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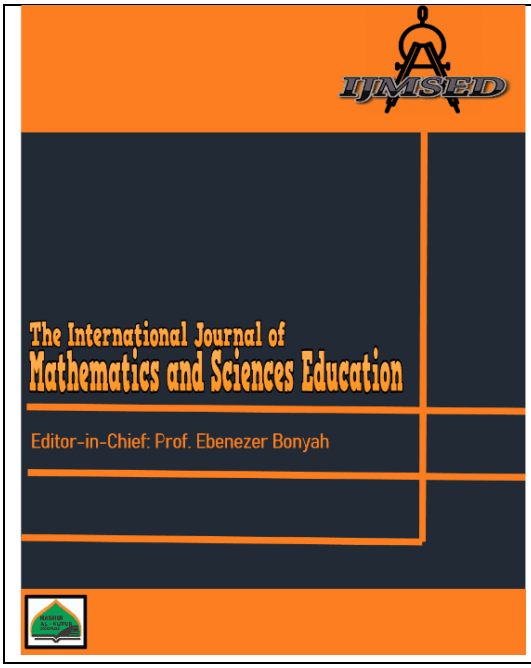

Exploring the effectiveness of modified algebra tile media in teaching single-variable linear equations: A case study

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Exploring the effectiveness of modified algebra tile media in teaching single-variable linear equations: a case study

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Abstract
Single-variable linear equations were open mathematical sentences that contained only one variable raised to the power of one and were connected by an equals sign ("="). This topic was often perceived as challenging by students, highlighting the importance of exploring innovative teaching strategies. This study examined the implementation of modified algebra tile media to enhance student understanding of single-variable linear equations. A qualitative case study approach was employed, involving a subject group consisting of student practitioners and 36 student observers. The research procedure included developing the modified algebra tile media followed by its application in teaching single-variable linear equations. Data were collected using the media, video recording devices, and field notes from the supervising lecturer. Interactive data analysis techniques revealed that the use of modified algebra tile media significantly facilitated students' comprehension of single-variable linear equations. By enabling hands-on manipulation of the media, students no longer needed to rely solely on abstract visualization of variables. These findings suggested that incorporating tangible, interactive teaching tools could effectively address learning difficulties in mathematics, particularly for abstract concepts.

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1. Introduction

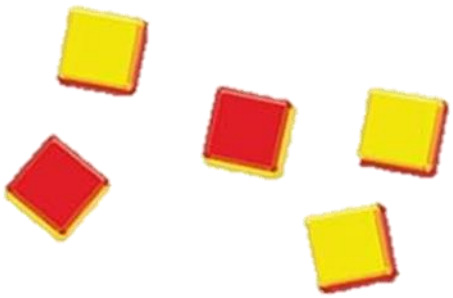
Single-variable linear equations (SVLE) are a mathematical learning material for eighth-grade students. According to the learning outcomes outlined by the Ministry of Education and Culture (Kemdikbud), by the end of Phase D, students should be able to solve problems related to single-variable linear equations (SVLE). Therefore, this material must be understood by students. SVLE is an open sentence that has only one variable, raised to the power of one, and is connected by an equal sign ("=" or equals) (Nafii, 2017; Hasan, 2020). Within SVLE, there are coefficients, constants, and variables. The coefficient is the number accompanying the variable (Kurniawan, 2019), while the constant is a fixed number in an algebraic expression that does not depend on the variable (BBGP DIY Yogyakarta, 2023). Meanwhile, the variable is a symbol representing a number whose value is not yet known (Sitanggang & Asmin, 2023).

The material of SVLE is considered difficult for students to understand. Students still have a poor understanding of SVLE due to its abstract nature (A'yuni, 2020; Mestika, 2021; Sulastri et al., 2017). This leads to misconceptions among students, causing errors in mathematical modeling and problem-solving (Khairat et al., 2022). These misconceptions occur because the initial concepts learned by students are incorrect, such as misunderstanding the prerequisite material of SVLE, namely integers (Husna, 2019; Habibah et al., 2020). Therefore, there is a need for a learning media that can help students

understand the concept of SVLE. One potential learning tool for teaching SVLE is algebra tiles (Rahmah & Argaswari, 2020).

