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Development of Interactive Learning Media on Grouped Data Measures of Central Tendency to Enhance Mathematical Representation Skills

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Abstract:

Mathematical representation ability is a crucial skill in mathematics education, as it assists students in understanding, presenting, and communicating mathematical ideas through various forms of representation to solve problems. This study aimed to develop "MIMOPU" (Mean, Median, and Mode for Grouped Data) an interactive learning medium that is valid, practical, and effective in enhancing the mathematical representation abilities of 10th-grade students at SMK Pawyatan Daha 1 Kediri. This study employed the Research and Development (R&D) method using the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The research subjects consisted of students from class X PH 2 (experimental group) and class X PH 1 (control group). The results indicated that the "MIMOPU" interactive learning medium met the criteria for high validity, with a media validity score of 88.1% and a content validity score of 91.45%. The medium was also deemed highly practical based on practitioner assessments (86%) and student responses (78.35%). Mann-Whitney test results revealed a significant difference between the experimental and control classes (Sig. = 0.000). Furthermore, the average N-Gain for the experimental class was 0.9019 (high category), which was higher than that of the control class at 0.5423 (medium category). Thus, the "MIMOPU" interactive learning medium is considered valid, practical, and effective for improving students' mathematical representation abilities regarding measures of central tendency for grouped data.

Keywords: Interactive Learning Media; MIMOPU; Mathematical Representation; Size of Group Data Centralization

Introduction

Advancements in information and communication technology (ICT) have transformed the delivery of instruction, including in mathematics education. The use of digital technology enables learning materials to be presented in various formats, such as text, images, animations, and interactive activities, thereby offering students a more flexible and engaging learning experience (OECD, 2019; Fauziah et al., 2024). Furthermore, the use of interactive multimedia allows information to be conveyed through complementary verbal and visual channels, helping students build an understanding of the concepts being studied (Aryani & Lestari, 2025).

One important mathematical skill to develop is mathematical representation. This skill enables students to understand and communicate mathematical ideas through various forms of representation, such as visual, symbolic, and verbal. Mathematical representation is also one of the process standards in mathematics education outlined by the National Council of Teachers of Mathematics (NCTM). However, the mathematical representation skills of students in Indonesia still require improvement. Results from PISA 2022 indicate that Indonesia's mathematics score was 366 points, remaining below the OECD average of 472 points (OECD, 2023). Numerous studies also show that students continue to struggle with presenting mathematical ideas in visual, symbolic, or verbal forms (Fitrianna et al., 2018; Cahyaningrum et al., 2023; Budiarty & Utomo, 2024).

Various efforts have been made to address this issue through the use of interactive learning media. Haryudita and Noer (2024) demonstrated that interactive learning media can help enhance mathematical representation skills by visualizing concepts through images, animations, and digital simulations. Haranti et al. (2025) also showed that the use of interactive digital media can increase student engagement in the learning process. Meanwhile, Anomeisa and Ernaningsih (2020) developed PowerPoint VBA-based interactive learning media for the topic of grouped data presentation and demonstrated that the media helped students understand statistical concepts through visualization and more engaging material presentation. However, that study did not specifically focus the media development on mathematical representation skills, nor did it test the media's effectiveness by comparing experimental and control classes.

Addressing these issues and gaps, this study develops MIMOPU (Mean, Median, and Mode for Grouped Data), an interactive learning medium designed to help students understand measures of central tendency for grouped data while fostering mathematical representation skills through various presentation formats and interactive activities. Unlike previous studies, MIMOPU goes beyond merely delivering statistical content; it is designed to integrate visual, symbolic, and verbal representations and provide students with opportunities to interact with the material during the learning process. The development of this medium also aims to leverage the digital facilities available at the school. Thus, this study seeks to develop the MIMOPU interactive learning medium, ensuring it is valid, practical, and effective, to enhance the mathematical representation skills of Grade X students regarding measures of central tendency for grouped data.

Methods

This study employs the Research and Development (R&D) method, aiming to develop interactive learning media for the topic of measures of central tendency for grouped data to enhance mathematical representation skills, while evaluating the media's validity, practicality, and effectiveness. The development process follows the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation.

The research subjects consisted of expert validators, a practitioner, and Grade X students from SMK Pawyatan Daha 1 Kediri. Product validation involved two lecturers from the Mathematics Education study program acting as expert validators, along with one teacher serving as a field practitioner. The small-scale trial involved six students, while the large-scale trial involved 25 students in the experimental class and 23 students in the control class. The research instruments comprised a media validation sheet, a content validation sheet, a test instrument validation sheet, a practicality questionnaire, a student response questionnaire, and a mathematical representation ability test.

