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PMRI-Based Interactive Learning Video on Counting Operations of Numbers in Mathematics at Elementary School

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ABSTRAK

Pembelajaran matematika di sekolah dasar masih menghadapi kendala dalam memahami operasi hitung bilangan cacah yang bersifat abstrak. Kurangnya media pembelajaran interaktif menyebabkan rendahnya pemahaman siswa. Penelitian ini bertujuan mengembangkan, menguji kelayakan, dan mengukur efektivitas video pembelajaran interaktif berbasis Pendidikan Matematika Realistik Indonesia (PMRI) dengan metode Research and Development (R&D) model ADDIE. Subjek penelitian melibatkan tiga ahli dan 14 siswa kelas III SD. Data dikumpulkan melalui observasi, wawancara, angket validasi, dan tes hasil belajar, dianalisis secara deskriptif kualitatif, kuantitatif, serta uji-t satu sampel. Hasil validasi menunjukkan kelayakan sangat baik (materi 93,18%, desain 94,44%, media 95,83%). Respons siswa juga sangat positif (perorangan 96,97%, kelompok kecil 92,93%). Uji efektivitas menunjukkan produk video pembelajaran interaktif berbasis PMRI, efektif diimplementasikan dalam pembelajaran. Implikasi penelitian ini menunjukkan bahwa video berbasis PMRI dapat meningkatkan pemahaman siswa terhadap operasi hitung bilangan cacah serta menjadi alternatif inovatif dalam pembelajaran matematika. Selain itu, media ini dapat meningkatkan motivasi dan hasil belajar siswa secara signifikan. Guru disarankan memanfaatkan teknologi sebagai strategi pembelajaran yang lebih efektif dan menarik bagi siswa.

ABSTRACT

Mathematics learning in elementary schools still faces obstacles in understanding abstract whole numbers of arithmetic operations. The lack of interactive learning media causes low student understanding. This study aims to develop, test the feasibility, and measure the effectiveness of interactive learning videos based on Indonesian Realistic Mathematics Education (PMRI) with the Research and Development (R&D) method of the ADDIE model. The subjects of the study involved three experts and 14 grade III elementary school students. Data were collected through observation, interviews, validation questionnaires, and learning outcome tests and analyzed descriptively, qualitatively, quantitatively, and through one-sample t-tests. The validation results showed excellent feasibility (material 93.18%, design 94.44%, media 95.83%). Student responses were also very positive (individual 96.97%, small group 92.93%). The effectiveness test showed that interactive learning video products based on PMRI were effectively implemented in learning. The implications of this study indicate that PMRI-based videos can improve students' understanding of a whole number of arithmetic operations and become an innovative alternative in mathematics learning. In addition, this media can significantly increase student motivation and learning outcomes. Teachers are advised to utilize technology as a more effective and engaging student learning strategy.

1. INTRODUCTION

Education is the main pillar in building high quality and competitive human resources. The main purpose of education is to develop the potential of students to become capable, creative, independent, and responsible individuals. Education holds an obligation as well as an important task that cannot be separated from life and the surrounding environment because of its absolute nature (Anzelina & Tamba, 2020; Rasyid et al., 2020) . In the era of globalization, which increasingly demands science and technology-based competencies, mathematics education is a very important aspect in shaping the ability to think logically, systematically, and analytically. Mathematics not only acts as a tool to complete calculations, but also builds a mindset that can be used in various aspects of life (Wahyudi et al., 2021; Wali et al., 2020) . However, in practice, mathematics is still one of the most difficult subjects for students to understand, especially at the elementary school level. Difficulties in understanding abstract mathematical concepts often lead to low

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student learning outcomes and decreased motivation in learning this subject (Bayu & Wibawa, 2021; Wandira & Fasha, 2022) .

