JTAM (Jurnal Teori dan Aplikasi Matematika)
http://journal.ummat.ac.id/index.php/jtam
p-ISSN 2597-7512 | e-ISSN 2614-1175
Vol. 8, No. 3, July 2024, pp. 965-982

Kanoma: Learning Media to Improve Students' Understanding Mathematical Concepts

Khofifah Aluh Sigarini[1], Laila Fitriana[1*], Rubono Setiawan[1]
[1]Departement of Mathematics Education, Sebelas Maret University, Indonesia
Lailafitriana_fkip@staff.uns.ac.id

Article History:
Received : 29-04-2024
Revised : 22-06-2024
Accepted : 26-06-2024
Online : 19-07-2024

Keywords:
Kanoma;
Learning Media;
Understanding Concept;
Quadratic Equations;
PLOMP Approach.

ABSTRACT

This research was conducted to determine the validity, practicality, and effectiveness of Kanoma's learning media in improving the understanding of mathematical concepts in high school students in class X. This research applied development research design with the PLOMP approach developed by Tjeerd Plomp. The stages of development using the PLOMP approach include preliminary investigation, product design, construction, testing, and implementation. The population in this research were all ten-grade students at a vocational high school. The research sample consisted of 16 students in the experimental class and 14 students in the control class. These students were selected randomly using the cluster random sampling technique. The instruments utilized in the study included assessments by media experts, questionnaires for students and teachers, and pretest and posttest evaluations of mathematical understanding. The instruments given to media experts is used to validate the Kanoma media and its content. The questionnaires for students and teachers were used to test the practicality of the developed Kanoma media. These quistionnaires gathered feedback on how easy and useful the media was in a classroom setting. The pretest and posttest were designed to measure students' understanding of mathematical concepts related to finding the roots of quadratic equations. The average value given by material experts from the two validators of Kanoma's media is 0.82. The average value given by media experts from the two validators is 0.90. The results show that the Kanoma media was categorized as "very valid" by both material and media experts. This indicates that media was suitable for use by class X students in senior high school. Kanoma media is also classified as practical based on the average percentage of student and teacher responses. The responses from students scored 73%, categorized as "practice". The responses from teachers scored 81%, categorized as "very practice." Kanoma media is effective based on the Mann-Whitney Asyptotic Sig. $(0.002) < \alpha\,(0.05)$. The results showed a significant improvement in mathematical understanding. Students who used the Kanoma media had a better grasp of the mathematical concepts than those who did not.

https://doi.org/10.31764/jtam.v8i3.23076

A. INTRODUCTION

Mathematics is a fundamental subject in formal education, being taught at every level of schooling (Monalisa et al., 2021). Among the various abilities required in mathematics, understanding concepts stands out as crucial. Concept understanding entails students' capacity to explain, provide evidence, offer examples and non-examples, generalize, apply, and articulate concepts (Yuliany et al., 2019). This ability is paramount for students' success (Farman et al., 2021) and serves as the cornerstone of their academic achievements (Fonseca & Henriques, 2020). In understanding concepts, students not only acquire knowledge of the material but also

develop the proficiency to apply procedures, thereby facilitating problem-solving (Rahmadiani et al., 2024). Furthermore, students who understand mathematical concepts are better positioned to comprehend more complex topics (Yuliany et al., 2019).

Despite the significance of concept understanding, the level of students' mathematical understanding is still low (Ammy, 2021). Many students encounter difficulties in achieving a good understanding of mathematical concepts (Rohmah & Setyaningrum, 2022). This struggle is evident in the persistent low learning outcomes observed among students (Manik et al., 2021). Based on interviews with tenth-grade mathematics teachers at vocational high schools, it was revealed that students face challenges in understanding quadratic equation material, particularly in determining the roots of quadratic equations. Moreover, there is a lack of appropriate learning media in schools to support the teaching-learning process. Teachers often resort to using PowerPoint presentations and traditional teaching models. This deficiency in suitable learning tools likely contributes to the students' low comprehension of mathematical concepts in related subjects.

In response to the identified challenges, exploring strategies to enhance students' understanding of mathematical concepts is imperative. One of the things that can be done to improve students' ability to understand mathematical concepts is the application of learning media (Afhami, 2022). Learning media serves as a conduit for delivering educational content from teachers to students Yulistia (2024), and engaging students in learning activities to achieve their academic objectives (Zahroni, 2022). The selection of appropriate learning media has the potential to enhance the quality of learning, thereby aiding students in comprehending the material more effectively (Topano et al., 2023). Previous research shows that Ludo Kartesius media can improve students' understanding of mathematical concepts. (Sumadi et al., 2022). In the other studies, the media of the Venn Gram can be used to improve the student's understanding of concepts of set operations Prillyana et al. (2020) and GeoGebra-based Fractional Gap media can be used to improve students' understanding of concepts in subtraction and addition of fractions (Nashiroh & Zainuddin, 2023). This shows the great potential of using learning media, which can deepen students' understanding of mathematical concepts if specifically designed and appropriate.

A questionnaire distributed to tenth-grade students at vocational high schools indicated their need for learning media, particularly preferring group learning settings. They preferred game-based learning tools to mitigate boredom during lessons while facilitating interactive learning experiences. In addition, game card media is the favorite chosen by students as the most desired learning media to help overcome difficulties in learning mathematics. Based on the data from interviews and student needs questionnaires, the solution that can be provided is the development of game card-based learning media specifically designed for finding the roots of quadratic equations.

