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**Navissa Briliani Sabilla^a, Mochammad
Taufan^{b*}**

^aMathematics Education Program,
Faculty of Teacher Training and
Education, University of Wiralodra,
Indramayu,

navissabrilianisabilla@gmail.com

^{b*} Lecturer, Mathematics Education
Program, Faculty of Teacher Training
and Education, University of Wiralodra,
Indramayu,

mochammad.taufan@unwir.ac.id

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Differences in Students' Mathematical Concept Understanding Ability in Problem Based Learning (PBL) Models Assisted by Geogebra and Kahoot on Quadratic Function Material

Navissa Briliani Sabilla^a, Mochammad Taufan^{b*}

^{a*} Mathematics Education Program, Faculty of Teacher Training and Education, University of Wiralodra, Indramayu, navissabrilianisabilla@gmail.com

^b Lecturer, Mathematics Education Program, Faculty of Teacher Training and Education, University of Wiralodra, Indramayu, mochammad.taufan@unwir.ac.id

* Correspondence: mochammad.taufan@unwir.ac.id

ABSTRACT

Students' ability to understand mathematical concepts in the quadratic function material is still low because students have difficulty in connecting algebraic forms with graphical representations. as well as apply draft in solution problem. Besides That, learning Which still centered on Teacher And lack of utilization technology cause student not enough active in building conceptual understanding. This study aims to determine the differences in mathematical concept understanding abilities of students who learn using the Problem Based Learning model assisted by GeoGebra and Kahoot , as well as to describe the feasibility of the media and test instruments used. The results of the learning media validation obtained an average percentage of 82.00% with category very valid , whereas validation instrument test get an average of 98.33% with a very valid category . The trial results show that the GeoGebra-assisted PBL class get mark average pre-test 54.20, post-test 84.60, And N-Gain 0.66, while the class Problem Based Learning assisted Kahoot get mark average pre-test 53.80, post-test 79.20, and N-Gain 0.55. Thus, the media and instruments used are suitable for application in learning, and there are differences in the ability to understand mathematical concepts. student between second model learning, where is the problem Based Learning GeoGebra assistance is more effective in improving students' mathematical concept understanding abilities in quadratic function material.

Keywords: Comprehension Ability Mathematical Concepts, Problem Based Learning, Geogebra, Kahoot, Quadratic Function.

1. Introduction

Education is a basic right of every citizen that is guaranteed by the 1945 Constitution of the Republic of Indonesia Article 31 paragraph (1) which states that every citizen country entitled get education. Furthermore, Chapter 31 paragraph (3) confirm that the government is working towards and organizing a national education system that aims to increase faith, piety and noble morals in order to enlighten life nation. In context education century 21st, learning mathematics It is hoped that mathematics will not only be oriented towards mastering procedures, but will also be able to develop critical, creative, collaborative, and communicative thinking skills. Therefore, mathematics learning should ideally be able to build a deep understanding of concepts so that students can connect various draft mathematics And apply it in real-life problem solving (NCTM, 2020).

The ability to understand mathematical concepts is one of the main goals of mathematics learning. According to the National Council of Teachers of Mathematics (NCTM, 2020), conceptual understanding enables students to understand the relationships between mathematical ideas, so that the knowledge gained is not merely rote (Haji & Yumiati, 2019). Curriculum Independent Also emphasize importance learning Which centered on participant educate through meaningful exploration, investigation, and problem solving. Therefore, teachers are required to For apply model learning innovative Which can help student build concepts actively and independently so that national education goals can be achieved optimally .

Based on the results of initial observations conducted at the research school, it was found that the ability understanding draft mathematical student Still classified as low, specifically on Quadratic function material. Most students have difficulty determining the relationship between the algebraic form of a quadratic function and its graphical representation. Furthermore, students still experience errors in determining the vertex, axis of symmetry, roots of the function, and interpreting changes in coefficients in relation to the parabola (Fauzi & Prihatnani, 2020). This condition indicates that students' understanding is still at the procedural level and has not yet reached a deep conceptual understanding.

