Development of web-based learning multimedia to improve students understanding of mathematical concepts in elementary schools

Runniarsiti Runniarsiti*, Arismunandar Arismunandar, Farida Febriati

Universitas Negeri Makassar, Indonesia

Abstract: Rapid technological advances in education have increased student engagement, but some schools still struggle with optimal understanding of mathematical concepts, which impacts learning outcomes. The purpose of this study was to create and evaluate web-based learning multimedia that can improve students' understanding of mathematical concepts. We conducted research and development involving fourth-grade elementary school students. A small-scale trial with six students aimed to observe student responses to the use of web-based learning multimedia in mathematics. Meanwhile, large-scale trials were conducted in three elementary schools with a total of 69 students. Validation involved media and design experts as well as material experts. Data were analyzed quantitatively using percentages and the Wilcoxon test. Interview results revealed a conventional learning process with minimal student participation and limited use of technology. Students tended to be more interested in the use of interactive media, such as videos and images, in the learning process. The results of media validation showed a very good validity level (96.25%), and material validation also showed a very high validity level (90.1%). The measurement results showed that teachers and students responded well, with a percentage above 80%. It indicates that the web-based learning multimedia is very practical. Effectiveness analysis indicates that the developed product effectively improves elementary school students' understanding of mathematical concepts (sig. < 0.05). This study concludes that the developed product, namely web-based learning multimedia, meets the standards of validity, practicality, and effectiveness in improving elementary school students' understanding of mathematical concepts.

Keywords: Mathematics, media development, technology in learning, understanding

Abstrak: Kemajuan teknologi yang pesat dalam pendidikan telah meningkatkan keterlibatan siswa, tetapi beberapa sekolah masih berjuang dengan pemahaman konsep matematika yang optimal, yang berdampak pada hasil belajar. Tujuan dari penelitian ini adalah untuk membuat dan mengevaluasi multimedia pembelajaran berbasis web yang dapat meningkatkan pemahaman siswa terhadap konsep matematika. Kami melakukan penelitian dan pengembangan yang melibatkan siswa sekolah dasar kelas empat. Uji coba skala kecil dengan enam siswa bertujuan untuk mengamati respons siswa terhadap penggunaan multimedia pembelajaran berbasis web dalam matematika. Sementara itu, uji coba skala besar dilakukan di tiga Sekolah dasar dengan total siswa sebanyak 69. Validasi melibatkan ahli media dan desain serta ahli materi. Data dianalisis secara kuantitatif menggunakan persentase dan uji Wilcoxon. Hasil wawancara mengungkapkan proses pembelajaran konvensional dengan partisipasi siswa yang minimal dan penggunaan teknologi yang terbatas. Siswa cenderung lebih tertarik pada penggunaan media interaktif, seperti video dan gambar, dalam proses pembelajaran. Hasil validasi media menunjukkan tingkat validitas yang sangat baik (96,25%), dan validasi materi juga menunjukkan tingkat validitas yang sangat tinggi (90,1%). Hasil pengukuran menunjukkan bahwa guru dan siswa merespons dengan baik, dengan persentase di atas 80%. Hal ini menunjukkan bahwa multimedia pembelajaran berbasis web sangat praktis. Analisis efektivitas menunjukkan bahwa produk yang dikembangkan efektif meningkatkan pemahaman konsep matematika siswa sekolah dasar (sig. < 0,05). Penelitian ini menyimpulkan bahwa produk yang dikembangkan, yaitu multimedia pembelajaran berbasis web, memenuhi standar validitas, kepraktisan, dan efektivitas dalam meningkatkan pemahaman konsep matematika siswa sekolah dasar.

Kata kunci: Matematika, pengembangan media, teknologi dalam pembelajaran, pemahaman

INTRODUCTION

Improving and equitable education quality is a major challenge in education development in Indonesia. The Indonesian government has taken various steps to improve education quality, from upgrading educational infrastructure and providing adequate facilities to enhancing teaching quality through teacher competency development programs (Elpina et al., 2021; Nurdina, 2021). These efforts align with the achievement of the Sustainable Development Goals (SDGs), particularly those related to quality education. One of the SDG targets for 2030 is to provide inclusive and quality education and increase lifelong learning opportunities for all (Lane et al., 2023; Mika, 2017; Shulla et al., 2020).