The abstract nature of mathematics is a major challenge in learning, especially for elementary students who are still in the concrete thinking stage according to Piaget's cognitive development theory. Mathematical concepts, such as integers and counting operations, cannot be observed directly as in the natural sciences, but must be understood through symbolic representations. This difficulty is exacerbated by a learning approach that is still dominated by the lecture method which tends to be one-way (Dara Asshofi et al., 2019; Misla & Mawardi, 2020; Utari et al., 2019) . As a result, many students are unable to understand the connection between mathematical concepts and their daily lives, which leads to low concept understanding and learning outcomes. The lack of use of learning media that supports concrete understanding can hinder students in building deeper mathematical concepts (Saparbayeva et al., 2024; Sukardjo & Salam, 2020) .

At SD Negeri 3 Selat, learning mathematics on the material of counting operations of small numbers still faces various obstacles. Based on the observation, the learning method is still dominated by lectures and only based on textbooks without any variation in the delivery of the material. As a result, many students have difficulty in understanding the basic concepts of counting numbers conceptually and applicatively. This can be seen from the average student learning outcomes which only reached 60.71, categorized in the "less" level based on the Benchmark Assessment (PAP) scale of 5. In addition, as many as 9 out of 30 students have not reached the Minimum Completion Criteria (KKM) of 63, which indicates that most students still experience obstacles in understanding the counting operations of small numbers. This condition is further exacerbated by students' low interest in learning due to the lack of use of innovative and contextual learning media.

Various studies have shown that the use of innovative technology-based learning media can improve learners' understanding and engagement in learning mathematics. Related research confirms that visual and interactive media are more effective in helping learners understand abstract concepts than conventional methods that only rely on oral explanations and practice problems (Balqis & Raksun, 2024; Nicolaou et al., 2019) . One innovation that has proven effective is the use of interactive learning videos that allow students to not only passively receive information but also actively participate in the learning process. Other studies have also found that video-based media can provide a learning experience that is more interesting, concrete, and easily understood by students (Irawan et al., 2023; Lapitan et al., 2021) . With attractive visual displays and animations, learning videos can reduce students' cognitive load in understanding abstract mathematical concepts.

In addition to innovations in learning media, the approach used in delivering material is also very influential on student understanding. Indonesian Realistic Mathematics Education (PMRI) is one of the learning strategies that has been proven effective in improving students' understanding of mathematical concepts (Hanifah et al., 2019; Refiesta, 2021) . PMRI emphasizes contextual learning that connects mathematical material with students' real experiences, so that they can understand concepts more meaningfully (Marhamah et al., 2024; Munawaroh & Hadi, 2024) . In PMRI, students are invited to discover and understand mathematical concepts through the exploration of everyday problems that are relevant to their lives. Findings in other studies also state that this approach not only improves students' understanding but also fosters a positive attitude towards mathematics, which in turn can increase their learning motivation (Hanaris, 2023; Hanifah et al., 2019) .

Although there have been many studies that develop PMRI-based learning media, its application in the form of interactive learning videos is still very limited, especially for counting operation materials in grade III SD. Related research on the development of PMRI-based learning videos on counting operations for grade II SD shows positive results with very high validity and good student responses (Nanda & Simamora, 2022) . However, the research was only limited to grade II SD and did not include a comprehensive coverage of counting operations, such as addition, subtraction, multiplication, and division in one unit of learning media. The next research that developed digital snakes and ladders learning media based on QR codes for multiplication material for class III elementary school with the Realistic Mathematics Education (RME) approach, but the media developed was not in the form of interactive learning videos (Dynawantika et al., 2023) . The next research in line shows that the development of PMRI-based e-books on whole number multiplication material for grade V SD is very valid and practical to use, but the media developed is still in the form of e-books, not interactive learning videos (Fransiska et al., 2022) . Therefore, this research becomes very important to fill the gap by developing PMRI-based interactive learning videos that not only introduce the concept of integers systematically but also include the four counting operations in an integrated manner to be more effective in improving students' understanding.