One of the game cards that can be used as learning media is domino cards. It can be used as learning media with modifications according to the material being taught (Khairurrijal et al., 2023). Previous research shows that using dominoes in multiplication operations in elementary schools can support students in mastering the material and help in memorizing multiplication operations (Adawiyah & Kowiyah, 2021). In addition, domino card media makes it easier for students to understand the concept of angle material in junior high school Rahman

& Amalia (2019), and domino card is effective in enhancing the student's understanding of animal life cycles in natural science (IPA) subject (Febriani & Arini, 2023). Although various studies have shown that domino cards can be a successful learning media that positively affects students' mathematical concept understanding ability, their use so far tends to be limited to the elementary school level and for subjects outside of mathematics. Furthermore, research has yet to specifically explore the application of domino cards to the material of finding the roots of quadratic equations. This shows the unexplored potential of dominoes media to improve students' mathematical concept understanding ability on finding the roots of quadratic equations at the senior high school level. This underlies the researcher's development of *Kartu Domino Matematika (*Kanoma). The difference between the Kanoma developed by researchers and other domino cards lies in the aspect of student abilities that will be improved and the content of the learning materials. The Kanoma focuses on enhancing the ability to understand mathematical concepts in quadratic equations, especially in finding the roots of quadratic equations. The distinction of Kanoma from other domino cards lies in its specialized development aimed at enhancing students' mathematical concept comprehension across four key indicators: (1) restating a concept, (2) providing examples and non-examples, (3) classifying objects based on specific properties related to the concept, and (4) utilizing, leveraging, and selecting specific procedures or operations. For instance, in Kanoma, the practice of providing examples and non-examples is integrated when teachers explain the material. Students restate concepts by describing how they can match one Kanoma card with another. Object classification is implemented as students seek card pairs under the condition "quadratic equation - roots of quadratic equations." They must match the quadratic equations on one Kanoma card with their corresponding roots on another, or vice versa. Furthermore, the indicator of using procedures or operations is implemented in Kanoma when students choose between factoring methods or quadratic formulas to determine the roots of quadratic equations. Additionally, the use of Kanoma requires students to match quadratic equation roots with their corresponding equations, aiding in the classification and grouping of equations by their roots, selecting appropriate methods, and expressing opinions in their own words, indicating that students can refine their understanding of mathematical concepts. Kanoma also includes a user guidebook intended for teachers to facilitate student use. The guide provides detailed explanations on how to use Kanoma in the classroom, including answer keys to materials presented through Kanoma. Furthermore, the Kanoma guidebook features a QR code directing students to the arrangement of Kanoma cards, accessible for independent learning after gameplay. Therefore, based on the background described previously, this research was conducted to determine the validity, practicality, and effectiveness of Kanoma learning media in improving understanding of mathematical concepts in class X students at vocational high school.

B. METHODS

1. Research Design

The type of research used in this study is development research, which aims to produce a product and test its effectiveness. Development research involves stages to create new products or improve existing products, followed by testing to assess their functionality and efficiency. The method used is research and development (RND) with the PLOMP approach. The stages of PLOMP are preliminary investigation, product design, construction, testing, and implementation (Budiyono, 2017). The preliminary investigation stage analyzes the problems that occur in the field. The product design stage includes making storyboards, indicators, logos, front and back of cards, making game rules, packaging displays, and making Kanoma media guidebooks. The construction stage is realizing the product design that has been made. The trial stage is conducting Kanoma media trials to see the advantages of Kanoma media compared to those who do not use Kanoma media. The implementation stage is the dissemination of research results. The population in this study were all ten-grade students at Batik Vocational High School 1 Surakarta. The research sample was taken based on the cluster random sampling technique. The cluster random sampling technique was used to select two classes, X TKJ 2 and X TKJ 3, from a total of nine classes based on the curriculum delivery schedule and the same teachers. Class X TKJ 2 consisted of 16 students and became the experimental group that received treatment using Kanoma media, while X TKJ 3, with 14 students, became the control group without Kanoma media.

2. Product Validity

In this study, each statement item in the validation questionnaire for material experts and media experts was scored using a Likert Scale with four scoring categories, namely score 4 for very suitable, 3 for suitable, 2 for less appropriate, and 1 for not suitable (Budiyono, 2017). The instruments given to media experts consisted of 12 items to validate the Kanoma media. The instrument for content experts included 15 items to validate the content of the Kanoma media. The analysis of product validity in this study was carried out using the Aiken Validity Index. The score obtained will be calculated using the following formula (Hastuti et al., 2023).

$$V = \frac{\sum(r - I_0)}{[n(c-1)]}$$

Information: V is the validity score, r is the score given by the validator, I_0 is the lowest possible score (i.e. 1), n is the number of validators, and c is the number of scoring categories (i.e. 4). After obtaining the validity value, the results will be interpreted into the following validity categories (Tisna MS et al., 2023), as shown in Table 1.

Table 1. Category Validity

Interval Values	Category
$0.80 \leq \bar{V} < 1.00$	Very high validity
$0.60 \leq \bar{V} < 0.80$	High validity
$0.40 \leq \bar{V} < 0.60$	Medium validity
$0.20 \leq \bar{V} < 0.40$	Low validity
$0.00 \leq \bar{V} < 0.20$	Very low validity
$0.00 < \bar{V}$	Not valid

Information: $\bar{V}$ is the average total validity score from all validators. Table 1 shows the six validity categories calculated using the Aiken validity index. The calculation of this index involves expert judgment on the relevance of each item. The results are categorized as 'Invalid' which indicates that the item does not meet the minimum criteria for validity. 'Very low validity' indicates that the item has significant problems and is barely valid. 'Low validity' indicates that the item has some issues and is not very valid. 'Medium validity' indicates that the item is moderately valid and meets the minimum criteria to be considered valid. 'High validity' indicates that the item is valid and measures the intended construct well. 'Very high validity' indicates that the item is highly valid and is an excellent measure of the intended construct. Each category is based on the calculated score of the Aiken validity index and is used to assess the validity of the items evaluating the Kanoma media. Items classified as 'Medium validity' and above are considered valid, where 'Very high validity' indicates the highest level of validity.

3. Product Practicality

The next step is to test the product based on its practicality. The product practicality test was conducted by distributing questionnaires for student and teacher responses. These questionnaires collect feedback on how easy and useful the media is in classroom learning. Each statement item on the practicality questionnaire for students and teachers was scored using a Likert Scale with five scoring categories, namely score 5 for strongly agree, 4 for agree, 3 for undecided, 2 for disagree, and 1 for strongly disagree (Budiyono, 2017). The score obtained will be calculated using the following formula (Arif & Mukhaiyar, 2020).

$$Practical\ Value = \frac{Score\ Obtained}{Maximum\ Score} \times 100\%$$

After calculating the practicality score, the average score will be interpreted into the following categories, as shown in Table 2.