Algebra tiles are manipulative media that can be directly and tangibly operated by students. This media can be used to understand the concept of SVLE and assist students in solving SVLE problems. Algebra tile media consists of two shapes. First, the square in Figure 1 represents unit numbers.

Figure 1
Algebra Tile Square



Second, the rectangle in Figure 2 represents the variable. Each algebra tile shape has two sides of different colors, with red symbolizing negative numbers.

Figure 2
Algebra Tile Rectangle

With the presence of algebra tile media, it is expected that students will find it easier to understand the concept of SVLE. The algebra tile media functions as a visualization tool for the concept of SVLE, so students do not need to imagine abstract mathematical symbols. The use of manipulative media can train students' thinking to identify the relationship between the manipulative ideas and the algebraic expressions being learned, such as variables and problem-solving related to algebraic operations (Castro, 2017). Abstract mathematical symbols can be visualized through this media. However, in its application, this media is limited to solving SVLE problems with coefficients, constants, and variable values as integer elements. Additionally, its small size makes it difficult to apply the media in front of a class, requiring students to remember the shapes and colors of algebra tiles as visual representations of SVLE.

The limitations in previous studies related to the development of algebra tile media highlight the importance of developing modified algebra tile media. Moreover, the researcher also practices the application of modified algebra tile media in teaching SVLE to examine its effectiveness. With this modified algebra tile media, it is hoped that it can become an innovation in teaching, offering an alternative to the monotonous lecture methods without media. Modified algebra tiles can also be easily created by teachers and do not require expensive costs, eliminating the need to search for pre-made algebra tiles. Therefore, the aim of this research is to develop modified algebra tile media and investigate the teaching of SVLE using this modified media to improve students' understanding of the SVLE concept and problem-solving.

2. Method

2.1 Design Research

This study used a qualitative approach, which emphasized a deep understanding of the phenomena being researched. In qualitative research, the researcher was directly involved in the situation and context of the phenomenon being studied, with the aim of gaining insight into reality through an inductive thinking process. The data were collected directly from the real-life situations experienced by the research subjects and analyzed to produce a deeper understanding (Adlini et al., 2022; Wijaya, 2020; Sudirman et al., 2023; Son et al., 2020; Nurfaidah et al., 2020). In this study, the researcher was directly involved in the creation of media, the practical application of the media, and the writing of the scientific article that formed part of the research results.

The type of research used was a case study. The focus of this case study was to understand the difficulties students faced in understanding the concept of a linear equation in one variable (LE1V) and solving problems related to LE1V. Therefore, this research identified and examined the use of appropriate learning media to help students overcome these difficulties. The main goal of case studies was to gain an in-depth understanding of specific phenomena by looking at particular conditions or situations, in this case, the difficulties students faced in understanding the LE1V material and how media could be used to address these issues (Assyakurrohim et al., 2023).

2.2 Subjects and Procedures

With purposive sampling, the subjects of this study were student teachers and 36 students. The subjects in this study were student teachers from the 2022 batch of the Mathematics Education Bachelor's program at Universitas Negeri Malang, who were taking the Mathematics Learning Media course. The research was conducted in a classroom setting that simulated a junior high school (SMP) classroom, with the researcher acting as the teacher and the other 36 students as the learners. The study also involved the lecturer who taught the course as an observer and evaluator of the learning process.

The procedure followed in this study included several stages. First, the researcher developed a modified algebra tiles learning media, which served as a tool for visualizing and helping students understand the LE1V concept. Second, the researcher carried out a practical teaching session using this media. The student teachers applied the media in the teaching session, with the researcher serving as a facilitator and observer. During the practice, the researcher also prepared all the necessary materials and tools for the learning activities.