The urgency of this research is increasingly evident considering that the low achievement of student learning outcomes in counting operations of numerical numbers indicates that the learning methods used today are not effective enough. A more innovative and contextual approach is needed so that students can more easily understand abstract concepts in mathematics. PMRI-based interactive learning videos are a relevant solution to make learning more interesting, interactive and easy to understand. In line with technological developments and educational policies that increasingly encourage the digitization of learning, the development of digital-based media is an urgent need to improve the effectiveness of learning in elementary schools. In addition, based on the results of previous research, the use of interactive video media has been proven to be able to significantly improve student learning outcomes (Diah Purnami Dewi & Wayan Suniasih, 2022; Suantiani & Wiarta, 2022) . Thus, the development of PMRI-based learning videos is expected to make a major contribution in improving the effectiveness of mathematics learning, especially on the material

of counting operations of small numbers in grade III SD Negeri 3 Selat.

This research offers novelty in several aspects. The learning video developed is PMRI-based by emphasizing a contextual approach that relates mathematical concepts to students' daily lives to make it easier to understand. The video is designed using Canva application that allows the integration of various visual and audio elements in an interactive way to create a more interesting learning experience. In addition, this video does not only cover one type of counting operation but also covers all basic operations in integers, namely addition, subtraction, multiplication, and division, in one systematic and integrated learning media.

This research aims to develop an interactive learning video based on PMRI as a learning media in counting operations for class III SD Negeri 3 Selat, assess its feasibility and analyze its effectiveness in improving student learning outcomes. In the future, the results of this study are expected to be a reference for educators in developing other digital-based learning media, especially in mathematics subjects at the elementary level. In addition, this media can also be adapted for other materials that require a contextual and interactive approach. With the development of technology and the increasing need for innovative learning media, the results of this research can also be used as a basis for the development of similar media with a wider scope. Thus, this research not only contributes to improving the quality of learning at SD Negeri 3 Selat, but can also be a model for other schools in implementing innovative and effective technology-based learning.

2. METHOD

This study uses a research and development (R&D) approach that aims to produce a product in the form of an interactive learning video based on Indonesian Realistic Mathematics Education (PMRI) that is valid and effective in improving student learning outcomes on the material of counting operations of small numbers. This approach is used because it allows researchers to develop learning media that suits the needs of students and test its feasibility and effectiveness in learning. The research model used in this research is the ADDIE development model *(Analysis, Design, Development, Implementation, and Evaluation* (Rustandi & Rismayanti, 2021; H. R. Setiawan et al., 2021) . This model was chosen because it has systematic stages in the development of learning products, starting from analyzing needs to evaluating the effectiveness of the products developed (Sulistyawati et al., 2022; Widiarta et al., 2024) . The research stages start from the analysis stage which includes subject analysis, learner characteristics, media needs and content needs. After that, proceed with the design stage, which includes determining *hardware* and *software*, making a design in the form of *flowcharts*, preparing *storyboards*, designing learning implementation, and making instruments. After the design stage is complete, proceed with the development stage. As for some of the activities carried out at the design stage, namely collecting materials and compiling material in the content of video content, developing media in the form of videos, compiling product validation questionnaires, making *post-test* questions, and carrying out validation tests. Then, next is the implementation stage, which includes product trials, video implementation and *post-test* implementation. The last stage in this research is the evaluation stage, which includes *post-test* analysis activities.

The subjects in this study consisted of three experts and third grade students of SD Negeri 3 Selat. The expert validity test involved three experts, namely material experts, learning design experts, and media experts, who pursue their fields of expertise to get some input related to the development of PMRI-based interactive video learning media. After the product was declared feasible by the experts, an individual trial was conducted with three students who had different ability levels, consisting of one high-achieving student in mathematics learning, one medium-achieving student, and one low-achieving student, to identify individual understanding of the learning media and find aspects that needed to be improved. Furthermore, the small group trial involved nine students, consisting of three students with high mathematics ability, three students with medium ability, and three students with low ability, with the aim of reaffirming the previous revisions to the development product before the field test. Furthermore, at the product effectiveness test stage, involving the same 14 students as the limited field trial subjects, aims to measure the improvement of student learning outcomes after using learning media through post-test.