Table 2. Category Practicality

Interval Values	Category
$0.80 \leq \bar{P} < 1.00$	Very practical
$0.60 \leq \bar{P} < 0.80$	Practical
$0.40 \leq \bar{P} < 0.60$	Moderately practical
$0.20 \leq \bar{P} < 0.40$	Less practical
$0.00 \leq \bar{P} < 0.20$	Not practical

Information: $\bar{P}$ is the average score of practicality score. Table 2 shows the five categories of practicality calculated from the student and teacher responses. The results are categorized as 'Very practical' indicating that the product is very easy to use and very effective in practical applications. 'Practical' indicates that the product is easy to use and effective in most practical applications. 'Moderately practical' indicates that the product is moderately easy to use and effective, but may require some improvements. 'Less practical' indicates that the product has some usability issues and is less effective in practical applications. 'Not practical' indicates that the product is difficult to use and ineffective in practical applications. Each category is based on responses from students and teachers regarding the practicality of the Kanoma media. Products classified as 'Practical' and above are considered practical for use.

4. Product Effectiveness

The effectiveness test was carried out by experimental research with the randomized static group comparison design. The design can be seen in Table 3 (Budiyono, 2017).

Table 3. Design of Randomized Static Group Comparison Design

	Treatment	Posttest
Experiment Class	X	T_2
Control Class	-	T_2

The researcher calculated this post-test data using the Mann-Whitney nonparametric statistic on the SPSS version 27 application. The Mann-Whitney test was chosen because it is suitable for comparing two independent groups when the data does not meet the normal distribution assumptions required for parametric tests. This statistic does not assume a particular data distribution, such as a normal distribution, and does not require the data to have equal variances. (Suharianto et al., 2022). The step is to enter the post test data from the experimental class and control class then enter:

Analyze → Nonparametric Tests → Independent Samples

Select the Mann-Whitney U test option then run the test to get the $Asymp.Sig.(2-tailed)$ value. Decision-making criteria are based on a comparison between the $Asymp.Sig.(2-tailed)$ and the significance level α (commonly set at 0.05). The significance level α represents the significance level used to assess whether the observed difference is statistically significant. If $Asymp.Sig.(2-tailed) < \alpha$ then the null hypothesis (H_0), which states that there is no significant difference between the two groups, is rejected. Whereas if $Asymp.Sig.(2-tailed) \geq \alpha$, then the null hypothesis (H_0) is accepted, indicating no significant difference between the groups.

C. RESULT AND DISCUSSION

The design and research were carried out in a vocational high school class X. The resulting product is a *Kartu Domino Matematika* (Kanoma) learning media on the material of quadratic equations. The product design and research process uses the Research and Development method with the PLOMP approach. Here are the steps to ensure the validity of the Kanoma learning media product:

1. Preliminary Investigation

a. Preliminary Research

Preliminary research in the form of the acquisition of student work shows a low understanding of mathematical concepts at vocational high school. This can be seen from the results of student work on arithmetic sequence material with *problem (a) Find the formula for the sum of the first n terms and the sum of the first 20 terms of the arithmetic sequence 2, 5, 8, 11,... and problem (b) If the 7th term of an arithmetic sequence is ten and the 13th term is -2, find the 15th term of the sequence!* Student work in solving problems can be seen in Figure 1 and Figure 2 as follows.

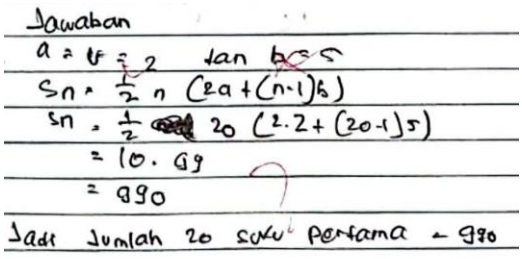


Figure 1. Sample Student Answer to Question *(a)*

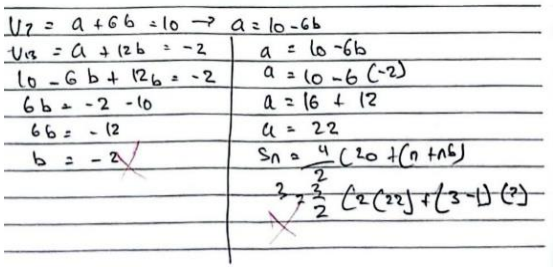


Figure 2. Sample Student Answer to Question *(b)*

Based on Figure 1, students are mistaken in writing the "difference" of the arithmetic sequence. This shows that students still do not understand "difference" in arithmetic sequences. Meanwhile, based on Figure 2, students need to be corrected in writing the formula for the nth term in an arithmetic sequence. This indicates that students' ability to understand concepts in arithmetic sequence material still needs to improve.

In addition, based on interviews with ten-grade mathematics teachers at vocational high school, information was obtained that students still have difficulty in quadratic equation material, especially in determining the roots of quadratic equations. Schools also still need more learning media to support the continuity of the learning process. The learning process in class usually uses PowerPoint media and discovery learning models. However, using media and learning models still needs to improve learning outcomes.

b. Need Analysis

To follow up on the interview results, the researcher distributed a learning media needs questionnaire to students to find out whether learning media was needed or not, the results were that 90% of students stated that they required learning media other than those commonly used. Based on the questionnaire results, 33% of students stated that game cards are the usual media used to learn math at school. In addition, 88% of students said that they prefer learning in groups. In the questionnaire, the researcher

also asked about the media that students choose to overcome difficulties in learning math, the results of which most students answered the game card media because they were not bored during lessons and could learn while playing. Based on these data, the researcher decided to develop math dominoes.

c. Literature study

The literature study was conducted to identify relevant materials. Researchers reviewed the quadratic equation material based on the learning objectives in this case. The learning objectives in this study are in Table 4 below.