In the 21st century, developments in information and communication technology (ICT) have influenced previously conventional learning paradigms (Dita et al., 2023; Mustofa et al., 2024). Technology has now become an integral part of the modern education system, not only introducing new concepts but also facilitating more efficient collaborative interactions (Amir et al., 2025; Pokhrel & Pokhrel, 2025; Salsabila & Suharto, 2025). This aligns with the principles of the Merdeka curriculum, which prioritizes technology-based learning (Arianti et al., 2023; Fatmawati, 2024). The Merdeka curriculum requires the use of technology in learning, emphasizing a learner-centered approach, where teachers function as facilitators who support student development and learning progress (Ningsih & Sari, 2024). In this regard, the use of technology in mathematics learning plays a crucial role in enhancing students' understanding of difficult concepts.

Although technology is readily available in many schools, including LCDs and smart TVs, its use in mathematics classrooms remains limited. Observations at several elementary schools in Makassar City revealed that despite the availability of supporting facilities, the use of these technologies in mathematics learning remains minimal. This indicates a gap between available technology and its utilization in learning. Therefore, developing web-based multimedia learning for mathematics is crucial to optimize existing technology to enhance students' understanding of the subject matter.

The development of web-based learning multimedia for mathematics subjects in elementary schools is very relevant and important to improve the quality of education, especially at the elementary school level (Lisnani et al., 2023; Suchyadi, 2022). Lisnani's (2023) study showed positive student responses, familiarity with mathematics learning using websites, and the achievement of fourth-grade elementary school students' learning outcomes, and has the potential to have a positive impact on improving 21st-century skills and understanding of geometry, measurement, and numbers. The research highlights the potential of web-based multimedia in improving students' learning outcomes, particularly in mathematics, contributing to the growing knowledge in educational technology (Satriani & Prasojo, 2024).

Multimedia is a technology-based educational tool that enhances teaching and learning experiences (Prasojo & Wibowo, 2014). It combines various media formats like symbols, images, text, audio, video, and animation to enhance students' comprehension and retention (Guan et al., 2018). Multimedia can be presented using computers or digital devices, and various forms of learning multimedia, including website-based multimedia (Satriani & Prasojo, 2024). Sabirova et al. (2019) examined the effectiveness of a web-based interactive educational platform called UCHI.ru in teaching mathematics to elementary school students aged 8-9 years. The platform tested, observed, and analyzed the educational

process, revealing its features, potential problem areas, and benefits. The platform increased student motivation, facilitated the development of search competencies, and addressed fundamental knowledge gaps.

Based on several research findings, it can be said that the use of multimedia websites has advantages for elementary school student learning. Suripah and Susanti (2022) research revealed that motivation to learn mathematics is high, with websites that offer various benefits. The optimization of a Website-Based Digital can significantly decrease the time and effort required by teachers in their preparation for learning (Sutisna et al., 2021). Thus, it is necessary to develop website-based multimedia to help improve students' mathematics concepts, especially in elementary schools. The purpose of this study was to create and evaluate web-based learning multimedia that can improve students' understanding of mathematical concepts.

METHOD

Web-based learning multimedia was developed to improve students' understanding of mathematical concepts and serve as additional teaching materials for teachers. This learning multimedia can be accessed directly through a website link, making it easy for users to access it anywhere and anytime. This research is a type of research and development. The research stages begin with: (1) needs analysis consisting of problem identification, literature review, identifying necessary resources, task analysis, and student analysis; (2) multimedia design; (3) development consisting of the development, production, and validation processes; (4) implementation; and (5) evaluation. The research was conducted in three elementary schools in Makassar City, each referred to as School A, B, and C in this research.

A small-scale trial with 6 students aimed to observe student responses to the use of web-based learning multimedia in mathematics. Meanwhile, a large-scale trial at School A with 25 students, School B with 25 students, and School C with 19 students.

Data collection used: (1) a questionnaire consisting of a needs identification questionnaire, a validation questionnaire, and a student response questionnaire; and (2) a test. Media and design experts assessed media quality, design, usability, and utilization, while content experts assessed learning material, learning content, and completeness, accuracy, and meaningfulness. Teacher and student responses were measured based on three aspects: the appearance of the learning multimedia (9 statements), the material (5 statements), and the use of the learning multimedia (5 statements).