The data collection method in this study was conducted through formative evaluation which included expert review as well as student testing in various stages. Data were collected through observations, interviews, questionnaires, and tests, which were categorized into qualitative and quantitative data. Observations were made to observe the learning process in the classroom, while interviews were used to find out the learning needs and constraints of students. Questionnaires or questionnaires were used in the expert validation test as well as student trials to assess the feasibility, effectiveness, and understandability of learning media. Tests in the form of multiple choice questions were given before and after the use of the media to measure the improvement of student learning outcomes. Data collection instruments include expert validation questionnaires, student response questionnaires, and learning achievement tests to evaluate the effectiveness of PMRI-based interactive learning videos. Instrument grids can be presented in Tables 1, 2, 3, 4, and 5.

Table 1. Learning Material Content Expert Instrument Grid

No.	Aspects	Indicator	Item number	Number of items
1	Curriculum	a. Suitability of material with basic competencies	1	2
		b. Suitability of material with learning objectives	2	
2	Material	a. The material explains the correct concept	3	7

No.	Aspects	Indicator	Item number	Number of items
		b. The material in the video is presented systematically	4	
		c. The material presented is in accordance with the scope of material for grade III students	5	
		d. The material contains important concepts that students need to know	6	
		e. The material is supported by the right media	7	
		f. The examples used in interactive learning video media are in accordance with the concept of the material	8	
		g. Exercise questions are in accordance with the learning indicators	9	
3	Linguistics	a. The language used is in accordance with the characteristics of the learners	10	2
		b. Conformity with Indonesian language rules	11	
Many				11

(Astri et al., 2022)

Table 2: Learning Design Expert Instrument Grid

No.	Aspects	Indicator	Item number	Number of items
1	Destination	a. Formulation of learning objectives in accordance with the ABCD format (*Audience, Behavior, Condition, Degree*)	1	2
		b. Learning objectives are in accordance with the basic competencies	2	
2	Strategy	a. Providing material in PMRI-based learning video media provides logical steps	3	
		b. The material in the learning video is packaged coherently	4	
		c. The delivery of material in video media provides learning motivation to students	5	5
		d. Presentation of material in accordance with student characteristics	6	
		e. Able to facilitate students to learn independently	7	
3	Evaluation	a. The instructions for working on the questions are clear	8	
		b. There are practice questions that are in accordance with the learning material	9	2
Many				9

(Astri et al., 2022)

Table 3. Learning Media Expert Instrument Grid

No.	Aspects	Indicator	Item number	Number of items
1	Technical	a. Media can be used easily	1	
		b. Information conveyed in video media is easy to understand	2	
		c. Video media can be played repeatedly	3	4
		d. Video media has good image quality with appropriate resolution	4	
2	View	a. Use of the right font and font size	5	
		b. The writing in the video can be read clearly	6	
		c. Images in the video can be seen clearly	7	
		d. Accuracy of image presentation	8	8
		e. Selection of appropriate *background* design	9	
		f. Use of narration with a clear voice	10	
		g. The attractiveness of the animation displayed	11	
		h. Clarity of the narrator's voice	12	
Many				12

(Astri et al., 2022)

Table 4. Individual and Small Group Test Instrument Grids

No.	Aspects	Indicator	Item number	Number of items
1	View	a. Attractive video start	1	4

No.	Aspects	Indicator	Item number	Number of items
		b. The writing in the video can be read clearly	2	
		c. Images in the video can be seen clearly	3	
		d. The explanation of the material can be heard clearly	4	
2	Material	a. Learning video material is easy to understand	5	
		b. It is easier to remember the material presented in the learning video	6	4
		c. The material presented in the video is in order	7	
		d. The description of the material presented in the video is clear	8	
3	Motivation	a. This learning video adds motivation to learning	9	1
4	Operation	a. Learning videos can be easily used	10	2
		b. Learning videos can be played repeatedly	11	
Many				11

(Astri et al., 2022)

