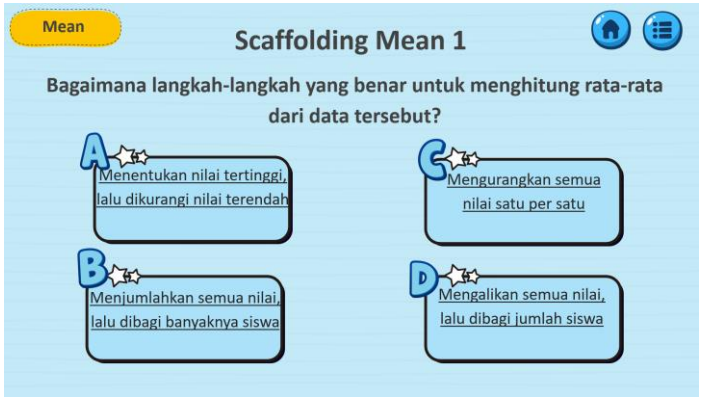
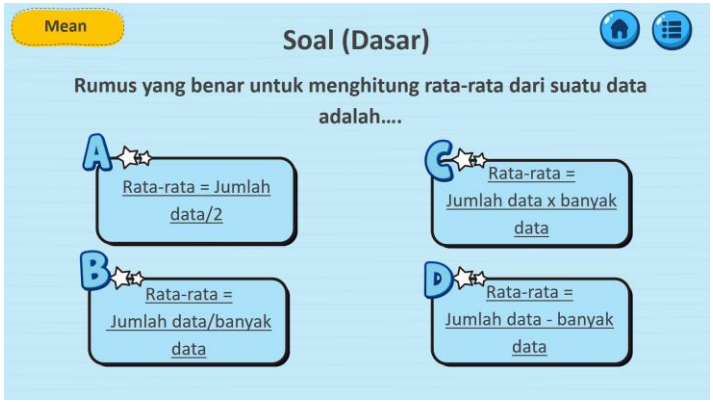
Table 3 presents the user interface of the "Stafolding" media, showing the main menu, learning material pages, and interactive exercise sections. Each component was carefully designed to promote an engaging learning experience while maintaining pedagogical consistency with the scaffolding approach.

Tabel 4. Several Interface of the "Stafolding" Interactive Learning Media

No.	Interface Display	Description
1.		Initial loading screen introducing the media
2.		Displays the *Welcome to Stafolding* greeting before entering the main menu.
3.		Provides usage guidelines for navigating and interacting with the media.

4.		Contains navigation buttons for accessing materials, exercises, and evaluations.
5.		Presents the identity and background of the media developer.
6.		Displays the learning outcomes in accordance with the curriculum.
7.		Lists subtopics of statistics materials included in the media.

8.		Presents a video-based explanation of statistical concepts.
9.		Provides access to practice problems for each subtopic.
10.		Contains problems related to calculating the mean.
11.		Displays a basic-level mean problem as the first challenge.

12		Shows feedback for correct responses and progression to the next level.
13		Provides redirection to scaffolding activities for easier guiding questions.
14		Ensures students understand how to determine the mean in a contextual problem.
15		Offers simpler guiding questions or the general formula for calculating the mean.

16		If the student answers incorrectly again, a learning video link appears for review.

3.4 Implement Stage

The Implement stage was conducted to test the practicality of the developed interactive learning media in an actual classroom setting. This stage aimed to determine how effectively the "Stafolding" media could be used by teachers and students during mathematics instruction. The implementation was carried out through a limited trial at SMP Negeri 1 Tibawa, involving one mathematics teacher and ten students as participants.

During the trial, the teacher acted as a facilitator, guiding the learning process and monitoring students' engagement, while students accessed and interacted with the media independently through their personal devices such as laptops or smartphones. The learning session was conducted in a computer-assisted learning environment, where students explored the materials, completed exercises, and received immediate feedback through the scaffolding features embedded in the media.

3.5 Evaluate Stage

The Evaluate stage was conducted to analyze the overall results of expert validation and practicality testing in order to determine the feasibility and effectiveness of the developed interactive learning media. This stage focused on presenting and interpreting the data obtained from both the validation and implementation processes. The evaluation served as the final phase of the ADDIE development cycle, ensuring that the media met the expected quality standards before being applied on a larger scale.

Data were analyzed using descriptive quantitative methods by calculating the mean percentage of each evaluation aspect and interpreting the results according to predetermined criteria. The analysis covered two main dimensions: feasibility, which included assessments by material and media experts, and practicality, which included teacher and student responses. The results are summarized in Table 5.

The results of the expert validation indicated that the **feasibility level** of the "Stafolding" media reached **91.11**% according to material experts and **93.33**% according to media experts. Both scores fall into the *excellent* category, demonstrating that the content

accuracy, conceptual relevance, visual quality, navigation structure, and integration of scaffolding principles were all of high quality.