Table 1. Validity and practicality criteria

Interval	Valid Criteria	Practical Criteria
81%-100%	Very Valid	Very Practical
61%-80%	Valid	Practical
41%-60%	Quite Valid	Quite Practical
21%-40%	Less Valid	Less Practical
0%-20%	Very Less Valid	Very Less Practical

(Source: Wijaya et al., 2021)

Validity data analysis was then categorized based on percentage intervals in Table 1. Products deemed valid by the experts were then piloted with students to measure their

practicality and effectiveness. Practicality criteria are presented in Table 1. Meanwhile, the effectiveness analysis of web-based multimedia used the Wilcoxon test, but first tested for data normality.

RESULTS AND DISCUSSION

The process of creating web-based learning multimedia to improve students' understanding of mathematics concepts begins with an analysis of students' needs for fourth-grade learning content. The needs analysis stage involves analytical steps such as student analysis, task analysis, concept analysis, and learning objective analysis. This stage begins with data collection through interviews with teachers at several elementary schools in the area. The interview results indicate that the learning process is still carried out conventionally, where students are less active and the use of technology is very limited. Many teachers are not yet familiar with the use of multimedia software that can help improve students' understanding of the material being taught. Infrastructure such as computers and projectors are already available, but have not been utilized optimally. The activity continued with an analysis of students to determine their characteristics and preferences in learning. Based on the analysis results, students tend to be more interested in the use of interactive media, such as videos and images, in the learning process. Therefore, it is necessary to develop web-based learning multimedia that can facilitate more interesting and interactive learning. Next, a task analysis is conducted to determine the material to be delivered, which in this case focuses on mathematics material for fourth grade. The material to be developed includes various topics, such as numbers, arithmetic operations, geometry, and others, which are arranged in accordance with the applicable curriculum and basic competencies.

The development of learning multimedia is carried out by first identifying student characteristics through a learning needs analysis. The results of the needs questionnaire indicate that the majority of students have a high interest in learning multimedia that presents a variety of content such as text, images, audio, and educational videos. They are attracted because the diversity of media makes the learning process more interactive, engaging, and easy to understand (Shahzad et al., 2021; Tawil & Dahlan, 2021). Furthermore, students stated that the use of learning multimedia in mathematics is highly relevant and effective in supporting the learning process in the classroom. This demonstrates strong support for technology integration in mathematics education. Students' interest in learning will increase if the material is presented in the form of interactive multimedia, because this format is considered more effective and is able to attract students' attention optimally (Amelia & Harahap, 2021; Anwar et al., 2019; Primamukti & Farozin, 2018).

