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Development of Kenik Aljabar Manipulative for Grade VII Students at MTs Tarbiyatul Islamiyah

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ABSTRACT

Algebraic expressions are often difficult for Grade VII students because the topic requires them to connect symbolic representations with concrete meanings, particularly when identifying coefficients and constants and simplifying algebraic equations. This study aimed to describe the development process and determine the quality of the Kenik Aljabar manipulative as a learning aid for Grade VII students at MTs Tarbiyatul Islamiyah. The study employed research and development using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation. The product was tested with 11 Grade VII students. Data were collected through validation sheets for the product, student response questionnaire, achievement test validation sheet, student response questionnaire, and achievement test. The data were analyzed using quantitative and qualitative descriptive techniques. The findings showed that the product obtained a validity score of 3.39, while the student response questionnaire and achievement test obtained validity scores of 3.50 and 3.35, respectively; all were categorized as valid. The students' response score reached 3.80 in the high category, indicating that the product was practical. The achievement test showed that 9 of 11 students achieved mastery, with an average score of 90.09 and a classical mastery percentage of 81.82%. Therefore, the Kenik Aljabar manipulative with a user guide was valid, practical, and effective for supporting students' understanding of coefficients, constants, and algebraic simplification.

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1. INTRODUCTION

Mathematics learning at the lower secondary level is not only directed toward calculation skills but also toward students' ability to understand relationships, patterns, and mathematical representations. Algebraic expressions are an important topic in Grade VII because students begin to use letters and numbers simultaneously to express unknown quantities, coefficients, constants, and relationships among quantities. In the Indonesian Phase D mathematics learning outcomes, students are expected to transform contextual situations into algebraic representations and use operation properties to obtain equivalent forms (Kemendikbudristek, 2024).

However, algebraic expressions often become difficult for students because algebra involves symbols that are more abstract than arithmetic operations. Students may be able to follow procedures without understanding the meaning of each symbol. Previous studies reported that students' difficulties in algebra may emerge when they need to connect concrete experiences with abstract symbols (Rahmah & Argaswari, 2020) and when conceptual understanding and procedural accuracy are weak (Isfayani, 2023). The preliminary observation in Grade VII at MTs Tarbiyatul Islamiyah showed a similar problem. Some students had difficulty distinguishing coefficients from constants and made errors when grouping algebraic components and simplifying equations. Learning activities were still dominated by oral explanation and written exercises, so students had limited opportunities to observe algebraic processes through concrete objects. This condition indicates the need for learning media that can bridge symbolic algebra and direct student manipulation.

Manipulative teaching aids can help students observe, hold, arrange, move, compare, and group objects that represent mathematical concepts. Teaching aids are not merely supplementary materials, but instructional supports that help clarify learning messages, reduce excessive verbal explanation, and stimulate students' attention during classroom activities (Dahniar, 2022; Rohani, 2020). Learning media can support the delivery of messages and attract students' attention (Sadiman et al., 2014), while teaching aids can strengthen communication between teachers and students during learning (Rasjid et al., 2022). Alshatri et al.(2019) also emphasized that teaching aids can improve the effectiveness of mathematics learning by providing concrete learning experiences. Although learning media may take various forms, including audio-visual media (Erna, 2022), this study focuses on physical manipulative media because algebraic concepts require students to arrange, compare, group, and move components directly. In algebra learning, physical manipulatives such as algebra tiles can support conceptual understanding because students can model algebraic forms using movable pieces (Rini, 2022).

Several previous studies have developed or used manipulative media for algebra learning. Dewi and Ratu (2018) developed ALPER Aljabar for Grade VII students and reported that the product met valid, practical, and effective criteria. Balila and Anas (2022) found that algebra-grid learning media influenced students' learning outcomes in algebraic addition operations. Setianingrum and Ramadianti (2024) Setianingrum and Ramadianti (2024) used Kenik Aljabar in learning linear equations in one variable, while Sonia (2025) introduced U-JABAR to support students' understanding of operations on algebraic expressions. These studies show that concrete representations can help students learn algebra, but the product in the present study is developed specifically from the needs of Grade VII students at MTs Tarbiyatul Islamiyah, especially for identifying coefficients and constants and simplifying algebraic equations.