The quantitative data analysis in this study encompasses results from media and content expert validation questionnaires, test instrument validation, practicality sheets, and evaluations of student learning outcomes. These data were processed to yield results that could serve as a basis for refining the media product. The expert validation process utilized questionnaires employing a five-point Likert scale. The assessment criteria for each response option on the questionnaires were validated and established by the experts.

Table 1. Validation and Practicality Sheet Rating Scale

Value	Information
1	Very good
2	Good
3	Pretty good
4	Not good
5	Very bad

The data obtained from the validators were then calculated using the following formula:

$$X = \frac{\text{the total score awarded}}{\text{maximum total score}} \times 100\%$$

The results obtained from the validity and practicality percentages were then converted into data using the following criteria for media validity and practicality:

Table 2. Validity Criteria

Value	Information
$80\% < X \leq 100\%$	Highly Valid
$60\% < X \leq 80\%$	Valid
$40\% < X \leq 60\%$	Not Valid Enough
$20\% < X \leq 40\%$	Invalid

Table 3. Practicality Criteria

Value	Information
$85\% < X \leq 100\%$	Very Practical
$70\% < X \leq 85\%$	Practical
$40\% < X \leq 70\%$	Not very practicals
$0 < X \leq 50\%$	Impractical

The effectiveness of the media was analyzed using pretest and posttest scores through the Kolmogorov-Smirnov normality test, homogeneity test, Mann-Whitney U test, and Wilcoxon test, as well as N-Gain analysis to determine the improvement in

students' conceptual understanding. The N-Gain value can be calculated using the following formula:

$$N - Gain = \frac{Posttest\ score - Pretest\ score}{Maximum\ Score - Pretest\ score}$$

The following is the classification of effectiveness based on N-Gain criteria:

Table 4. N-Gain Classification Criteria

Value	Information
$N - Gain > 0.7$	High
$0.3 < N - Gain < 0.7$	Middle
$N - Gain < 0.3$	Low

Results and Discussion

Media Development

The media developed in this study utilized the Research and Development (R&D) method, adapting the ADDIE model through a systematic five-step process: analysis, design, development, implementation, and evaluation.

1. Analysis

The analysis phase was conducted to identify the requirements for developing learning media. This phase encompassed an analysis of learning media, the curriculum, and student characteristics. The results indicated that the topic of data central tendency requires media capable of helping students grasp the concepts in a more concrete manner.

2. Design

The design phase involves drafting the media and its supporting components. This stage encompasses the review and preparation of the content used for media development, specifically, material regarding measures of central tendency for grouped data. This topic was selected due to its inclusion of diverse, relatively complex representations and its relevance to everyday life. The content incorporated into the developed media covers the mean, median, and mode.

This stage involved designing the MIMOPU interactive learning media, utilizing Articulate Storyline as the primary software for development and assembly. The design process encompassed the layout, navigation, content, practice exercises, and interactive features. Various additional tools and resources supported the design process; Canva was used to source and design visual elements, such as buttons and other graphic components, while a character-generation website was employed to create the characters featured in the media. Subsequently, all prepared visual components and content were integrated into Articulate Storyline to construct the interactive learning media. Following the media design phase, the instruments required for data collection were developed. The researcher created three types of instruments to assess the validity, practicality, and effectiveness of the developed media.

3. Development

This stage involves the development of interactive digital media, a media feasibility test, and subsequent revisions. The interactive learning media was developed with a focus on fostering students' mathematical representation skills. It comprises several key sections: an introductory page, usage instructions, learning objectives, content on measures of central tendency for grouped data, example problems, practice exercises, and feedback mechanisms. The material is presented interactively, utilizing a

combination of text, visuals, and graphic elements to help learners grasp concepts regarding the mean, median, and mode of grouped data. Additionally, the media features navigation tools and answer verification capabilities, enabling learners to submit responses and receive immediate feedback on their answers.

4. *Implementation*

Following the development phase, the interactive learning medium "MIMOPU" was implemented with both small-scale and large-scale test groups. The small-scale trial involved six Grade X students studying Mathematics at SMK Pawyatan Daha 1 Kediri, students who were distinct from the experimental and control classes. Prior to using "MIMOPU," the students took a pretest to assess their baseline knowledge regarding measures of central tendency for grouped data. After the pretest, the students used "MIMOPU" directly during their mathematics lessons. Subsequently, they were asked to complete an evaluation of their learning outcomes and fill out a questionnaire regarding their response to the "MIMOPU" medium.