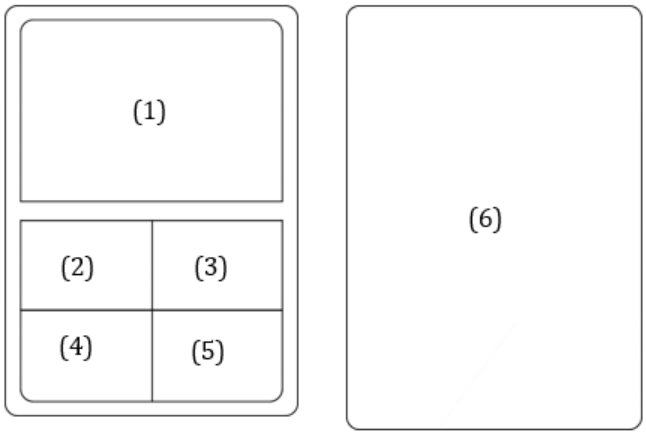
Table 4. Learning Objectives

Learning Objectives
Students can determine the roots of quadratic equations by factoring and quadratic formula (ABC formula)

2. Product Design

a. Create a Storyboard

This step is done by creating an overview of the Kanoma media design developed. The Kanoma media storyboard consists of the front and back views of the Kanoma media, the Kanoma media game rules, and the Kanoma packaging display. The following is an explanation of the Kanoma media storyboard as shown in Figure 3, Figure 4, and Figure 5.



(a) (b)

Figure 3. Storyboard: Part 1 (Kanoma Card View) (a) The front card view; and (b) The back card view

Description: (1) is Quadratic equation; (2) and (5) is the first root of the quadratic equation; (3) and (4) is the second root of the quadratic equation; and (6) Kanoma logo and cover.

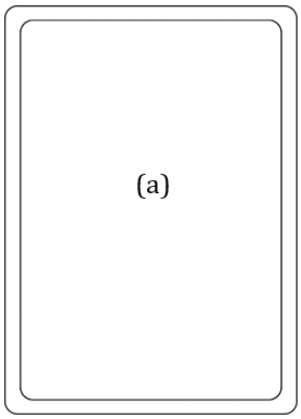


Figure 4. Storyboard: Part 2 (Kanoma Game Rules View)

Description: (a) is Game rules.

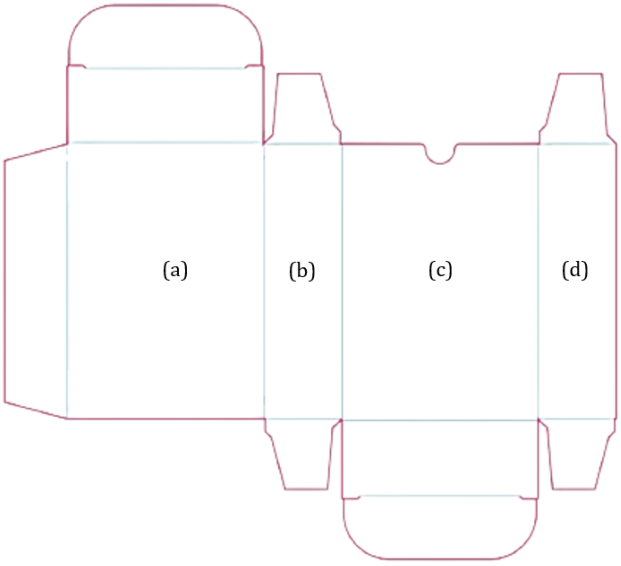


Figure 5. Storyboard: Part 3 (Kanoma Packaging Display)

Description: (a) is Kanoma Logo and Cover; (b) is Media Developer; (c) is Game Rules; and (d) is writing: Math Domino Cards-Roots of Quadratic Equations.

b. Develop Kanoma Media Indicators

Kanoma media is designed to meet the indicators of understanding mathematical concepts. The indicators used consist of (1) restating a concept, (2) giving examples and non-examples of concepts, (3) classifying objects according to specific properties according to their concepts, and (4) using, utilizing, and selecting specific procedures or operations. The concept discussed in this study is related to quadratic equations, especially in finding the roots of quadratic equations by factoring or using the quadratic formula. Based on the Kanoma media storyboard, several quadratic equations and roots of quadratic equations are needed. In this case, five different quadratic equations and the origins of the five quadratic equations were developed into 25 cards.

c. Develop Kanoma Media Logo

The Kanoma media logo was developed in the Instagram application, namely by uploading a plain white background photo to the Instagram story and then writing the

word ”Kanoma” in the center of the background. After that, the image was saved and converted into .png format, resulting in the Kanoma logo, as shown in Figure 6 below.

Figure 6. Kanoma Media Logo

d. Develop Kanoma Media Display

The creation of the front and back views of the Kanoma media is based on the explanation on the storyboard and is made using the Canva application. The selection of basic black, red, yellow, green, and blue colors aims to produce an attractive visual composition. Design elements such as icons, images, and text are selected from Canva and arranged in such a way as to be consistent and easily understood by users. The Kanoma media display is shown in Figure 7 and Figure 8 below.

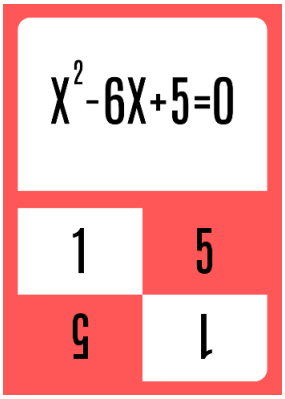


Figure 7. The front card view

Figure 8. The back card view

e. Develop Kanoma Game Rules Display

The Kanoma game rules display is similar to the back card view of the Kanoma media, as in Figure 8, but there is an additional white space to put the writing of the Kanoma media game rules, as in Figure 9. The Kanoma media game rules are made separately first and then placed on one side of the Kanoma media packaging according to the storyboard that has been made. The game rules of the Kanoma media are as follows: (a) divide the cards equally. If there are leftover cards, keep them at the center of the tournament table; (b) the game begins by opening one card from the remaining deck of cards. If no remaining cards exist, the game is started by one of the players chosen according to mutual agreement; (c) match the card on one side of the open card with the provisions of "quadratic equation-root of the quadratic equation;" (d) the game rotates clockwise; (e) if you do not find a matching card, you must take one card from the remaining pile (if the card from the remaining pile runs out, the game continues to the

next-turn player); and (f) the winner is taken from the player who finishes the card first. The following is the Kanoma Games Rules Display, as shown in Figure 9.