This problem is thought to be influenced by the learning process, which is still dominated by lecture methods and routine practice exercises. During the learning process, teachers more Lots explain material in a way verbal without supported media visual Which inadequate. As a result, abstract concepts in quadratic functions are difficult for students to grasp concretely. (Purwadewi & Ruqoyyah, 2021) explain that learning that is still teacher-centered And minimal use media learning can cause student experience difficulty in understanding mathematical concepts in depth. Furthermore, (Erlangga et al., 2023) stated that low student engagement in the learning process results in limited opportunities for students to explore and construct their own understanding. By Because That, required innovation learning Which capable increase student activity and facilitate understanding of concepts in a more concrete and meaningful way.

Various efforts have been made to improve the ability to understand mathematical concepts. student. Wrong One approach Which Lots used is implementation model Problem Based Learning (PBL). This model places students at the center of learning through problem solving. problem contextual so that student can construct knowledge in a way active. (Handayani & Muhammad, 2020), state that model PBL is capable practice ability

high-level thinking because students are actively involved in the learning process. In addition, (Erlangga et al., 2023) explain that implementation PBL give influence positive towards students' understanding of concepts and problem-solving abilities through investigative activities and finding solutions to the problems given.

In addition to the application of innovative learning models, the integration of technology in mathematics learning Also Keep going developed. Utilization technology education allows Abstract mathematical concepts are visualized in a more concrete and engaging way. (Aien et al., 2025) explain that the use of GeoGebra-based learning technology can help students visualize mathematical concepts dynamically, thereby increasing learning interest and conceptual understanding. In addition, (Nursyahira et al., 2024) found that the use of interactive digital media in mathematics learning can increase student motivation, participation, and learning outcomes. However, the use of technology in mathematics learning is still not optimal, and there is not much research directly comparing the effectiveness of two different media within the PBL model framework.

Learning media is anything that can be used to convey messages, stimulate the thoughts, feelings, attention and will of students so that it can encourage learning. learning process. (Sudianto, 2021), explains Learning media plays a crucial role as a medium for delivering material, enabling students to more easily understand abstract mathematical concepts. Furthermore, (Hasiru et al., 2021) stated that the use of appropriate learning media can improve student motivation, learning outcomes, and understanding in mathematics. Therefore, media plays a crucial role because it can help students understand draft abstract through representation visual, simulation, and activity interactive which supports concept formation.

One form of technology-based learning media development widely used in mathematics learning is GeoGebra and Kahoot. (Aien et al., 2025) explain that GeoGebra is dynamic mathematics software that allows students to explore concepts through interactive visualizations of graphs, geometry, and algebra. Meanwhile, (Lubis & Ulfah, 2024) explain that Kahoot is a platform learning based game (game-based learning) Which provides interactive quizzes with immediate feedback to increase student motivation and engagement in learning. Both media have different characteristics but both have the potential to support the implementation of the Problem-Based Learning model in quadratic function material.

Previous research has shown that the use of GeoGebra and Kahoot has a positive impact on mathematics learning. Research (Baye et al., 2021) demonstrated that GeoGebra can improve understanding of mathematical concepts by helping students connect symbolic and visual representations. (Ziatdinov & Valles, 2022) also found that GeoGebra effectively improves mathematical concept exploration skills. in a way independent. Temporary that, (Wang & Tahir, (2020) conclude that Kahoot can significantly increase learning motivation, student participation, and learning outcomes. Research (Licorish et al., 2018) also shows that using Kahoot increases student engagement. student during process learning ongoing. Although thus, study which specifically compares students' mathematical concept understanding abilities in the GeoGebra-assisted PBL model and Kahoot-assisted PBL is still relatively limited.

This study important because ability understanding draft mathematical is foundation main in learning mathematics, specifically on material function quadratic equations that require visualization skills and understanding of relationships between concepts. (Aprilian, 2024) states that understanding mathematical concepts is a basic skill that students must have in order to connect various mathematical representations and solve problems. problem in a way meaningful. Besides That, (Seto et al., 2025) explain that quadratic function material is one of the Abstract material requires the assistance of interactive visualization media so that students can better understand the concept. Developments in educational technology also require teachers to choose learning media that are effective in support process learning. By Because That, required study which is able to provide empirical evidence regarding the differences in students' mathematical concept understanding abilities between the use of the GeoGebra-assisted *Problem Based Learning model* and the Kahoot-assisted *Problem Based Learning model* so that it can be a basis for consideration for teachers in determining appropriate learning media.