In the design phase, the design process focuses on designing and formulating the multimedia learning product to be used in the research. The goal of the design phase is to determine appropriate media for the learning material, thereby effectively supporting the achievement of learning objectives. The Canva and CapCut applications were used to design the multimedia learning product. Before the development process began, this phase also included the formulation of learning objectives, the creation of a storyboard (Figure 1), and the development of a prototype that would serve as a reference in the subsequent development phase.
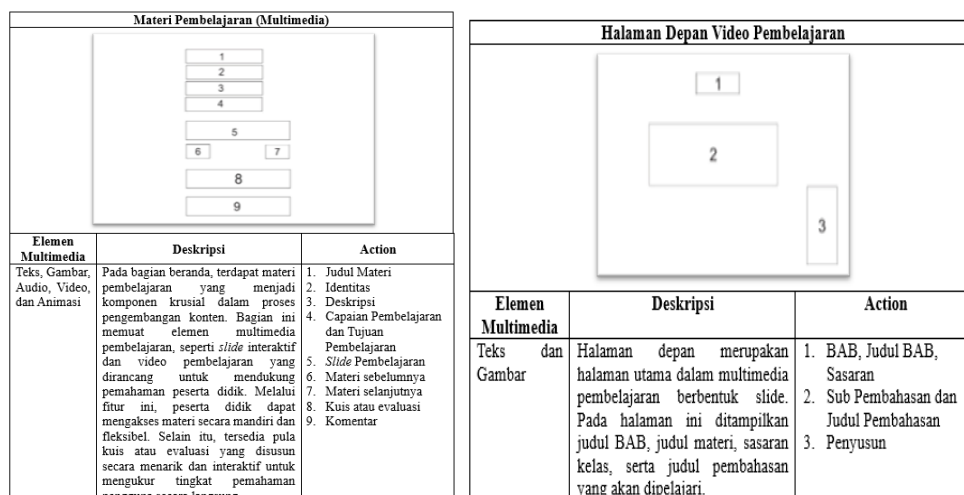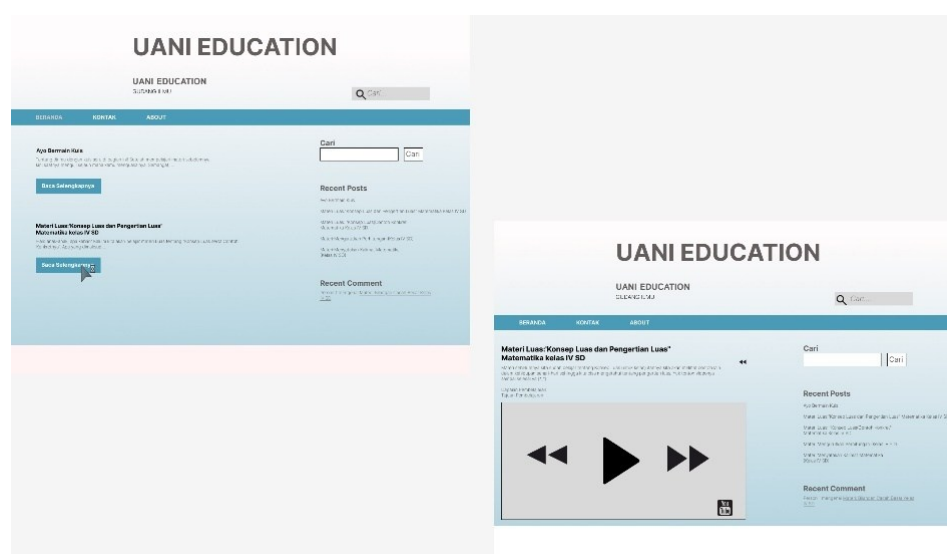
Fig. 1. Storyboard example

Fig. 2. Learning multimedia prototype

The prototype design (Figure 2) of the web-based learning multimedia shows that the website has three main sections: homepage, contact, and about. The homepage is the key to the learning multimedia because this is where the learning content is available. When users click "read more," the learning multimedia in the form of interactive slides, learning videos, and quizzes will appear. In addition, the Uani Education website also provides student testimonials, a contact page for questions, and an about page containing profiles and the development team. The website is built using WordPress with a responsive theme and plugins such as H5P, YouTube Embed, and Elementor, with special attention to accessibility and user data security to support an optimal learning experience across devices. Elementary school students show high interest in mathematics learning due to varied media, including Wordprees, which offers various video lessons and online class discussions (Fitriyah & Rindaningsih, 2023).
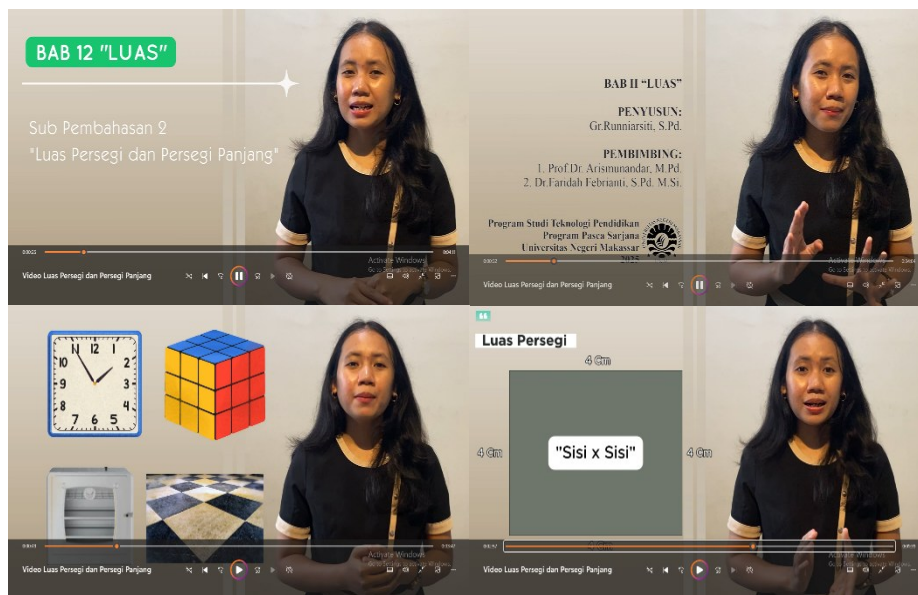
Fig. 3. Slideshow of learning materials