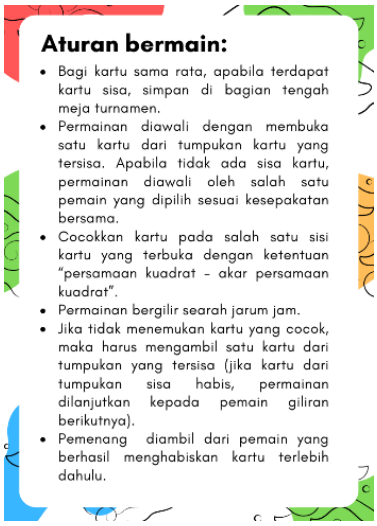


Figure 9. Kanoma Games Rules Display

f. Develop a Kanoma Packaging Display

The packaging design development for Kanoma media was carried out in two stages, utilizing the Templatemaker website and the Canva design application. The first stage is creating a packaging framework using Templatemaker, an online platform specifically designed to produce basic patterns or packaging nets. The framework produced at this stage serves as the basis or initial canvas that will be developed further. The process then continues to the second stage, where the design elements are applied using Canva. Through Canva, the previously created framework is transformed into a packaging design with various visual aspects such as color selection, text placement, and images. The Kanoma media packaging display can be seen in Figure 10 and Figure 11. The blue triangle on the image is only used as a signpost when printing the Kanoma media packaging design. The Kanoma media packaging display will then be printed, cut out following the lines on the packaging net, and glued using glue to form a card packaging box, as shown in Figure 10 and Figure 11.

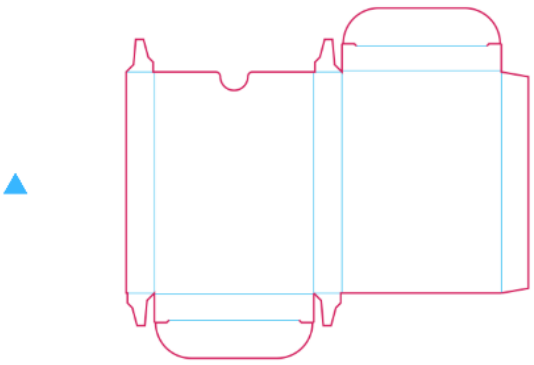


Figure 10. The inside packaging view

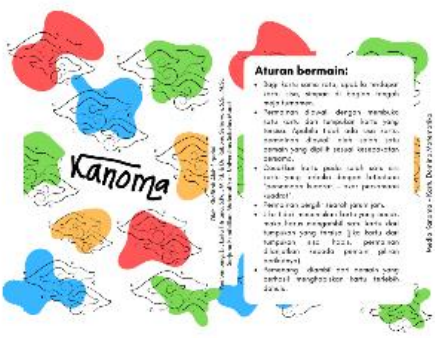


Figure 11. The outside packaging view

g. Develop a Guidebook for Using Kanoma Media

A guidebook for using Kanoma media was developed using Microsoft Word. The primary purpose of making this guidebook is to support teachers in facilitating students' use of Kanoma learning media. The content of the manual includes several components designed to support learning activities. First, the guidebook provides a detailed explanation of how to use the Kanoma media in the classroom. Second, the guidebook has an answer key to the content presented through Kanoma media. The availability of the answer key is expected to facilitate teachers in checking and evaluating students' understanding of the material taught using Kanoma media. Finally, the guidebook for using Kanoma media is also accompanied by a QR Code that directs students to the arrangement of Kanoma media cards that can be accessed independently. Including this QR Code also shows the utilization of technology in supporting student engagement with learning materials. Overall, the Kanoma media usage guidebook is designed not only as a usage guideline but also as a means to improve learning effectiveness through Kanoma learning media.

3. Construction

The construction stage is carried out by printing all Kanoma media components, namely Kanoma cards, packaging boxes, and a guidebook for using Kanoma media. After the Kanoma cards are printed, the edges are trimmed to form a curve and not sharp. Meanwhile, the printed Kanoma packaging is cut out following the lines on the packaging net and glued using glue to form a card packaging box.

4. Testing

a. Validity

1) Materi Expert Validation Results on Kanoma Learning Media

The results of validating the Kanoma learning media with a questionnaire consisting of 12 statements that were assessed by a lecturer and a mathematics teacher in vocational high school or validators can be seen in the following Table 5.

Table 5. Material Expert Validation Results

$\overline{V}$	Category
0.82	Very High Validity

2) Media Expert Validation Results on Kanoma Learning Media

The results of validating the Kanoma learning media with a questionnaire consisting of 15 statements that were assessed by a lecturer and a mathematics teacher in vocational high school or validators can be seen in the following Table 6.