Based on the background description, the problem formulation in this research is: (1) Is there a difference in the ability to understand mathematical concepts between students who learn using the Problem Based Learning (PBL) model assisted by GeoGebra and students who Study use model Problem Based Learning (PBL) assisted Kahoot on quadratic function material? (2) Is the mathematical concept understanding ability of students who learn using the Problem Based Learning (PBL) model assisted by GeoGebra better than the specified criteria? (3) Is the mathematical concept understanding ability of students Which Study use model Problem Based Learning (PBL) assisted Kahoot better than the specified criteria? (4) Is the use of GeoGebra effective in improving ability understanding draft mathematical student on material function square? and (5) Is the use of Kahoot effective in improving the ability to understand mathematical concepts? student on material function square? Formulation problem This expected can provide clear direction in conducting research.

2. Methods

This research uses a quantitative approach with a quasi-experimental method (experiment). pseudo). Approach quantitative used Because study aim measure and compare students' ability to understand mathematical concepts objectively through numerical data Which analyzed use statistics inferential. According to (Creswell, 2023), Quantitative research is a research approach used to test theories by measuring the relationships between variables using research instruments and statistical analysis. The quasi-experimental method was chosen because it prevented random assignment of research subjects, but allowed researchers to still administer treatment to existing groups. This study aimed to determine differences in comprehension abilities. draft mathematical student Which Study use model Problem Based Learning (PBL) assisted GeoGebra And Problem Based Learning (PBL) assisted Kahoot on quadratic function material.

Design study Which used is Nonequivalent Control Group Design. Design This study involved two experimental groups that received different treatments, namely the first group using the Problem Based Learning (PBL) model assisted by GeoGebra and the second group using the Problem Based Learning (PBL) model assisted by Kahoot. study started with giving pre-test to second group For to determine students' initial mathematical concept understanding abilities. Next, both groups were given treatment in accordance with media learning Which used during process learning function

After all the material was taught, students were given a post-test to determine their mathematical concept comprehension after the treatment. The pre-test and post-test results were then compared to determine improvements in student abilities and differences in effectiveness. second internal media support implementation model Problem Based Learning (Fraenkel et al., 2022).

Table 1

Design Study

Kelompok	Pretest	Perlakuan	Posttest
Eksperimen I	O_1	X_1 (PBL + GeoGebra)	O_2
Eksperimen II	O_3	X_2 (PBL + Kahoot)	O_4

Information:

O_1, O_3 = Pretest conceptual understanding ability mathematical

O_2, O_4 = Posttest ability understanding of mathematical concepts

X_1 = Treatment PBL assisted GeoGebra

X_2 = PBL Treatment with the help of Kahoot

Subject study is student SENIOR HIGH SCHOOL Which currently learn material function square in the current semester. The study involved two classes with relatively similar characteristics based on academic ability and previous mathematics learning outcomes. One class was designated as experimental group I, receiving GeoGebra-assisted problem-based learning, while the other class, as experimental group II, received Kahoot-assisted problem-based learning. In addition to students, the mathematics teacher Also involved in process implementation learning. (Sugiyono, 2023) explains that subject study is individual or group Which become source data research and selected according to the established research objectives. In addition, expert validators, consisting of material experts, media experts, and evaluation experts, are tasked with assessing the suitability of learning devices and research instruments before they are used in the research.

The research instruments used consisted of a mathematical concept comprehension test, a validation sheet, and a student response questionnaire. The mathematical concept comprehension test was used in the form of a pre-test and post-test to measure students' abilities before and after treatment. The test questions were structured based on indicators of mathematical concept comprehension, namely the ability to restate concepts, classify objects according to certain properties, provide examples and non-examples, and present concepts in various mathematical representations. as well as use draft For finish problem. Sheet validation The questionnaire was used to obtain assessments from material experts, media experts, and evaluation experts regarding the learning tools used. Furthermore, a student response questionnaire was used to determine students' responses to the use of GeoGebra and Kahoot during the learning process. (Arikunto, 2021) states that research instruments must meet the principles of validity and reliability so that the data obtained can be trusted and scientifically accounted for. Therefore, Because That, all over instrument Which used in study This moreover formerly validated before use in the data collection process.