2.3 Data Sources and Research Data

The data sources in this study came from two main groups: the student teachers and the lecturer of the Mathematics Learning Media course. The student teachers were the primary subjects involved directly in the creation and application of the media, while the course lecturer acted as an observer and evaluator. Data was collected through several sources, including:

(a) Activities of the student teachers during the practice session, including their interactions with the students and the use of the media in teaching LE1V.

(b) Video recordings of the teaching practice, which provided a clearer picture of how the media was used and how students responded to the lesson.

(c) Evaluation notes provided by the course lecturer as feedback on the teaching practice and the application of the media by the student teachers.

2.4 Data Analysis Techniques

The data analysis technique used in this study was the interactive data analysis technique, formulated by Miles and Huberman. This technique has been used because it is very good for analyzing qualitative data. This technique consisted of four main stages:

a) Data Collection: Data was collected from the practice activities, video recordings, and evaluation notes provided by the course lecturer. Data collection occurred during the teaching practice and evaluation sessions.
b) Data Presentation: The collected data was presented in the form of narratives that described the learning process, student reactions to the use of the media, and the evaluation notes from the lecturer. This presentation helped to understand the phenomena occurring during the research.
c) Data Reduction: The data obtained from these sources was reduced or filtered to focus on aspects relevant to the research objectives. This reduction allowed the researcher to focus on the factors that helped understand the effectiveness of using media in teaching LE1V.

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d) Conclusion or Verification: After analyzing the data, the researcher drew conclusions based on the findings. Verification was performed to ensure that the conclusions drawn were consistent with the data and reliable in answering the research questions. This process also involved comparing the findings with previous studies to strengthen the validity of the research results (Darmawan & Yusuf, 2022).

3. Results and Discussion

3.1 Results

Before conducting the teaching practice, the researcher created the modified algebra tiles media. The materials needed for this are (1) red and green buffalo paper, (2) scissors, (3) glue, (4) a printer, and (5) a laptop. The first step in creating the media was designing the algebra tiles on the laptop using Microsoft Word, creating the designs shown in Figures 3 and 4.

Figure 3
Positive Modified Algebra Tile Design

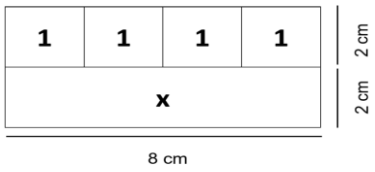
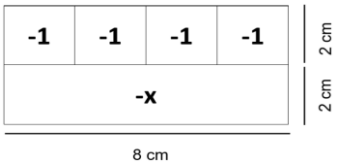


Figure 4
Negative Modified Algebra Tile Design

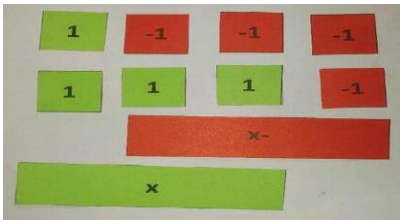


Second, the design in Figure 3 was printed on green buffalo paper, while the design in Figure 4 was printed on red buffalo paper. The printed media is shown in Figure 5.

Figure 5
Printed Modified Algebra Tile Design

Third, the printed design in Figure 5 was cut, resulting in square and rectangular shapes as shown in Figure 6.