Table 6. Media Expert Validation Results

$\overline{V}$	Category
0.92	Very High Validity

b. Practicality

The students's responses to Kanoma media showed a practicality percentage of 73%. This indicates that the Kanoma media developed is considered practical. On the other hand, the teacher's responses to Kanoma media showed a practicality percentage of 81%, which is classified as "very practical." Based on the results of the practicality test, it can be concluded that the Kanoma media developed is practical for use in learning.

c. Effectiveness

Before testing the effectiveness of Kanoma learning media, the data obtained were tested for normality first. Normality testing and the effectiveness of Kanoma media were carried out using SPSS version 27 to get more accurate results, as shown in Figure 12.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Posttest_Score	Control	.278	14	.004	.878	14	.055
	Experime	.207	16	.066	.917	16	.148

a. Lilliefors Significance Correction

Figure 12. SPSS K-S Normality Test Experimental and Control Class

Based on the normality test results in Figure 12, the Sig. The Kolmogorov-Smirnov column shows a value of 0.04 for the control class. This indicates that the $p\ value < 0.05$ so H_0 Is rejected. This means that the control class sample data is not normally distributed. On the other hand, the Sig. The Kolmogorov-Smirnov column shows a value of 0.066 for the experimental class. This indicates that the $p\ value > 0.05$ so H_0 Is accepted. This means that the experimental class sample data is normally distributed. Since one data group is not normally distributed, all sample data is not standard. Therefore, this shows that the conditions for using the Mann-Whitney nonparametric statistical test are met. The researcher also used SPSS version 27 to ensure the accuracy of calculating the Kanoma media effectiveness test. Figure 13 below shows the results.

Independent-Samples Mann-Whitney U Test Summary

Total N	30
Mann-Whitney U	184.000
Wilcoxon W	320.000
Test Statistic	184.000
Standard Error	23.399
Standardized Test Statistic	3.077
Asymptotic Sig.(2-sided test)	.002
Exact Sig.(2-sided test)	.002

Figure 13. SPSS Effectiveness Test Results

Based on Figure 13, it can be seen that the Asymptotic Sig. (2-sided test) value is 0.002. This shows that Asymptotic Sig. (2-sided test) < 0.05 so H_0Is rejected. Thus, there is a difference in mathematics learning outcomes between the experimental class that uses Kanoma media and the control class that does not use Kanoma media. Furthermore, based on Figure 14 below, it can be seen that the average value of the posttest in the experimental class using Kanoma media is 60.1563, with a standard deviation of 21.51489. Meanwhile, the mean value of the posttest in the control class that did not use Kanoma media was 41.0714, with a standard deviation of 10.31775. this shows that the difference between the means of the experimental and control classes is quite significant, namely 19.0845, as shown in Figure 14.

Posttest_Score

Class	Mean	N	Std. Deviation	Std. Error of Mean
Control	41.0714	14	10.31775	2.75754
Experimental	60.1563	16	21.51489	5.37872
Total	51.2500	30	19.51734	3.56336

Figure 14. The Results of the Posttest Descriptive Data

5. Implementation

The implementation stage in this study is the activity of disseminating Kanoma media to users. After the media was declared valid, practical, and effective, researchers conducted Kanoma media dissemination activities to mathematics teachers at vocational high schools. This research and development uses the PLOMP approach, which has the stages of preliminary investigation, product design, construction, testing, and implementation. The learning media produced through this research and development is a game card called Domino Math Cards (Kanoma). Kanoma media is based on the problems found in schools, the needs of students and teachers, and the learning objectives to be achieved on related materials. Kanoma media then enters the design stage, starting from creating a storyboard, Kanoma logo, the appearance of the front and back of the Kanoma card, developing Kanoma game rules, Kanoma packaging display, and developing a guidebook as a reference when using Kanoma learning media during learning. After all the designs have been made, the next stage is the construction stage, which prints the designs into natural products. The construction stage produced a guidebook for using the media, a packaging box, and three levels of Kanoma media, with each level containing 25 cards. Kanoma cards are rectangular with a size of 6.35 × 8.89 cm and made of glossy art paper.

After all Kanoma media components are formed, Kanoma media is consulted to material experts and media experts, each consisting of two validators. The results of expert validation are obtained from the results of the validator's assessment by filling out the material expert and media expert assessment sheets. The material expert assessment sheet consists of 12 statement items, while the media expert assessment sheet consists of 15 statement items representing Kanoma media's validity. The results of the validity of Kanoma media from material experts consisting of a lecturer and a mathematics teacher at a vocational high school show that the Kanoma media developed is included in the category of products with very high validity with a

validity value of 0.82. Meanwhile, the assessment of media experts, who consisted of a lecturer and a mathematics teacher at a vocational high school, obtained a score of 0.92. This shows that Kanoma media has very high validity. The validity of Kanoma media is also obtained based on the suggestions and input provided by the validator. The results of the revision of Kanoma media after being validated in the form of additional levels of Kanoma cards. Kanoma 1 media consists of 25 cards containing five quadratic equations with a coefficient x squared of1. Kanoma 1 media is intended for student groups with low learning ability category. Kanoma 2 media consists of 25 cards containing five quadratic equations with a coefficient x squared of2. Kanoma 2 media is intended for students with medium ability. Kanoma 3 media consists of 25 cards containing five quadratic equations with coefficsquared is 3. Kanoma 3 media is designed for students with high ability. To play Kanoma media, students must find pairs of cards with the terms "quadratic equation-root of a quadratic equation." students must match the quadratic equation on a Kanoma card with the root of the quadratic equation on another Kanoma card. After revisions, the Kanoma learning media was declared to apply to learning in schools.

The application of Kanoma media in schools is aimed at assessing the practicality and effectiveness of Kanoma media in improving students' concept understanding ability on the material of finding the roots of quadratic equations. The practicality of Kanoma media is measured from student and teacher responses. In contrast, the effectiveness of Kanoma media is measured by comparing learning outcomes between classes that use Kanoma learning media and classes that do not use Kanoma learning media. The practicality test results from student responses show that the Kanoma media developed are included in the practical category with a practicality value of 73%. Meanwhile, the practicality value obtained from the math teacher's response was 81% and included in the practical category. With the acquisition of a good practicality value, Kanoma media is expected to improve students' mathematical concept understanding ability at school, especially in terms of finding the roots of quadratic equations.