The validity of learning devices and research instruments includes media validity, data validity, and material, And validity evaluation. Evaluation done by validator use scale

Likert with range score 1–5. Score 1 show category No agree, score 2 not enough agree, score 3 is neutral, score 4 is agree, and score 5 is strongly agree.

Table 2

Validation Assessment Scale

Criteria	Value/Score
Very Agree (SS)	5
Agree (S)	4
Neutral (N)	3
Not enough Agree (KT)	2
No Agree (TS)	1

Results calculation percentage used For determine level validity media, materials, and instrument evaluation Which developed. According to (Riduwan, 2022), scale Likert very It is suitable for measuring perceptions, opinions and expert assessments of an educational product because it produces quantitative data that is easy to analyze and interpret.

Interpretation of validation results is carried out based on the percentage score obtained from the validator. Product stated worthy used if fulfil category valid or very Valid. The eligibility criteria used in this study refer to the following modifications (Riduwan, 2022):

Table 3

Criteria Interpretation Eligibility

Criteria	Percentage (%)
No Valid	0% - 20%
Less Valid	21% - 40%
Enough Valid	41% - 60%
Valid	61% - 80%
Very Valid	81% - 100%

Products that earn a percentage minimum 61% stated worthy used in learning process with or without minor revisions. Conversely, products that achieve a percentage below 61% need to be revised according to the validator's suggestions before being used in research.

Data analysis was conducted to determine the effectiveness of the use of the Problem Based Learning model assisted by GeoGebra and Kahoot on students' mathematical concept understanding abilities. The initial stage of analysis included testing the validity and reliability of the test instrument. Next, descriptive statistical analysis was conducted in the form of average values, maximum scores, minimum scores, and standard deviations. Before testing the hypothesis, the data were first tested using normality tests and homogeneity tests as prerequisite tests for analysis. Hypothesis testing was conducted using the Independent Sample t-Test to determine the differences in mathematical concept understanding abilities between the GeoGebra-assisted PBL group and the Kahoot-assisted PBL group. In addition, the increase in student abilities was analyzed using the N-Gain calculation to determine the level of effectiveness of each treatment. According to (Meltzer, 2002), N-Gain is an effective method for measuring improvements in learning outcomes based on the difference between score pre-test And post-test. Analysis results the used For determine more effective media in improving students' mathematical concept understanding on quadratic functions. The N-Gain calculation is used to determine the effectiveness of the applied learning with the formula:

$$g = \frac{\text{Skor Post test} - \text{Skor Pre test}}{\text{Skor Maksimum} - \text{Skor Pre test}}$$

Results calculation N-Gain Then interpreted based on category N-Gain according to (Meltzer, 2002).

Table 4
Classification Mark Standard N- Gain

Mark Standard N- Gain	Classification
$G > 0.7$	Tall
$0.7 > g > 0.3$	Currently
$G < 0.3$	Low

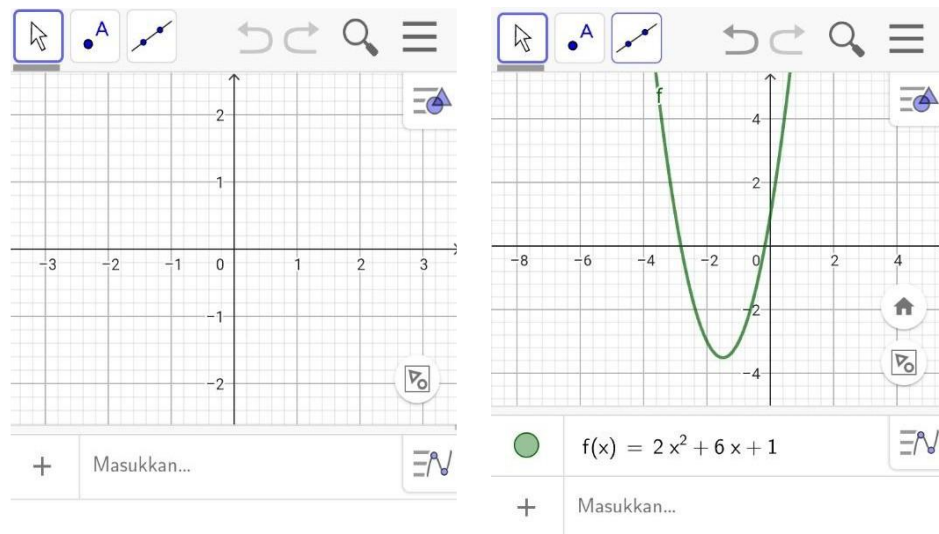
Results analysis N-Gain used For determine level effectiveness model Problem Based Learning (PBL) assisted by GeoGebra and Kahoot to improve students' mathematical concept understanding ability in quadratic function material.