Table 5. Grid of Cognitive Domain Learning Outcome Test Instruments

Basic Competencies	Indicator	Knowledge Aspect						Many Questions
		C_1	C_2	C_3	C_4	C_5	C_6	
3.1 Explain the properties of counting operations on integers	3.1.1 Learners are able to understand the concept of integers and the concept of counting operations		√					6
	3.1.2 Learners are able to perform counting operations on integers related to story problems			√				18
	3.1.3 Learners are able to analyze *open ended* story problems related to counting operations of integers.				√			6

The data collection instrument trial stage was carried out in this case, the quality of the instrument was tested first through *Expert Judgement*. This method is used to assess the validity and reliability of the instrument of multiple choice questions, which is carried out by experts in the field of mathematics. Some of the requirements that must be met include: (1) test item validity, (2) test device reliability, (3) difficulty level, and (4) differentiating power.

This study used three data analysis techniques, namely qualitative descriptive analysis, quantitative descriptive analysis, and one-sample t-test inferential statistics. Qualitative analysis was used to process data from the reviews of material experts, design experts, and media experts, as well as student responses in the form of criticism, suggestions, and input for media improvement. Quantitative analysis was used to process questionnaire data in the form of percentages with a Likert 4 scale to determine the validity of the learning video. Inferential statistical analysis used a one-sample t-test to measure the effectiveness of the media by comparing the test results after the use of the media against a predetermined standard, which was preceded by a normality test and homogeneity test as a prerequisite for analysis.

3. RESULT AND DISCUSSION

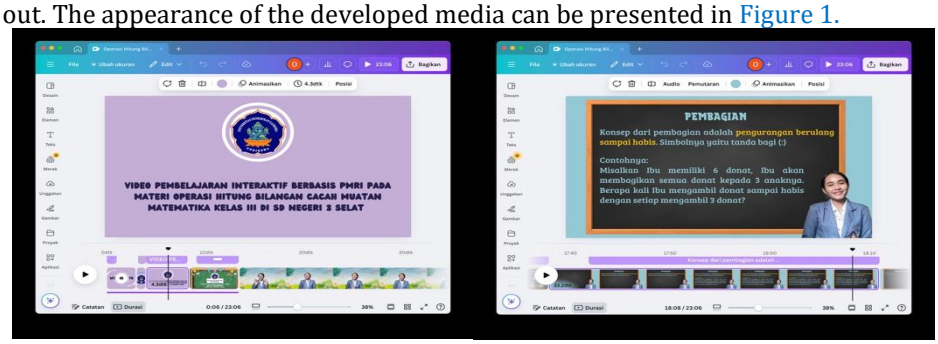
Result

The research on the development of interactive learning videos based on the Indonesian Realistic Mathematics Approach (PMRI) on the material of counting operations of small numbers in mathematics content was carried out in class III at SD Negeri 3 Selat, totaling 14 students. The design of this PMRI-based interactive learning video is in the form of electronic media that can be accessed through *links* or files directly. The learning video contains the concept of arithmetic operation material of numerical numbers in accordance with curriculum 13 in grade III. The parts contained in the learning video are (1) cover or cover page, (2) developer profile, (3) learning objectives, (4) the concept of counting numbers, (5) examples of problems and discussion of counting operations and *open ended* numbers, (6) practice questions, (7) closing page. This media was developed using the ADDIE model which consists of five stages: analysis, design, development, implementation, and evaluation. The analysis stage includes subject analysis, student characteristics, media needs, and content needs. Based on an interview with the third grade teacher of SD Negeri 3 Selat, it was found that students have difficulty in understanding counting operations of small numbers, especially in solving story problems. This difficulty is caused by the lack of understanding of basic concepts, the lack of use of interactive learning media, and conventional learning methods. Analysis of student characteristics also showed that they were more interested in audio-visual-based learning than the lecture method. Therefore, learning video media was developed to help improve students' understanding. The basic competencies and learning indicators are shown in Table 6.