Furthermore, the effectiveness of Kanoma media was tested by processing data from the post-test results of experimental and control class students. The data from the posttest results were first checked for distribution, whether customarily distributed or not. The test was conducted using SPSS version 27 with results showing that the posttest data of experimental class students were normally distributed. Still, the posttest data of control class students were not normally distributed. Due to the non-normality of the data, the Mann-Whitney test was used to test the effectiveness of Kanoma media. Testing was also carried out using SPSS 27 to test the null hypothesis, namely H_0 (the distribution of posttest scores is the same across class categories). The results showed that. H_0Is rejected. Thus, there is a difference in mathematics learning outcomes between the experimental class that uses Kanoma media and the control class that does not use Kanoma media. This can be seen from the fact that the difference between the means of the experimental and control classes is quite large, namely 19.0845.

Compared to previous studies, Kanoma, a game-based learning media specifically designed to improve students' understanding of quadratic equations, is introduced in this study. Although various instructional approaches have been explored previously, Kanoma uniquely integrates interactive games with targeted learning objectives tailored to different learning abilities. The findings from this study build on previous research by showing that Kanoma significantly improves students' understanding of mathematical concepts, especially in

identifying the roots of quadratic equations, as evidenced by the assessment of practicality and effectiveness.

The interpretation of these results emphasizes the effectiveness of Kanoma in an educational setting. By engaging students through interactive games aligned with curriculum objectives, Kanoma not only enhances conceptual learning but also encourages deeper engagement with quadratic equations. Its practical implications include its potential to complement traditional teaching methods, meeting the diverse learning needs of students. However, limitations such as the need for further adaptation for different educational contexts and potential biases in assessment methodologies are also recognized. The findings contribute to existing knowledge by demonstrating the efficacy of game-based learning media such as Kanoma in improving math learning outcomes. Addressing the specific challenges of teaching quadratic equations, Kanoma enriches instructional practice with a tangible tool that supports teachers and students. This contribution is not only limited to the theoretical framework, but also to practical applications in educational settings, potentially influencing curriculum development and learning strategies. Despite its strengths, limitations of this study include its focus on a specific age group and educational setting. Future research could explore the scalability of Kanoma across different grade levels and subjects to further validate its wider applicability. Also, although the Mann-Whitney test provided strong statistical evidence, future research may consider using complementary methodologies to triangulate the findings and reduce potential bias.

D. CONCLUSION AND SUGGESTIONS

Kanoma media developed through the PLOMP research and development approach is a very valid. Material validity experts gave very high validity scores (0.82), which indicates a strong alignment between Kanoma media and educational content standards. Similarly, media validity experts gave a score of 0.92, which confims that Kanoma media meets high standards in terms of its instructional design, presentastion, and suitability for educational purposes. To assess the effectiveness of Kanoma media in improving students' understanding of mathematical concepts, specifically, finding the roots of quadratic equations in class X of vocational high school, a posttest comparison was conducted between the experimental class that used Kanoma media and the control class that did not use Kanoma media. The results of statistical analysis using SPSS version 27 show that the value of Asymptotic Sig. (2-sided test) < 0.05, which indicates a significant difference in math learning outcomes between the experimental and control groups. This rejection of the null hypotesis (H_0) sopports the conclusion that Kanoma media effectively improves student's learning outcomes in mathematical concepts compared to traditional methods. The practicality of Kanoma media was confirmed through high satisfaction ratings from students (73%) and teacher (81%), who categorized it as 'practical' and 'very practical' respectively. These findings underscores the usefulness and effectiveness of Kanoma media in teaching mathematics concepts.

Based on the research results on the Kanoma learning media design on the Quadratic Equation material for class X students at vocational high school, the researcher recommends that teachers integrate this media into the curriculum by compiling a module that contains steps for use and organizing a planned schedule for its use. Teachers can use Kanoma in

collaborative learning in class, monitor student progress, and provide feedback. Students are expected to use the QR code in the guide for self-study at home, and complete all questions to improve concept understanding. In addition, it is important for students to pay attention to the teacher's instructions when using Kanoma in order to maximize the benefits of this media. The researcher also suggested making a video tutorial on the use of Kanoma media that can be accessed by students before learning takes place. This is important to do so that all students can understand the use of Kanoma media better and evenly, even though the media has been practiced in front of the class. The next suggestion is for other researchers. Other researchers are expected to develop Kanoma with a wider range of materials to improve students' understanding of mathematical concepts.

ACKNOWLEDGEMENT

Thank you to all those who have encouraged the author during the completion of this article. Hopefully, this small effort will be of great benefit. No ivory does not crack; suggestions and constructive criticism from readers will be received with pleasure.

REFERENCES

Adawiyah, A. R., & Kowiyah, K. (2021). Pengembangan Media Kartu Domino pada Pembelajaran Matematika Operasi Perkalian Siswa Sekolah Dasar. *Jurnal Basicedu*, *5*(4), 2370–2376. https://doi.org/10.31004/basicedu.v5i4.1224

Afhami, A. H. (2022). Aplikasi Geogebra Classic terhadap Pemahaman Konsep Matematika Siswa pada Materi Transformasi Geometri. *Plusminus: Jurnal Pendidikan Matematika*, *2*(3), 449–460. https://doi.org/10.31980/plusminus.v2i3.1878

Ammy, P. M. (2021). Approach in Improving Students' s Mathematical Understanding Abilities. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *5*(2), 463–469. https://doi.org/10.31764/jtam.v5i2.4743

Arif, A., & Mukhaiyar, R. (2020). Pengembangan Multimedia Interaktif pada Mata Pelajaran Dasar Listrik dan Elektronika Kelas X Teknik Instalasi Tenaga Listrik di SMK Muhammadiyah 1 Padang. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *6*(1), 114. https://doi.org/10.24036/jtev.v6i1.107717

Budiyono. (2017). *Pengantar Metodologi Penelitian Pendidikan*. UNS Press.