3. Results And Discussion

The analysis and design stages were conducted through initial observations of mathematics learning on quadratic functions at the high school where the research took place. The results of the observations showed that part big student Still experience difficulty in understand The relationship between the algebraic form of a quadratic function and the graphical representation of a parabola. The learning process tends to be teacher-centered and the use of learning media is still limited to textbooks and blackboards, so students lack the visual experience to support conceptual understanding. In addition, the results of interviews with mathematics teachers indicate that students' mathematical conceptual understanding is still relatively low, especially in the indicators of determining the peak point, the roots of a function, and the relationship between coefficients and form chart function square. Based on condition the, required learning which can activate students through problem-solving and is supported by technology-based media. Therefore, learning was designed using the Problem Based Learning (PBL) model assisted by GeoGebra. and Kahoot that suits the characteristics high school students which has been on stage think formal operational. On stage This Also arranged device learning in the form of media, pre-test and post-test questions on conceptual understanding skills mathematical, as well as student response questionnaires. The instrument was developed based on indicators of mathematical concept understanding, which include the ability to restate concepts, classify objects, provide examples, and non-example, represent draft in various form, as well as apply draft in problem solving.

The development stage is carried out by creating learning devices according to the Problem syntax. Based Learning (PBL). On class experiment I developed learning GeoGebra-assisted learning facilitates dynamic visualization of quadratic function graphs, while in experimental class II, Kahoot-assisted learning was developed as a game-based interactive evaluation tool. After the media was developed, validation was carried out by two lecturers. education mathematics And One Teacher mathematics. Validator give a number of The input included improvements to the GeoGebra user manual, adjustments to the difficulty level of the Kahoot questions, and improvements to the language to make it more communicative. After revisions, the media was revalidated and the following results were obtained.