Table 6. Basic Competencies and Learning Indicators

Basic Competencies	Indicator
3.1 Explain the properties of counting operations on integers	3.1.1 Understand the concept of counting operations on integers **(C2)** 3.1.2 Perform arithmetic operations on integers **(C3)** 3.1.3 Analyze *open ended* story problems related to arithmetic operations of noncountable numbers **(C4)** 3.1.4 Working on LKPD related to arithmetic operations of noncountable numbers **(P3)**

Furthermore, in the design stage, concept design is carried out based on the results of the analysis with the aim of facilitating the design of learning video media. The design stage includes determining *hardware* and *software*, making designs in the form of *flowcharts*, preparing *storyboards,* designing learning implementation, and making instruments. After the design stage, followed by the product development stage, at this stage the realization or development of the product is carried out. The appearance of the developed media can be presented in Figure 1.



Media Display

In addition to developing the product, a validation questionnaire, post test questions and validity testing were also carried out by the validator using a questionnaire that had been prepared and approved by the supervisor. Validation aims to get input and suggestions in improving the interactive learning video media that has been developed. After the validity test was carried out, several trials were also carried out (individual trials and small group trials) and the implementation of the post test (effectiveness test) at the implementation stage. The results of validity tests and trials can be presented in Table 7.

Table 7. Results of Validity Test Assessment and Product Trial

No.	Subject	Yield (%)	Qualification
1	Learning Content/Material Expert	93,18	Very good
2	Learning Design Expert	94,44	Very good
3	Media Expert	95,83	Very good
4	Individual Trial	96,97	Very good
5	Small Group Trial	92,93	Very good

In the test, both from experts and individual and small group trials, some input and suggestions were obtained from the subjects in the test. Input and suggestions from experts and students during the product trial were used as a refinement of PMRI-based interactive learning video media before the effectiveness test. Feedback and suggestions from each subject can be presented in Table 8.

Table 8. Feedback and Suggestions from Research Subjects

Subject	Feedback/Suggestions
Learning Content/Material Expert	1. Improvement of cognitive domain in learning objectives 2. Improvement of skill assessment rubric on lesson plan 3. Addition of *open ended* material on counting operations 4. Use verbs in questions that match the grid
Learning Design Expert	1. The presentation of learning objectives is too fast and if necessary the objectives are delivered by the presenter. 2. Grade 3 children do not understand "*open ended*", need to be given the Indonesian equivalent
Learning Media Expert	The intro needs to be given music to make it more interesting
Individual Trial	1. The video is very interesting 2. The video is easy to understand 3. The video is very creative
Small Group Trial	1. The video is very interesting

2. The video is good
3. The video is easy to understand

After the revision was carried out, it was continued with the effectiveness test. The effectiveness of this PMRI-based interactive learning video media development was carried out using the test method. To be able to collect data on student learning outcomes after the use of PMRI-based learning video media, the test used is in the form of multiple choice questions that will be answered by grade III students. The results obtained were then analyzed using a one-sample t-test. To be able to analyze the data using the t-test, the data must be normally distributed and homogeneous which is a prerequisite for the t-test. The normality of the data in this study used the Saphiro Wilk formula because the sample used was less than 30. Based on the normality test of the data distribution, the daily test data and *post-test* data obtained t_{count} of 0.918 and 0.921. When compared with $t_{(table)\ at}$ the 5% significance level which is 0.874, then, the results of $t_{calculate}$ daily test and *post-test* data are more than t_{table}, so it is declared normally distributed. Next is the variance homogeneity test. Based on data analysis, the calculated F price is 1.894. The calculated F price is compared with the F table with a significance level of 5% which is 2.58. From these results show F count < F table, so it is concluded that the two groups of data are homogeneous. After the prerequisite test is carried out, then proceed with hypothesis testing, hypothesis testing is carried out using the one-sample t test formula presented in table 9.