Subsequently, the "MIMOPU" media underwent large-scale testing with students from SMK Pawyatan Daha 1 Kediri; specifically, class X PH 2 served as the experimental group. This trial involved 25 students in class X PH 2, each accessing the "MIMOPU" media via their own devices during the learning process. In addition to the experimental group, the researcher utilized class X PH 1, comprising 23 students, as the control group. Instruction for the control group followed a conventional approach, without the use of interactive learning media. This large-scale trial was conducted to evaluate the implementation of the "MIMOPU" media in the classroom and to compare learning outcomes between the class using the "MIMOPU" media and the class that did not.

5. *Evaluation*

The evaluation phase was conducted to assess the quality of the media based on validity, practicality, and effectiveness. This evaluation was carried out continuously throughout the development process, involving revisions based on feedback from validators and trial results. The evaluation results indicate that the MIMOPU interactive media meets the criteria for suitability, making it appropriate for use as a learning tool for the topic of measures of central tendency for grouped data.

Data Analysis

1. *Product Validity Analysis*

The validation process employed encompassed media validation, content validation, and test instrument validation. This validation aimed to determine the validity level of MIMOPU as a manipulative learning medium. The process involved three validators who served as both content and media experts: two were mathematics education lecturers, and one was a mathematics teacher.

Table 5. Validation Results by Media Experts

Number	Rated aspect	Validator	
		1	2
1.	Performance	83%	93,3%
2.	Media Components	90%	85%
3.	Animation, Audio, Interactivity	80%	95%
4.	Performance and Responsiveness	90%	90%

Source: Author's Personal Document

An average percentage of 88.1% was obtained. When this assessment result is converted using the validity criteria table, it falls into the "highly valid" category.

Table 6. Validation Results by Subject Matter Expert

Number	Rated aspect	Validator	
		1	2
1.	Accuracy of Content	80%	90%
2.	Relevance to Learning Objectives	90%	100%
3.	Depth and Breadth of Content	86,7%	93,3%
4.	Accuracy of Information	100%	100%
5.	Language Use	85%	90%

Source: Author's Personal Document

Based on the assessments from the three media expert validators, an average score of 91.4% was obtained. When this score is converted against validity criteria, it falls into the "highly valid" category. Subsequently, the validation of the test instrument was conducted by two subject matter experts who are lecturers in Mathematics Education.

Table 7. Results of Test Instrument Validation by Subject Matter Experts

Number	Rated aspect	Validator	
		1	2
1.	Material	51%	95,8%
2.	Construction	83,3%	91,7%
3.	Language	98,3%	100%

Source: Author's Personal Document

Based on the assessments by the two subject matter experts, an average score of 84.3% was obtained. When this result is mapped against the validity criteria table, it falls into the "highly valid" category.

2. Analysis of Product Practicality

The assessment of the product's practicality was obtained from two field practitioners who are mathematics teachers. In addition to the evaluation by field practitioners, the practicality of the developed media was also measured through the responses of students serving as the trial subjects. The trials were conducted on two scales: small-scale and large-scale.

Table 8. Practicality Assessment by Field Practitioners

Number	Rated aspect	Praktisi	
		1	2
1.	Ease of Use	83%	83%
2.	User Time Efficiency	90%	90%
3.	Material Comprehensibility	80%	86,7%
4.	Student Interest	90%	90%
5.	Alignment with Student Needs	90%	90%

Source: Author's Personal Document

The assessments provided by the two practitioners yielded an average score of 86%. This score was then converted into the practicality criteria, indicating that the developed product was classified as "highly practical."

Table 9. Results of Small-Scale and Large-Scale Student Responses

Number	Rated aspect	Praktisi	
		Small scale	Big scale
1.	Ease of Use	87,8%	71,5%
2.	Time Efficiency	85%	75,3%
3.	Comprehensibility of Material	81,1%	72%
4.	Student Interest	88,3%	71,9%
5.	Alignment with Student Needs	81,7%	68,8%

Source: Author's Personal Document

The average student response rate was 84.8% for the small-scale trial and 71.9% for the large-scale trial. Consequently, the combined average response rate was 78.35%, which, when converted according to practicality criteria, corresponds to the "highly practical" category.

3. Product Effectiveness Analysis

The effectiveness of the Statventure medium was evaluated based on the results of mathematical representation ability tests conducted during a large-scale trial involving experimental and control classes. Prior to instruction, both classes took a pretest to assess the students' initial abilities. The results indicated that the initial abilities of both classes were comparable, making them suitable subjects for the study.