Figure 1.
 Appearance GeoGebra



Picture 2.
 Kahoot View

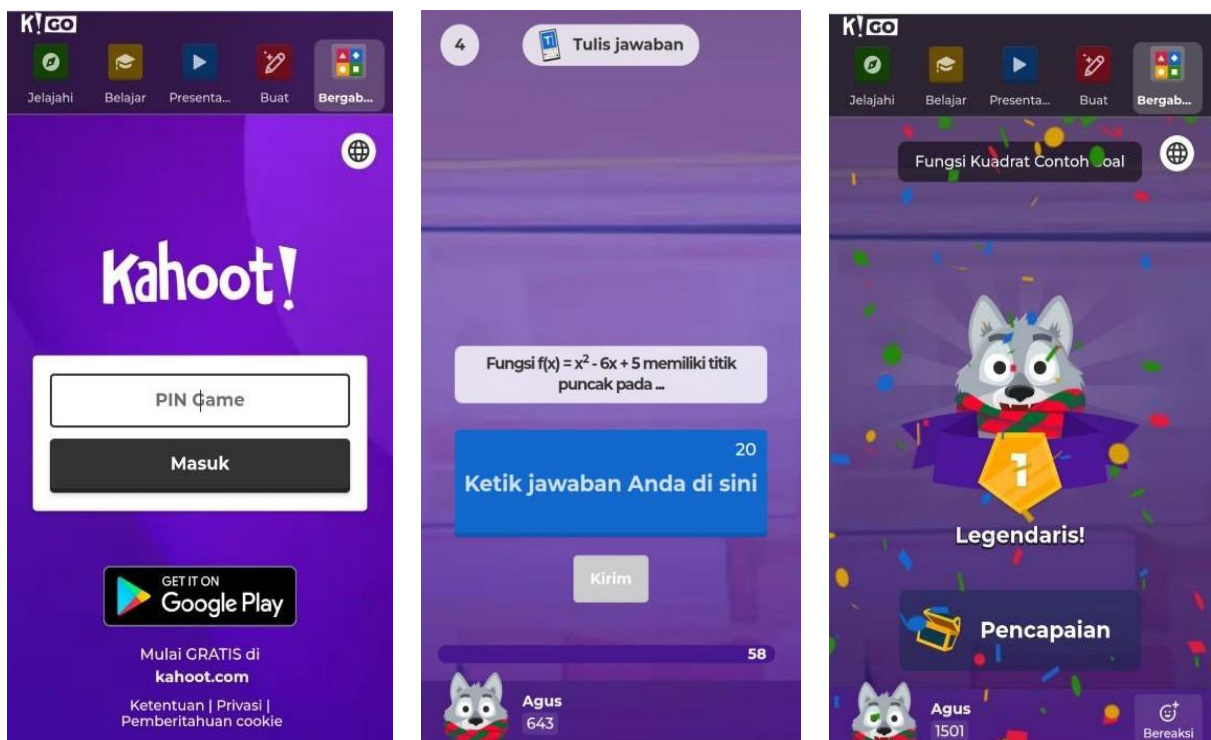


Table 5
Recapitulation Results Validation Expert Media

Component	Mark
Score obtained	41
Score maximum	50
Percentage eligibility	82.00%
Category	Very Valid
Decision Validator	Valid used with revision in accordance with suggestions

Based on the table, the media validation percentage was 82.00% with the category very valid. Results the show that media learning Which The developed software meets the feasibility criteria and can be used in the learning process. This finding aligns with research by Hohenwarter and Lavicza (2021) which found that GeoGebra can improve the visualization of mathematical concepts, and research by Wang and Tahir (2020) which showed that Kahoot can increase student engagement in the learning process.

Apart from learning media, validation is also carried out on The test instruments used to measure students' mathematical concept understanding abilities are pre-test and post-test questions. Validation done by expert material and expert evaluation use scale Likert 1–5 Which includes aspects of suitability of indicators, question construction, clarity of language, and suitability of material quadratic function.

Table 6
Recapitulation Results Validation Instrument Pretest And Posttest

Component	Mark
Score obtained	59
Score maximum	60
Percentage eligibility	98.33%
Category	Very Valid
Validator's Decision	Can be used with revision small

Based on obtained percentage validation instrument as big as 98.33% with category highly valid. These results indicate that the pre-test and post-test questions developed have met very high validity criteria in terms of material, construction, and language. Thus, the test instrument is suitable for measuring students' mathematical conceptual understanding of quadratic functions without requiring significant revision. The high percentage validation show that every grains question has in accordance with indicator The ability to understand the mathematical concepts being studied, thereby producing accurate and reliable data. According to (Sugiyono, 2023), an instrument with a very high level of validity will provide more accurate measurement results in describing the students' actual abilities.

After the learning media and research instruments were declared valid, the research was carried out. on two class experiment Which get treatment different, that is Problem Based Learning (PBL) learning assisted by GeoGebra and Problem Based Learning (PBL) assisted by Kahoot. Measurement of students' mathematical concept understanding abilities was carried out through test written shaped question description Which done in a way manual on sheet answer Handwritten. A pre-test was administered before the lesson to determine students'

initial abilities in the quadratic function material, while a post-test was administered after the treatment to determine improvements in students' mathematical conceptual understanding. Assessment was conducted based on scoring guidelines that had been developed according to indicators of mathematical conceptual understanding.