Figure 6
Cut Algebra Tiles



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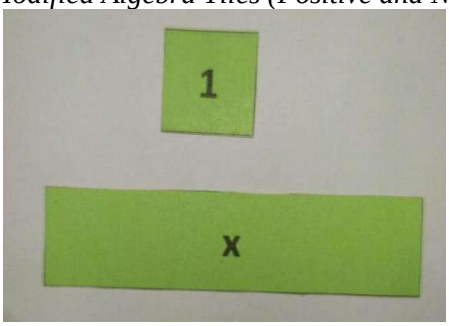
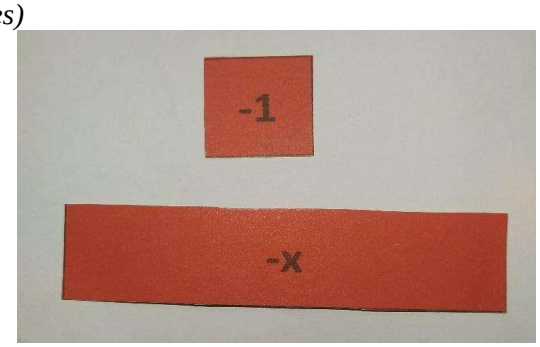
Fourth, the cut media was glued together using paper glue, adhering to the rule that the shapes should be the same, but in different colors. This resulted in the media shown in Figure 7, where the square algebra tiles represent unit numbers, while the rectangular ones represent variables. The green side represents positive numbers, while the red side represents negative numbers.

Figure 7

Modified Algebra Tiles (Positive and Negative Sides)



Modified Algebra Tiles (Positive Side)



Modified Algebra Tiles When Flipped (Negative Side)

After the development of the modified algebra tiles media was complete, the next step was the teaching practice on solving linear equations in one variable (LE1V). In addition to using the modified algebra tiles, the practice also involved materials such as clear mica sheets, paper, and whiteboard markers. The practice lasted for 15 minutes, focusing on critical thinking skills. According to Facione (2011), the indicators of critical thinking include interpretation, analysis, and inference. In the interpretation indicator, students are expected to understand and express the meaning or intent of a problem. In the analysis indicator, students are expected to identify relationships between statements, questions, concepts, descriptions, and others. Furthermore, in the inference indicator, students are expected to draw conclusions or provide reasons for the steps taken (Rani et al., 2015).

Before starting the main activities in the lesson using the algebra tiles media, the teacher posed an ice-breaker question: "Three times your sibling's age plus 2 is 11. How old is your sibling?" This question was designed to motivate students to study LE1V. The teacher awaited the students' responses but did not expect a correct answer. Students could respond using their prior understanding of previously taught material.

After the pre-activity, the teacher carried out several steps. First, the teacher introduced the learning media by showing the model of variables and constants using the modified algebra tiles as shown in Figure 8.

Figure 8

Introduction to the Model of Variables and Constants Using Modified Algebra Tiles

Next, the teacher provided an example of modeling 2x using the modified algebra tiles. This modeling was done by using two green rectangles, as shown in Figure 9.

Figure 9
Modeling 2x with Modified Algebra Tiles

The teacher then demonstrated modeling -2x using the modified algebra tiles. This modeling was done with two red rectangles, as shown in Figure 10.
Figure 10
Modeling -2x with Modified Algebra Tiles

Next, the teacher asked the students: "How would you model 3x and -5?" In this practice, the students were able to answer the question correctly. After the students understood the modeling of LE1V using the modified algebra tiles, they were directed to solve LE1V problems. For example, to solve 2x = 8, the first step is to write the equation on the clear mica sheet as shown in Figure 11.
Figure 11
Writing the Problem 2x = 8 on a Clear Mica Sheet

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Then, students modeled 2x and 8 using the modified algebra tiles. 2x was represented by two green rectangles placed in the left column (under 2x), and 8 was represented by eight green squares placed in the right column (under 8). This modeling is shown in Figure 12.

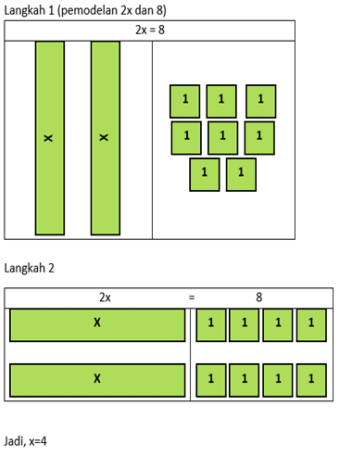
Figure 12

Modeling 2x and 8

After that, the two rectangles were placed above the eight squares, divided into two groups, so that x = 4. This arrangement is shown in Figure 13.