Table 9. T-test Results

Results of the t-test	
Description	**Results**
Average	83,57
S	6,021937961
n	14
dk	13
T count	12,78
T table	1,77

Based on the explanation in table 8, the data obtained shows the value of t_{count} which is 12.78 more than t_{table} which is 1.77, it can be concluded that H_0 is rejected and H_1 is accepted. In this case, it can be stated that PMRI-based interactive learning video products are effectively implemented in learning.

Discussion

The design of this PMRI-based interactive learning video is in the form of electronic media that can be accessed through *links* or files directly. The learning video contains the concept of arithmetic operation material of numerical numbers that is in accordance with the material of class III. The parts contained in the learning video are (1) cover or cover page, (2) developer profile, (3) learning objectives, (4) the concept of counting numbers, (5) examples of problems and discussion of counting operations and *open ended* numbers, (6) practice questions, (7) closing page.

The development of an interactive learning video based on the Indonesian Realistic Mathematics Approach (PMRI) on the material of counting operations of small numbers in class III SD Negeri 3 Selat uses the ADDIE model *(Analysis, Design, Development, Implementation, and Evaluation).* This model was chosen because it is systematic, flexible, and can be applied in various learning contexts to produce valid and effective media (Saeidnia et al., 2022; Spatioti et al., 2022) . In the world of education, the development of learning media based on the ADDIE model has been widely used because of its clear stages, from identifying needs to evaluating its effectiveness (Fahmi Mauliansyah et al., 2023; Nabila et al., 2021) .

In the analysis stage, the needs of students and teachers were identified through interviews with the third grade teacher of SD Negeri 3 Selat. The results of the interview showed that students have difficulty in understanding counting operations of small numbers, especially in solving story problems. This difficulty is caused by the lack of understanding of basic concepts and the lack of interactive learning media that can connect abstract concepts with students' real experiences. Students at the concrete operational stage find it easier to understand concepts if given visual and contextual-based learning experiences (Wedayanti & Wiarta, 2022; Widyaputri & Agustika, 2021) .

This is in line with research which states that a realistic approach in learning mathematics helps students understand concepts better because the material is presented in the context of everyday life (Qomario et al., 2020; Rahmawati, 2013) . In the design stage, the selection of hardware and software used in media development is carried out. The hardware used is a laptop and camera phone, while the software used is the Canva application, which allows the incorporation of animation, text, and audio interactively. Effective multimedia design should pay attention to the integration of visual and audio elements to make learning more interesting and easy to understand (Onyejelem & Aondover, 2024; M. D. Setiawan & Firdaus, 2025) . In addition, the creation of flowcharts and storyboards is used to design the flow of material presentation in the video, which aims to increase student understanding and engagement (Amin & Bahri, 2024; Hidayati Rofiah et al., 2024) . In the development stage, the materials that have been designed are converted into video format using the Canva application. The narration and text are arranged systematically in accordance with the principles of the *Cognitive Theory of Multimedia Learning* which states that the combination of text,

images, and sound can improve student understanding compared to using text or sound alone. The use of videos in learning mathematics is also supported by research that found that animation-based media increased students' motivation and understanding in learning abstract mathematical concepts (Akmalia et al., 2021; Cevahir et al., 2022) .

Media validity was tested through two stages, namely expert validation and student testing (individual and small group). Validation was conducted by three experts, namely material experts, learning design experts, and media experts, each of whom assessed aspects of the suitability of the content, design, and appearance of learning media. The validity test results showed that the learning video received a score of 93.18% from material experts, 94.44% from learning design experts, and 95.83% from media experts, all of which were in the excellent category. These results indicate that the developed media have met the standards of content, design, and visual appearance feasibility in supporting learning (Ghai & Tandon, 2022; Sukarini & Manuaba, 2021) . Input from experts was used to improve the learning video before it was tested on students. The material expert suggested the addition of open-ended questions to be in accordance with PMRI principles and revised the rubric for skills assessment in the lesson plan. The design expert suggested that the learning objectives be shown longer and delivered by the presenter, because third graders may have difficulty reading the text quickly. Meanwhile, the media expert suggested adding music to the video intro to attract students' attention. These results are consistent with research which states that visually and audibly appealing learning designs can increase students' motivation and understanding in learning (Kurniawan et al., 2020; Welch & Fleming, 2022) .