Table 7

Results Pre-test, Post-test, And N- Gain

Class	Pre- test	Post- test	N- Gain	Category
PBL + GeoGebra	54.20	84.60	0.66	Currently
PBL + Kahoot	53.80	79.20	0.55	Currently

Based on the table, it can be seen that the average pre-test scores of students in both classes are relatively The same, Which show that ability beginning student is at on level Which comparable before given treatment. After process learning ongoing, mark post-test on Both classes experienced improvement. The class that received GeoGebra-assisted PBL learning obtained an average post-test score of 84.60 with an N-Gain of 0.66, while the class that received learning PBL assisted Kahoot get average mark post-test as big as 79.10 with an N-Gain of 0.55. Based on the classification (Meltzer, 2002), both N-Gain values are in the moderate category. However, the increase in students' mathematical concept understanding in the GeoGebra class was higher than in the Kahoot class. This indicates that the use of dynamic visualization through GeoGebra is more effective in helping students understand the concept of quadratic functions, especially in connecting algebraic forms with graphical representations and solving problems related to quadratic functions.

The results of the study show that the learning media used in the Problem Based Learning (PBL) model, both assisted by GeoGebra and Kahoot, have met the eligibility criteria for use in the mathematics learning process on quadratic function material. Matter This proven by results validation media Which get average percentage by 82.00% with category very valid. The height mark validation the show that display aspect, convenience use, suitability material, And interactivity media has in accordance with the needs of mathematics learning at the high school level. Valid media enables the learning process ongoing more effective Because capable help student understand the concepts that nature abstract through presentation Which more interesting And interactive. Results This in line with Mayer's opinion (2021) which states that the use of technology-based media can improve the learning process through visual and verbal integration which helps students build a deeper understanding of concepts.

In addition to the learning media, the research instrument used to measure students' mathematical conceptual understanding also achieved an average validation score of 98.33%, categorized as highly valid. These results indicate that the pre-test and post-test questions met the appropriateness criteria for material, construction, language, and indicators of mathematical conceptual understanding. The high level of instrument validity indicates that the instrument was able to accurately and consistently measure the abilities being studied. According to (Sugiyono, 2023), instrument Which own validity tall will produce more accurate data so that the research conclusions obtained can be trusted.

4. CONCLUSION

Based on results study, can concluded that media learning GeoGebra and Kahoot used in the Problem Based Learning (PBL) model have met the criteria for highly valid, with a media validation percentage of 82.00% and an instrument validation percentage of 98.33%. The results also showed that students' mathematical concept understanding ability increased in both experimental classes. The class that received the learning PBL assisted GeoGebra get mark N-

Gain as big as 0.66, whereas classes that received PBL learning assisted by Kahoot get grades N-Gain of 0.55 which both of them including category currently. However, improvement ability understanding mathematical concepts student on class GeoGebra more tall compared to class Kahoot. With Thus, there is a difference in students' mathematical concept understanding ability between learning using the GeoGebra-assisted Problem Based Learning (PBL) model and the Kahoot-assisted Problem Based Learning (PBL) model on the quadratic function material, where the GeoGebra-assisted PBL model is more effective in improving students' mathematical concept understanding ability.

Based on research findings, GeoGebra and Kahoot learning media applied in the Problem-Based Learning (PBL) model were declared highly valid and suitable for use in mathematics learning on quadratic functions. The research findings showed that both media were able to improve students' understanding of mathematical concepts. student, However improvement Which obtained through use GeoGebra more higher than Kahoot. This is indicated by the N-Gain value of 0.66 for the GeoGebra-assisted PBL class and 0.55 for the Kahoot-assisted PBL class. Therefore, GeoGebra is more effective to use. For increase ability understanding draft mathematical students because capable facilitate visualization and exploration draft function square in a way more deep.

The findings of this study indicate that the use of Problem Based Learning (PBL) models assisted by GeoGebra and Kahoot are both able to improve students' mathematical conceptual understanding of quadratic functions. However, the improvement obtained by students through GeoGebra-assisted PBL learning is higher than that obtained through Kahoot-assisted PBL learning. In addition, the media and instruments used have met the requirements. criteria very valid so that worthy used in learning. With Thus, GeoGebra can be recommended as a more effective learning medium in supporting the improvement of students' mathematical concept understanding abilities in quadratic function material.

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