Fig. 4. Learning video display

The learning video (Figure 4) was created using the CapCut application, which is designed to help students understand mathematical concepts visually and interactively. After the slides and learning video were developed, both were then uploaded to a website created using the WordPress application (see Figure 5). The website's appearance consists of a main menu (Home), contact, and about sections. In addition, learning materials include descriptions, learning outcomes, learning objectives, core material, quizzes, and other features to support the learning process.
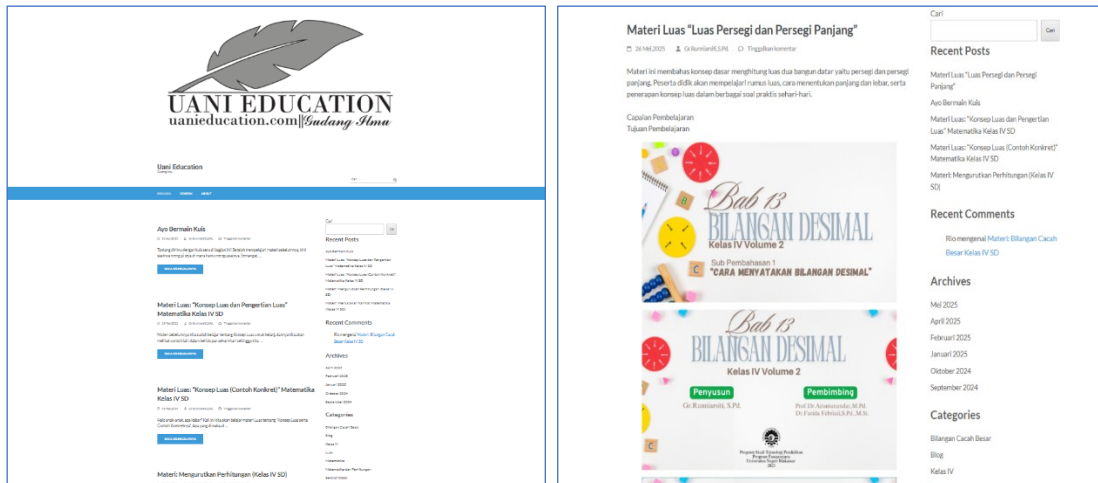
Fig. 5. Homepage view and content on the website

The development of multimedia learning is carried out by designing engaging and varied elements to enrich students' learning experiences. The multimedia design includes an attractive color combination to create a pleasant and engaging atmosphere for students. Furthermore, the learning materials are structured clearly and systematically for easy understanding. In this multimedia content, the photos and images provided are carefully selected and tailored to the subject matter, particularly when discussing mathematical concepts. The goal is to provide illustrations that clarify the concepts being taught and facilitate student understanding.

The use of images in materials (see Figure 3) can help students express the information contained in a material, allowing for a clearer understanding of the relationships between various components. Research indicates that optimally managed image media can enhance student enthusiasm and improve mathematics learning concepts, fostering a positive learning environment and fostering curiosity (Khuluq et al., 2024). Additionally, this multimedia is equipped with audio features to support the learning material, such as verbal explanations or relevant recordings (see Figure 4). This aims to deepen students' understanding of the material presented through direct listening. Furthermore, there are also learning videos that aim to provide students with a deeper understanding. Learning using video media tends to make it easier for students to remember and understand the lesson because it doesn't involve a single sense. (Ellyana & Tegeh, 2023). Learning videos aim to help convey educational messages effectively, thereby providing more efficient understanding to students (Burga et al., 2025; Qurrotaini et al., 2020). The use of video media in learning activities can attract students' attention, foster curiosity, and increase their learning motivation.