After expert validation, individual and small group trials were conducted to determine students' understanding and response to the learning media. The individual trial was conducted on three students with high, medium, and low abilities, while the small group trial involved nine students with the same distribution. The trial results showed that students gave a very positive response to the learning media developed, with a score of 96.97% in the individual trial and 92.93% in the small group trial, which is included in the excellent category. Students stated that this learning video is interesting, easy to understand, and creative, which indicates that this media has met their needs in understanding counting operations of integers. These results are in line with research that found that the use of interactive videos in mathematics learning can increase student engagement and understanding compared to the conventional lecture method (Lo & Hew, 2020; Nurdin et al., 2019) .

These results support research, which states that the application of the PMRI approach in video-based learning media can improve student understanding by connecting abstract concepts with real situations (Anugrahana & Pamekas, 2024; Ermiana & Fauzi, 2024) . By combining animation, text, and narration, students can more easily understand counting operations of integers without being burdened by long texts or monotonous verbal explanations. This is in accordance with the findings that contextual-based digital learning media can increase students' cognitive engagement and help them build a better understanding of mathematical concepts (Chaiarwut et al., 2025; Juwita et al., 2023) .

This research has several advantages, including the use of the ADDIE development model which is systematic and flexible, resulting in valid and effective learning media. In addition, the developed PMRI-based interactive learning video integrates interesting visual, audio, and animation elements, so that it can increase students' engagement and understanding of counting operations of natural numbers. Another advantage is the thorough validation by material, design, and media experts, as well as individual and small group trials, so that the quality of the video can be improved before it is widely implemented. The results of this study also show significant effectiveness in improving student learning outcomes, which is supported by statistical tests. Contributively, this study provides insights for teachers and learning media developers regarding the importance of using interactive videos in teaching mathematics, especially with the PMRI approach based on real contexts. In addition, this study contributes to the development of digital learning media that can be adapted for other materials in the elementary curriculum. The findings can also serve as a basis for future research to explore the effectiveness of PMRI-based media in various learning models, such as blended learning and flipped classroom, to improve the quality of mathematics learning in elementary schools.

The implication of this research shows that PMRI-based interactive learning videos are effective in improving students' understanding of counting operations of small numbers. This media helps students connect math concepts with real experiences, making it easier to understand. For teachers, this media can be an alternative in delivering material more interestingly, reducing dependence on the lecture method. In addition, the results of this study support the development of PMRI-based digital learning media for other materials and their application in various learning models, such as blended learning and flipped classroom. The limitation of this study lies in the limited scope of the sample, which is 14 students from one school, so the results cannot be widely generalized. In addition, this study only measured the effectiveness in the short term, without looking at the long-term impact on students' understanding. The evaluation also focused on the post-test, without using additional methods such as in-depth observation or interviews to further understand the students' learning process.

The recommendation based on this study is to expand the scope of the research by involving more schools and students so that the results are more generalizable. Future research is also recommended to measure the long-term impact of using PMRI-based media to determine its effectiveness in maintaining student understanding. In addition, the effectiveness test can be expanded by comparing the learning outcomes of students who use this media with students who learn using conventional methods, so that a more comprehensive picture of the effect of using PMRI-based learning videos on student learning outcomes can be obtained.

4. CONCLUSION

This research shows that PMRI-based interactive learning videos are effective in improving students' understanding of counting operations of small numbers. The realistic approach in mathematics learning helps students connect abstract concepts with real experiences, making it easier to understand. In addition, the use of digital technology-based learning media is proven to increase learning motivation and enable students to learn independently. For teachers, this media is an innovative alternative in delivering material in a more interesting and interactive way. Conceptually, the results of this study confirm that context-based learning and visualization can optimize student understanding, so similar media development can be applied to other mathematical concepts to support more effective learning.

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