Table 5. Summary of Validation and Practicality Results

Evaluation Aspect	Source of Data	Percentage (%)	Category
Feasibility – Content (Material Experts)	Expert Validation	91.11	Excellent
Feasibility – Media Design (Media Experts)	Expert Validation	93.33	Excellent
Practicality – Teacher Response	Implementation Test	92.00	Very Practical
Practicality – Student Response	Implementation Test	92.00	Very Practical

The practicality analysis also showed highly positive results, with both teachers and students giving an average score of 92%, categorized as very practical. These findings indicate that the media are user-friendly, easily accessible, and effectively support the teaching and learning process. Teachers reported that the media facilitated their role as facilitators in the classroom, while students found the digital scaffolding features helpful in understanding problem-solving procedures more independently.

Overall, the evaluation results confirmed that the "Stafolding" interactive learning media met both the feasibility and practicality criteria for use as a computer-based scaffolding tool in mathematics learning. The combination of structured guidance, interactive design, and instant feedback proved effective in supporting students' understanding of statistical concepts and enhancing their problem-solving abilities. The evaluation outcomes thus validate the success of the development process and provide a solid foundation for future implementation on a broader scale.

3.6 Discussion

The results of this study indicate that the "Stafolding" interactive learning media successfully met the criteria of feasibility and practicality as a computer-based scaffolding tool in mathematics learning. The integration of scaffolding principles—through features such as step-by-step guidance, automated feedback, and interactive exercises—proved effective in providing structured learning support that guided students through the problem-solving process. These features align with the essential components of scaffolding as described by Belland (2017), who emphasized that effective scaffolding involves the gradual release of responsibility from the teacher to the learner while maintaining cognitive support throughout the process.

The high feasibility scores obtained from material and media experts (91.11% and 93.33%, respectively) demonstrate that the developed media not only meet pedagogical and content accuracy standards but also achieve a high level of usability and technical

quality. The interactive interface, supported by visual explanations and contextualized examples, helped clarify abstract statistical concepts that are often challenging for students to grasp in conventional instruction. These findings are consistent with Kim et al. (2020), who found that computer-based scaffolding significantly improves students' engagement and achievement in STEM education by providing adaptive feedback and individualized support.

The practicality results, with an average of 92% from both teachers and students, further reinforce the effectiveness of the media in classroom implementation. Teachers reported that the "Stafolding" media facilitated their role in guiding students without requiring continuous direct supervision. This shift from a teacher-centered to a student-centered learning environment is particularly valuable in large classes, where the teacher-to-student ratio limits individualized assistance. Students also expressed positive perceptions of the media's ease of use, interactivity, and clarity of feedback, which contributed to their motivation and independence in learning. These results correspond with previous studies highlighting that e-scaffolding promotes conceptual understanding and encourages learners to engage in self-directed problem-solving[7][8].

Moreover, the incorporation of digital scaffolding through multimedia elements provided a dual advantage: enhancing students' conceptual understanding and catering to their digital learning preferences as members of the digital native generation. This is consistent with Damayanti et al. [13], who reported that students' engagement and comprehension improved significantly when mathematical content was presented through interactive digital media that aligned with their technological habits.

In the context of mathematics education, particularly in teaching statistics, these findings hold important pedagogical implications. The use of computer-based scaffolding media offers a sustainable solution to the limitations of traditional scaffolding practices, especially in settings with large class sizes and limited instructional time. By enabling independent exploration supported by adaptive guidance, "Stafolding" helps bridge the gap between teacher-led instruction and student-centered learning.

Overall, this study reinforces the growing body of evidence that technology-enhanced scaffolding can effectively support students' problem-solving development. The "Stafolding" media not only facilitate comprehension of statistical concepts but also foster students' autonomy, engagement, and confidence in mathematics learning. Future research may focus on expanding the implementation to broader contexts and exploring the long-term effects of computer-based scaffolding on students' higher-order thinking skills.

This study was limited to a small-scale implementation involving ten students; therefore, further large-scale studies are needed to examine the effectiveness of the Stafolding media across different topics and student groups.

4. Conclusion

This study resulted in the development of an interactive learning medium called "Stafolding", designed based on the principles of computer-based scaffolding and developed through the ADDIE model—comprising the stages of Analyze, Design, Develop, Implement, and Evaluate. The media were aimed at enhancing students' mathematical problem-solving ability in the topic of statistics.

The validation results from both material and media experts demonstrated high levels of feasibility, with average scores of 91.11% and 93.33%, respectively, categorized as excellent. Likewise, the practicality tests conducted with teachers and students each achieved an average score of 92%, categorized as very practical. These findings confirm that the developed media meet the required quality standards for effective use in mathematics learning.

The "Stafolding" media feature several key components that embody digital scaffolding principles, including step-by-step problem-solving guidance, automated feedback, and interactive exercises that allow students to learn progressively and independently. The results show that this digital scaffolding system provides effective learning support, enhances students' understanding of statistical concepts, and fosters independent learning behavior.

In conclusion, the developed computer-based scaffolding interactive learning media are feasible and practical to be used in mathematics learning, particularly in the teaching of statistics. The implementation of "Stafolding" offers an innovative and efficient alternative to conventional scaffolding practices, addressing challenges related to large class sizes and limited instructional time. Furthermore, the findings highlight the potential of technology-integrated scaffolding to enhance both learning outcomes and student engagement. Future studies are recommended to expand the scope of implementation and examine the media's impact on students' higher-order thinking and long-term learning retention.

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