These learning videos are obtained from trusted sources, namely educators with expertise and knowledge relevant to the subject matter being taught. With these learning videos, it is hoped that students will gain a better and more comprehensive understanding of the material being studied. The website that has been developed is then validated by experts (Table 2). To determine the validity of the developed learning multimedia, a product validation process is conducted. Validation aims to obtain constructive feedback, suggestions, and criticism regarding the multimedia so that it can be improved and

therefore suitable for testing on research subjects. This validation consists of media validation and material validation.

Table 2. Validation results

Validator	Validation Aspects	%	Average (%)
Media and Design	Media	100	96.25
	Design	90	
	Usability	95	
	Utilization	100	
Learning Material	Learning	92	90.1
	Content	97	
	Completeness, Accuracy, and Meaningfulness	93.3	

The media validation results (Table 2) showed an excellent level of validity with several assessed aspects, namely media, design, and utilization. In the media aspect, the assessment included the suitability of multimedia to student characteristics, the selection of appropriate font types and sizes, and clear and comfortable color contrast. In the design aspect, the clarity of the program identity, ease of use, the display of images and videos that match the material, and the harmonious proportion of colors and visual elements were assessed. In line with this, Pradita et al. (2024) stated that effective digital-based learning design can significantly improve student learning outcomes. Furthermore, Meliyani and Tirtayani (2022) emphasized that the compatibility between mutually supporting text and images, attractive visual aesthetics, and clear dubbing and sound effects can stimulate student learning interest, thus positively impacting their learning outcomes. In terms of usability, multimedia was assessed as easy to understand and easy to access, and the navigation buttons functioned well and supported the learning process optimally. Setyantoko et al. (2023) stated that learning media that have an attractive appearance, complete navigation, real interactive effects, and good video quality can motivate students and improve improve student learning comprehension.

The results of the material validation (Table 2) also showed highly valid results with high levels of learning, content, completeness, precision, and meaningfulness. The multimedia material was tailored to the learning objectives and student characteristics, using easy-to-understand communicative language, and designed to be engaging, thus motivating and stimulating students to understand the material and facilitating the achievement of learning objectives. The development of learning multimedia must consider the suitability of the material to basic competencies, indicators, and learning objectives, the validity of the concepts and theories used, and grammar that is appropriate to the characteristics of students to create appropriate and effective media for use (Meliyani & Tirtayani, 2022).

Based on the media and material validation results, the developed learning multimedia was declared highly valid and suitable for use in the learning process, particularly in mathematics. According to Dita et al. (2023), and Setyantoko et al. (2023), the product, validated by the validator, can be applied in trials, for example, with small groups. Table 3 shows the results of the trial in small groups.

Table 3. Results of small group trials

Respondents	Ideal Percentage (%)	Criteria
S1	85.6	Very Practical
S2	81.1	Very Practical
S3	75.6	Practical
S4	91.1	Very Practical
S5	82.2	Very Practical
S6	86.7	Very Practical
Average	83.7	Very Practical

Based on the results of the small group trial data analysis, it can be concluded that web-based learning multimedia in mathematics subjects is considered very practical by the majority of respondents. Of the six respondents involved, five of them gave an assessment with the criteria "very practical", while one respondent gave an assessment "practical". The percentage of ideality given by respondents ranged from 75.6% to 91.1%, with an overall average reaching 83.7%. This indicates that in general, students feel that the use of this learning multimedia facilitates the teaching and learning process. Thus, it can be concluded that this web-based learning multimedia is worthy of being implemented as an effective learning aid, because it provides convenience and attracts students' interest. Further analysis on practicality testing in large groups (Figure 6).
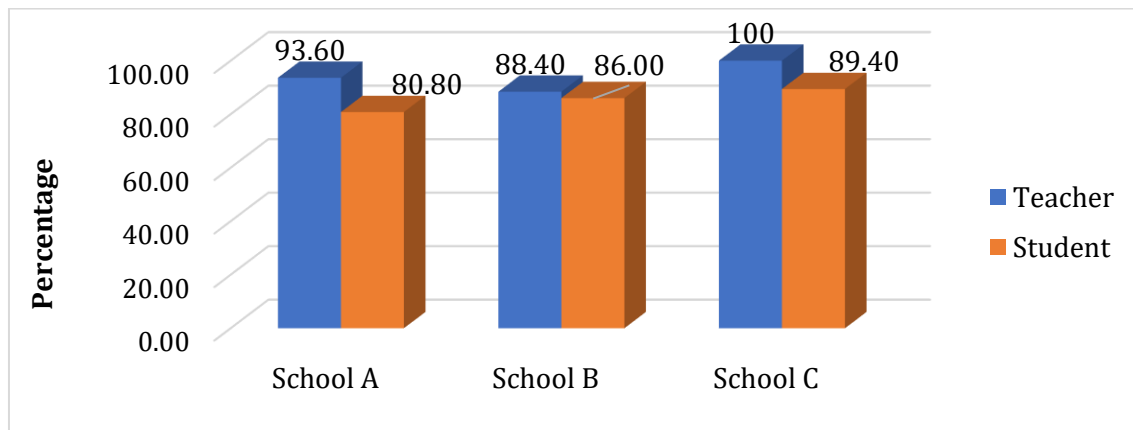