Therefore, this study aimed to describe the development process and determine the quality of the Kenik Aljabar manipulative in terms of validity, practicality, and effectiveness. The main contribution of this study is the development of a simple stick-based manipulative that differentiates coefficients and constants using colors and supports students in observing the relationship between the left and right sides of an algebraic equation.

2. METHODS

This study used a research and development approach because the study aimed not only to identify classroom learning problems but also to produce, validate, revise, and test an educational product (Okpatrioka, 2017). The development model was ADDIE, consisting of analysis, design,

development, implementation, and evaluation (Branch, 2009). This model was selected because it provides systematic stages for analyzing learning needs, designing a product, developing and validating the product, implementing it in learning, and evaluating its quality..

The study was conducted at MTs Tarbiyatul Islamiyah with 11 Grade VII students as the trial participants. The product developed in this study was the Kenik Aljabar manipulative, consisting of a main board, red sticks as coefficient representations, green sticks as constant representations, placement holes, operation symbols, example questions, and a user guide. The product was designed for the topic of algebraic expressions, especially coefficient and constant identification and algebraic equation simplification.

The validity of the manipulative and research instruments was calculated by averaging the validators' scores at the indicator, aspect, and total levels, following the validation analysis procedure used by Hidayati (2017). Student response data were analyzed descriptively because response questionnaires can be used to determine the practicality of learning materials or media after classroom implementation (Hidayati et al., 2021; Mardianto et al., 2022).

Table 1. ADDIE-based development procedure

Stage	Main activity	Output
Analysis	Identifying learning problems, student characteristics, material scope, and media needs.	Need for a concrete algebra manipulative.
Design	Designing the board, sticks, symbols, example questions, user guide, and instruments.	Initial product design and research instruments.
Development	Producing the manipulative, preparing the user guide, validating product and instruments, and revising.	Validated Kenik Aljabar manipulative.
Implementation	Trying out the product in Grade VII learning activities.	Student response and achievement data.
Evaluation	Analyzing validity, practicality, effectiveness, and revision notes.	Final product quality decision.

The validity score for each indicator was calculated using Equation (1), followed by the average of each aspect in Equation (2), and the total validity score in Equation (3).

$$\bar{V_i} = (\Sigma_{j=1}^{n} V_{ji}) / n \quad (1)$$

$$\bar{A_k} = (\Sigma_{i=1}^{m} \bar{V_i}) / m \quad (2)$$

$$V_a = (\Sigma_{k=1}^{p} \bar{A_k}) / p \quad (3)$$

In the equations, $\bar{V_i}$ is the mean score of the i-th indicator, V_{ji} is the score given by the j-th validator for the i-th indicator, n is the number of validators, $\bar{A_k}$ is the mean score of the k-th aspect, m is the number of indicators in the aspect, V_a is the total validity score, and p is the number of aspects.

The student response score and classical learning mastery were calculated using Equation (4) and Equation (5).

$$\bar{R} = (\Sigma_{i=1}^{N} \Sigma_{j=1}^{q} R_{ij}) / (N \times q) \quad (4)$$

$$KB = (T / N) \times 100\% \quad (5)$$

Here, $\bar{R}$ is the mean student response score, R_{ij} is the response score of the i-th student on the j-th statement, N is the number of students, q is the number of questionnaire statements, KB is classical mastery, and T is the number of students who achieved the minimum mastery criterion.

3. FINDINGS AND DISCUSSION

3.1. Product Development Findings

The analysis stage showed that students needed a concrete medium to help them distinguish coefficients and constants and follow the simplification process of algebraic equations. Based on this need, the product was designed using a main board and colored sticks. Red sticks represented coefficients, while green sticks represented constants. The product also included placement holes and operation symbols to support students in arranging algebraic components on both sides of an equation.

During the development stage, the prototype was produced using simple and locally available materials such as plywood, ice-cream sticks, PVC elbow pipes, nails, glue, and paint. A user guide was also prepared so that teachers and students could operate the product in a structured way. The final prototype is shown in Figure 1.

Figure 1. Final prototype of the Kenik Aljabar manipulative

3.2. Product Validity

The validity results showed that the product and instruments were feasible for classroom implementation. The product validation score was 3.39, the student response questionnaire validation score was 3.50, and the achievement test validation score was 3.35. The overall mean score was 3.41, so all components were categorized as valid. The summary is presented in Table 2.