A large-scale trial of the MIMOPU media was conducted with 25 students from class X PH 2 at SMK Pawyatan Daha 1 Kediri. Descriptive statistical analysis of the test scores from this large-scale trial revealed that the 25 students in the experimental class achieved a mean score of 93.68; the minimum score in this class was 75, while the maximum was 100. Meanwhile, descriptive statistical analysis for the control group showed that the 23 students achieved a mean score of 74.74, with a minimum score of 41 and a maximum score of 91.

The next step was to analyze the students' test results from the experimental and control classes based on indicators of conceptual understanding.

Table 10. Analysis of Large-Scale Conceptual Understanding Ability

Results	Mathematical Representation Ability Indicator		
	Verbal	Pictorial (Visual)	Symbolic
Class	Experiment		
Total Score	89	95	98
Maximum Score	100	100	100
Percentage	89%	95%	98%
Class	Control		
Total Score	68	74	66
Maximum Score	92	92	92
Percentage	73,9%	80,4%	71,7%

Source: Author's personal document

Following the instruction, students' conceptual understanding was analyzed based on three indicators: verbal, visual, and symbolic. The analysis results indicate that the experimental class achieved higher percentages across all indicators compared to the control class. For the verbal indicator, the experimental class achieved 89%, while the control class achieved 73.9%. For the visual indicator, the experimental class achieved 95%, whereas the control class achieved 80.4%. Finally, regarding the symbolic indicator, the experimental class achieved 98%, while the control class achieved 71.7%.

The Mann-Whitney test results yielded a significance value of 0.000 ($p < 0.05$), indicating a significant difference in mathematical representation abilities between the experimental and control classes following the intervention. Furthermore, the N-Gain analysis revealed that the experimental class achieved an average N-Gain of 0.9019, placing it in the high category, whereas the control class fell into the medium category. These findings demonstrate the effectiveness of using mimopu media in enhancing students' mathematical representation abilities compared to conventional instruction.

Discussion

The "MIMOPU" interactive learning medium was deemed valid, as assessments of its content, media design, and evaluation instruments, used to measure students' mathematical representation skills, all fell into the "highly valid" category. This validity confirms that the developed medium aligns with learning objectives, competency achievement indicators, and the prevailing curriculum. Revisions made based on validator feedback further enhanced the medium's quality prior to its implementation with students. This underscores the importance of the validation stage in development research, ensuring the final product meets user needs.

Based on practicality test results from field practitioners and student feedback, the "MIMOPU" interactive learning medium is classified as highly practical for mathematics instruction. Its practicality is demonstrated by its ease of use, suitability for the allotted lesson time, and alignment with student needs, all without significant issues arising during the learning process. Clear navigation, a systematic layout, and easily understandable features enable students to operate the medium independently. Furthermore, the presentation of content, complemented by examples, illustrations, and interactive exercises, helps students grasp the concept of measures of central tendency for grouped data in a step-by-step manner. The use of images, animations, and interactive features creates a more engaging learning experience, thereby fostering student attention and participation. The alignment of the medium's content and features with student characteristics and needs allows MIMOPU to serve as an effective, student-centered learning aid.

The effectiveness of the MIMOPU interactive learning medium is demonstrated by the improvement in students' mathematical representation skills following instruction using the tool. Research findings indicate that mathematical representation proficiency in the experimental class was higher than in the control class, a result supported by statistical tests confirming a significant difference between the two groups. This improvement stems from MIMOPU's presentation of grouped data central tendency concepts through a combination of visualizations, examples, animations, and interactive exercises; these features enable students to comprehend and express concepts in visual, symbolic, and verbal forms. Throughout the learning process, students do not merely receive information passively but actively explore the material, respond to prompts, and complete exercises embedded in the medium. These activities help students connect various forms of mathematical representation, fostering a more meaningful

understanding of grouped data central tendency concepts. Consequently, the use of the MIMOPU interactive learning medium facilitates a more active learning experience and supports the enhancement of students' mathematical representation skills.

Conclusion

This development research produced the "MIMOPU" interactive learning media, focused on the topic of measures of central tendency for grouped data, which met the criteria of being highly valid, highly practical, and effective for enhancing the mathematical representation skills of Grade X high school (SMA/SMK) students. Validity was demonstrated through expert validation results showing media validity at 88.1%, material validity at 91.4%, and test instrument validity at 84.3%, all falling into the "highly valid" category. Regarding practicality, teacher assessments yielded a score of 86% (highly practical), while student responses averaged 78.35% (practical). The media's effectiveness was evidenced by Mann–Whitney test results showing a significant difference in conceptual understanding between the experimental and control classes (Sig. = 0.000 < 0.05), as well as N-Gain analysis results indicating that the experimental class achieved a score of 0.9019 (categorized as "high"), whereas the control class fell into the "medium" category.

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