Fig. 6. Student and teacher respons

The practicality test was conducted by administering a questionnaire to teachers and students. The purpose of this test was to determine how teachers and students responded to the use of multimedia learning. The measurement results showed that teachers responded well, with a percentage above 80%. This indicates that web-based multimedia is highly practical. The teacher response questionnaire assessed aspects such as the attractive and organized multimedia display, the appropriateness of the display, fonts, and colors used. The content was easy to understand, the use of multimedia was seamless, and the instructions were clear. The material presented aligned with the learning objectives and was able to attract students' interest. The practice questions provided could be used both inside and outside the classroom. The choice of words and sentences was structured in easy-to-understand language. The integrated learning videos strengthened students'

understanding. Each activity in the multimedia had an appropriate purpose, varied media types, enriched knowledge, and facilitated understanding and mastery of the material. This learning multimedia was also deemed capable of attracting students' attention, easy to use, and effective in the learning process. Learning multimedia is highly sought after for its ability to present images, audio, and video, enriching the learning experience by providing a more concrete and visual context (Hadi et al., 2022; Rajendra & Sudana, 2018).

In the student response questionnaire, the assessment covered aspects of multimedia display, the material presented, and interest in and use of learning multimedia. In terms of display, students provided responses related to visual aesthetics, clarity of images, writing, and color combinations used. They also assessed the quality and relevance of the material presented, such as its suitability to learning needs and the use of easy-to-understand language. Aspects of interest in and use of learning multimedia included students' level of interest in learning through digital media, their level of motivation in using learning multimedia as a learning resource, and factors influencing their desire to utilize it effectively in their daily learning process. The results in Figure 6 show that web-based multimedia is very practical with a student response percentage above 80%. Therefore, learning multimedia is not only visually appealing, but also facilitates the independent learning process, while increasing students' motivation and overall learning outcomes (Churiyah et al., 2021; Silalahi et al., 2018).

Dita et al. (2023) revealed that the availability of learning multimedia in the learning context has great potential to increase students' interest and enthusiasm in understanding certain topics or materials. Yani's (2024) research results show that the website is very practical, with an average response rate of 82.50 from user members, which indicates a high level of user satisfaction. The presence of learning multimedia with an interactive interface provides a more interesting and engaging learning experience for students. This advantage not only makes them more interested in engaging in learning but also encourages their enthusiasm and motivation to dig deeper into the learning process. Based on the results of the teacher and student response questionnaire that has been conducted, the developed learning multimedia is declared very practical and suitable for use in the learning process, especially in mathematics subjects.

Table 4. Results of data normality test

School	Shapiro Wilk		
	Statistic	N	Sig.
School A			
Pretest	0.944	25	0.184
Posttes	0.766	25	0.001
School B			
Pretest	0.894	25	0.014
Posttes	0.762	25	0.001
School C			
Pretest	0.923	19	0.130
Posttest	0.881	19	0.023

The results of the normality test in Table 4 show that only the pretests from School A and School C met data normality. Other data showed abnormalities, so further analysis used non-parametric analysis using the Wilcoxon test.