Table 2. Summary of product and instrument validity

o.	Validated component	Mean score	Category
	Kenik Aljabar manipulative	3.39	Valid
	Student response questionnaire	3.50	Valid
	Achievement test	3.35	Valid
	Overall mean	3.41	Valid

3.3. Product Practically

Product practicality was determined from students' responses after learning with the Kenik Aljabar manipulative. The six questionnaire statements obtained scores ranging from 3.55 to 4.00. The overall average response score was 3.80, which was in the high category. This indicates that students

considered the product easy to use, visually clear, interesting, and helpful for learning algebraic expressions. This result is consistent with previous studies stating that student response questionnaires can describe the usability, attractiveness, and practicality of learning products after classroom implementation (Hidayati et al., 2021; Mardianto et al., 2022).

Table 3. Student response score by questionnaire statement

No.	Statement indicator	Mean score	Category
1	Clarity and relevance of the manipulative	3.73	High
2	Ease of use	3.55	High
3	Support for understanding algebraic components	3.73	High
4	Learning engagement	3.91	High
5	Attractiveness of the product	4.00	High
6	Usefulness for understanding coefficients and constants	3.91	High
	Overall mean	3.80	High

3.4. Product Effectiveness

Product effectiveness was measured through students' achievement test scores after the implementation. Nine out of 11 students achieved learning mastery, while two students did not. The average achievement score was 90.09. Using Equation (5), the classical mastery percentage was calculated as follows:

$$KB = (9 / 11) \times 100\% = 81.82\% \quad (6)$$

Because the classical mastery percentage exceeded the minimum criterion of 80%, the product was categorized as effective. The achievement summary is presented in Table 4.

Table 4. Summary of achievement test results

No.	Indicator	Result
1	Number of students	11
2	Students who achieved mastery	9
3	Students who did not achieve mastery	2
4	Average score	90.09
5	Classical mastery percentage	81.82%
6	Effectiveness category	Effective

3.4. Discussion

The findings indicate that the ADDIE procedure successfully guided the development of a manipulative that responded to students' learning needs. The validity score shows that the product was appropriate in terms of material relevance, media design, component function, safety, and usability. This result is consistent with development research in mathematics education, which emphasizes validation and revision before classroom implementation (Sugiyono, 2015).

The high practicality score can be interpreted from the product design. The use of different colors for coefficients and constants provided visual cues that helped students identify algebraic components. The placement holes also enabled students to observe the structure of both sides of an equation. This aligns with the idea that manipulative media can help students connect concrete experiences with abstract algebraic symbols (Rahmah & Argaswari, 2020; Rini, 2022).

The effectiveness result suggests that the product supported students' understanding after learning. Students did not only follow symbolic procedures but also observed changes in the physical representation before writing algebraic simplification steps. This result is in line with Balila and Anas (2022), who reported that algebra-grid learning media influenced students' learning outcomes in algebraic addition. Similar results were also reported by Dewi and Ratu (2018), Setianingrum and Ramadianti (2024), and Sonia (2025), who found that concrete algebra media could support Grade VII students in learning algebra. Nevertheless, the present study is limited to a small-scale trial involving 11 students, so broader implementation and comparative designs are needed in future research.

4. CONCLUSION

This study produced a Kenik Aljabar manipulative for Grade VII students at MTs Tarbiyatul Islamiyah using the ADDIE development model. The development process began with the identification of students' difficulties in understanding coefficients, constants, and algebraic equation simplification, followed by product design, product production, validation, classroom implementation, and evaluation.

The product met the quality criteria of validity, practicality, and effectiveness. The validity scores for the product, student response questionnaire, and achievement test were 3.39, 3.50, and 3.35, respectively, with an overall mean of 3.41 in the valid category. The student response score was 3.80 in the high category, indicating that the product was practical. The achievement test results showed that 9 of 11 students achieved mastery, with an average score of 90.09 and a classical mastery percentage of 81.82%, indicating that the product was effective.

The Kenik Aljabar manipulative can be used as a concrete learning aid to help students identify coefficients and constants and understand algebraic simplification more systematically. Future studies should involve more participants, different schools, longer implementation periods, and experimental designs with pretests, posttests, or comparison groups to strengthen evidence of product effectiveness.

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