Farman, F., Hali, F., & Rawal, M. (2021). Interest and Resilience in Online Mathematics Learning and Its Impact on Concept Understanding. *SAINSMAT: Journal of Applied Sciences, Mathematics, and Its Education*, *10*(2), 60–67. https://doi.org/10.35877/sainsmat1022222021

Febriani, D. S., & Arini, N. W. (2023). *Development Of Modified Domino Card Learning Media In Science Learning Material On Animal Life*. *7*(2), 29–43. https://doi.org/10.32934/jmie.v7i2.556

Fonseca, V. G. da, & Henriques, A. C. C. B. (2020). I am learning with Understanding the Continuity Concept: A Teaching Experiment with Brazilian Pre-service Mathematics Teachers. *International Electronic Journal of Mathematics Education*, *15*(3), em0606. https://doi.org/10.29333/iejme/8462

Hastuti, T. A., Sari, I. P. T. P., & Andrianto, S. D. (2023). *Analysis of the Aiken Index to Know the Content Validity of the Lesson Plan Evaluation Instrument on Physical Fitness Materials Viewed from Learning Strategies* (Issue Yishpess). Atlantis Press International BV. 276-282. https://doi.org/10.2991/978-94-6463-356-6_31

Khairurrijal, I., Hermansah, B., & Ayurachmawati, P. (2023). Development of Domino Card Media in Science Learning in Grade Vi Elementary School. *Jurnal Cakrawala Pendas*, *9*(2), 285–297. https://doi.org/10.31949/jcp.v9i2.4523

Manik, T. M., Syahputra, E., & ... (2021). Development of Rme Based Mathematics Learning Media To Improve Concept Understanding Ability of Elementary School .... *Sensei International Journal of Education and Linguistic*, *1*(4), 822–841. http://www.sijel-journal.sensei-journal.com/index.php/jbo/article/view/58

Monalisa, L. A., Susanto, Fatahillah, A., Prihandini, R. M., Hussen, S., & Fajri, E. D. R. (2021). The

development of online interactive learning media using Google Classroom was assisted by geogebra software on the quadratic function material. *Journal of Physics: Conference Series*, *1832*(1), 1-9. https://doi.org/10.1088/1742-6596/1832/1/012059

Nashiroh, F., & Zainuddin, A. (2023). Development of GeoGebra-Based Fraction Gap Learning Media to Improve Understanding of the Fraction Concept of Grade V Elementary School. *DIDAKTIKA TAUHIDI Jurnal Pendidikan Guru Sekolah Dasar*, *10*(1), 55–69. https://doi.org/10.30997/dt.v10i1.8238

Prillyana, F. S., Cahyono, H., & Farida, A. (2020). Developing Interactive Learning Media of "Venn Gram" to Improve Conceptual Understanding of Set Operations Fadhanila Syainuralita Prillyana, Hendarto Cahyono, Anis Farida Jamil. *Mathematics Education Journals*, *4*(1), 86–94. https://doi.org/10.22219/mej.v4i1.11473

Rahmadiani, R., Alfisyahra, A., Lefrida, R., & Pathuddin, P. (2024). Concept Understanding Students on the Two-Variables Linear Equation System Material in Terms of Mathematics Ability. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *12*(1), 160. https://doi.org/10.33394/j-ps.v12i1.10532

Rahman, A. A., & Amalia, Y. (2019). Development of Domino Card as Math Learning Media to train students' Conceptual understanding. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *9*(2), 91–100. https://doi.org/10.30998/formatif.v9i2.3089

Rohmah, R. N., & Setyaningrum, W. (2022). Learning Mathematics Through Videos Lines and Angles : How to Analyze Students ' Understanding of Mathematical Concepts ? *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *6*(2), 386–396. https://doi.org/10.31764/jtam.v6i2.7403

Suharianto, J., Arwansyah, Tambunan, K. E., & Saragih, I. R. (2022). The Effectiveness of Nonparametric SPSS Based Statistic Practicum Module Development in Improving the Student Learning Result. *Proceedings of the 2nd International Conference of Strategic Issues on Economics, Business and, Education (ICoSIEBE 2021)*, *204*(ICoSIEBE 2021), 262–268. https://doi.org/10.2991/aebmr.k.220104.040

Sumadi, I. P., Kusmayadi, T. A., & Fitriana, L. (2022). Validity, Practicality, and Effectiveness of Ludo Cartesius Learning Media to Improve Understanding of Mathematical Concepts. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *6*(3), 581. https://doi.org/10.31764/jtam.v6i3.8477

Tisna MS, G. D., Kusuma, K. C. A., Muliarta, I. W., & Darmawan, G. E. B. (2023). Content validity of D-MESS: Articulate storyline 3-based learning media in sport massage courses. *Journal Sport Area*, *8*(1), 105–116. https://doi.org/10.25299/sportarea.2023.vol8(1).11266

Topano, A., Kurniawan, D., & Saputra, E. A. (2023). Developing of STEM-based charta learning media to improve critical thinking ability student on plant structure and function material. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(3), 462–469. https://doi.org/10.22219/jpbi.v9i3.28352

Yuliany, N., Yana, A. J., Nur, F., Pamungkas, M. D., Uyuni, A., & ... (2019). The Comparison of Students' Understanding Ability on Mathematics Concept by Using the Team Games Tournament Learning Model and Think Pair Share. *Isimmed.Uny.Ac.Id*, *20*, 47–54. http://isimmed.uny.ac.id/sites/isimmed.uny.ac.id/files/Proceeding2019/8 Nur Yuliany%3B Asri Juli Yana%3B Fitriani Nur%3B Megita Dwi Pamungkas%3B Ainul Uyuni Taufiq%3B Baharuddin%3B Jusmawati%3B Andi Ika Prasasti Abrar%3B Hafsyah%3B Nidya Nina Ichiana.pdf

Yulistia, T. (2024). Analysis of the Need for Padlet-Based Learning Media Development to Improve Understanding of Concepts in Class XI Circular Motion Material at SMA Kota Bengkulu. *FINGER : Jurnal Ilmiah Teknologi Pendidikan*, *3*(1), 102–107. https://doi.org/10.58723/finger.v3i1.201

Zahroni, S. (2022). A systematic review of learning media research trends from 2011 to 2021. *Journal of Educational Technology and Instruction*, *1*(1), 36–47. https://ijeti-edu.org/index.php/ijeti/article/view/8%0Ahttps://ijeti-edu.org/index.php/ijeti/article/download/8/6