Figure 13

Arrangement and Illustration of Using the Algebra Tile Media



The lesson continued with solving more complex LE1V problems. In the second problem, which involved solving -2x = 6, the teacher asked a student to work on the problem in front of the class. During the process, the student received help from the teacher, as shown in Figure 15. For the final problem, 2x - 4 = 2, the solution was worked on together by the teacher and the students.

Figure 14

Student Solving the LE1V Problem

3.2 Discussion

This study found several limitations in the use of the media, particularly the small size of the modified algebra tiles. The small size of the tiles made it difficult for students sitting far from the teacher to see the media. Additionally, placing the media on the desk made it hard for most students to observe the demonstration of the media's use. This situation also led to a lack of interest from students in approaching the teacher for a clearer understanding of the media and the LE1V material, making this a weakness of the media. Even though the teacher had encouraged students to approach the media, students still showed no interest. Moreover, a further shortcoming in this teaching practice was the teacher's incorrect use of the term "min" instead of "negative" for numbers.

Throughout the lesson, all critical thinking indicators were achieved. The interpretation indicator was met when students thought of answers to the ice-breaker question. Students were able to model an equation using the modified algebra tiles, thus fulfilling the analysis indicator (Taufan et al., 2024). The analysis indicator was achieved when students concluded the value of a variable in a given problem.

The use of modified algebra tiles proved beneficial for teaching LE1V. The use of algebra tiles to study algebraic material helped students understand abstract concepts by thinking concretely (Çaylan, 2018). Additionally, algebra tiles made it easier for students to distinguish between variables and constants. This is consistent with research by Rahmah & Argaswari (2020), which found that students more easily understood the concepts of coefficients and constants after using algebra tiles.

The use of modified algebra tiles reduced errors in calculations. This is in line with research by Saraswati et al. (2016), which found that algebra tiles helped reduce errors that commonly occurred when solving linear equations in one variable (LE1V). Through the use of algebra tiles, students were less likely to make errors in applying arithmetic operations.

4. Conclusion

The development of this modified algebra tile media offers several advantages. One of the key benefits is that the materials and tools used for the media are easily accessible and affordable. This makes it a practical solution for teachers who wish to integrate hands-on learning tools without significant cost. Furthermore, using modified algebra tiles in teaching can effectively assist students in understanding one-variable linear equations (PLSV) with greater ease. The tactile interaction with the tiles allows students to visualize and manipulate algebraic concepts, helping them grasp abstract ideas in a more concrete manner. However, to improve the effectiveness of this learning tool, it is recommended to create the algebra tiles in a larger size, ensuring that they are clearly visible to students seated further away from the teacher. Additionally, the current setup places the media on the table, which may limit visibility for all students. A potential improvement would be to use algebra tiles that can be attached directly to the whiteboard, making them more accessible to the entire class and allowing for a more interactive and inclusive learning environment.

Limitations

This study is limited to the application of modified algebra tile media in teaching single-variable linear equations (SVLE) to students in middle school, specifically in seventh-grade classrooms or their equivalent. The research focuses on the use of this media in traditional classroom settings where conventional teaching methods are employed. The media used in this study consists of simple, easily accessible materials such as colored buffalo paper and adhesive, with the algebra tiles designed to facilitate the understanding of SVLE concepts. It does not include the use of technological devices or digital applications in the teaching process. The scope of this study is confined to the subject of single-variable linear equations, covering topics such as identifying and solving linear equations with one variable, excluding other related algebraic topics such as systems of linear equations or multi-variable equations. Data collection will primarily involve case study methods, including classroom observations, teacher interviews, and student interviews or assessments. The data will focus on student responses to the media used, their understanding of SVLE, and their engagement in the learning process. Furthermore, the study will be conducted over a limited period, not exceeding four weeks, during which students will engage with the modified algebra tile media to solve SVLE problems. The research is also

restricted to one or a few schools in a specific region, and the diversity of locations or educational systems outside the selected schools will not be part of the study.

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Conflict of Interest
The authors declare no conflict of interest.

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