Table 5. Wilcoxon test results

School	Data	N	Mean	Z	*Sig.*
A	Pretest	25	58.4	-3.090	0.002
	Posttest	25	78.8		
B	Pretest	25	61.6	-4.315	0.001
	Posttest	25	86.4		
C	Pretest	19	50	-3844	0.001
	Posttest	19	82.63		

The analysis results in Table 5 show that the use of web-based multimedia can improve elementary school students' mathematics concepts. This improvement in student mathematical concepts is influenced by the use of websites equipped with learning media such as images and videos, which facilitate understanding and provide high learning motivation due to the engaging and innovative multimedia features available.

Web-based multimedia learning makes a significant contribution to strengthening and implementing various modern learning theories. First, in accordance with constructivism theory, this multimedia allows students to actively construct knowledge through interaction with rich, contextual content, making the learning process more meaningful and personalized. Second, based on the theory of multiple intelligences, the use of web-based multimedia supports various styles and types of student intelligence, such as visual-spatial, kinesthetic, and interpersonal intelligence, making learning more inclusive and adaptive to individual needs.

The use of multimedia in learning can significantly increase students' learning motivation (Aziz et al., 2024; Rahayu et al., 2024). The right media makes students more interested and enthusiastic in participating in learning, so that the learning process becomes more effective and enjoyable, such as the use of multimedia learning. Web-based learning multimedia significantly increases students' motivation and understanding mathematical concepts (Etyarisky & Marsigit, 2022; Irmawan et al., 2022), where changes in students' learning outcomes are significantly influenced by motivation (Yen et al., 2011) and teacher creativity (Yurida et al., 2021), especially for elementary school students (Nasir et al., 2023). When students are motivated, they are more enthusiastic and active in the learning process, significantly improving their academic achievement and understanding of the material. Website-based multimedia is a creative product created by teachers to motivate and engage their students. This, in turn, leads to improved students' mathematics concepts.

The advantages of the developed web-based learning multimedia are as follows.
1. The website contains learning multimedia with diverse material on fourth-grade mathematics. This multimedia is tailored to the material and students' needs.
2. Interactive quizzes are available that allow students to test their understanding after studying the material. This feature supports immediate feedback-based learning and increases student engagement.

3. The multimedia is designed responsively, allowing it to be accessed easily through various devices such as computers, tablets, and smartphones. This makes it easy for students to learn anytime and anywhere.
4. The material is structured to support independent learning, allowing students to learn at their own pace and learning style.
5. The simple, child-friendly interface design makes website navigation easy and enjoyable for students.

Despite the various advantages of the web-based multimedia learning that has been developed, there are also some disadvantages, namely:
1. Access to materials and quizzes requires a stable internet connection. This can be a challenge for students in areas with limited internet access.
2. Use of computers, tablets, and smartphones. Digital books can be accessed using electronic devices. If students do not have one of these devices, they cannot learn using the digital books.
3. Although there are interactive quizzes, this website may not yet provide advanced interactivity features such as simulations or educational games that can further enhance understanding of mathematical concepts.
4. Currently, the available materials are only for fourth grade. There are no materials for other grades, limiting the use of this website to certain educational levels.
5. Although the user interface is child-friendly, the website's visual design is quite simple and may be less appealing to students who prefer more dynamic and modern design elements.

The process of developing learning multimedia faces several obstacles, particularly during the video and image editing stage, which requires supporting elements to ensure students understand the learning material properly. One of the main challenges is finding the right visual and audio elements that are appropriate for the material to be used as multimedia content. This process often involves searching for these elements online, paying attention to copyright, and then editing them independently using applications such as Corel Draw, Photoshop, and Canva to adapt them to learning needs.

CONCLUSION

This study concludes that the developed product, namely web-based learning multimedia, meets the standards of validity, practicality, and effectiveness in improving elementary school students' understanding of mathematical concepts. The validator has given a very valid assessment. Student and teacher responses indicate that web-based learning multimedia is very practical to use in teaching and learning. It is also effective in improving the understanding of mathematical concepts of fourth grade elementary school students. This study recommends that future research can measure other variables to calculate the effectiveness of web-based learning multimedia. The relationship between motivation and conceptual understanding in the use of this product was not measured, so this needs further testing.

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