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The Effect of Discovery Learning Model Assisted by CERMAT Educational Game on Mathematical Problem-Solving Ability of Trigonometric

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Abstract

This study aims to determine the effect of Discovery Learning Model learning assisted by the CERMAT educational game on mathematical problem-solving skills on the concept of Trigonometry. This type of research is quasi-experimental research using Pretest-Posttest Control Group Design, which is data collection using tests (essays) supported by N-gain data analysis with variance tests to determine the difference in character in each group (experimental and control). The CERMAT educational game media is the main learning media containing student worksheets, and quizzes (formative test questions). This type of educational game is categorised as RPG (Role Playing Game). The subjects of this study consisted of a sample of 59 class X students at SMKN 12 Bandung. The data collection technique used was a pretest-posttest problem-solving skills test in the form of 5 questions about trigonometry material; 2.) student response questionnaire with as many as 20 statements. In the experimental group, the learning used was the discovery learning model assisted by the CERMAT educational game, while the control group only used the discovery learning model without the CERMAT educational game. The results of data analysis show that the average N-Gain test results of 67.9511 or 67,95% are included in the moderately effective category, and the results of the Mann-Whitney Difference Test show that the Discovery Learning Model assisted by the CERMAT Educational Game Media has a significant effect on improving the mathematical problem-solving skills of students in Class X SMKN 12 Bandung which has an impact on improving learning outcomes, especially on the concept of Trigonometry.

Keywords: CERMAT, Discovery Learning, Problem Solving, Trigonometry

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INTRODUCTION

Based on a survey conducted by the World Bank in its publication on measuring the quality of education services in Indonesia in 2020, there are main findings that make the quality of Indonesian education still relatively low, including those related to student learning outcomes measured in national exams and international assessments, as well as the role of teachers and teacher knowledge which is still relatively low in delivering and using science and technology as a delivery of learning materials, especially in learning mathematics (Yarrow et al., 2020). Therefore, all aspects of education starting from primary, secondary and higher education need to be improved and addressed, especially in the field of mathematics.

As a science that underlies various fields of science, mathematics has an important and inseparable role in everyday life. One of the abilities that students must master in studying the field of mathematics is the ability to solve mathematical problems (problem-solving), because every human being is always faced with problems in his life. (Aisyah et al., 2018; Maharani & Bernard, 2018). Therefore, to realise the improvement of students' mathematical abilities, problem-solving skills need to be improved and developed.

In essence, problem-solving skills are needed and become the basis of skills in learning and exploring mathematical material. This is following the basic and secondary education process standards stipulated in Permendikbud No. 5 of 2022 which states that the Merdeka Curriculum used in the current curriculum prioritises High Order Thinking Skills (HOTS), including concept understanding, reasoning and problem-solving (Kemendikbudristek BSKAP, 2022). Based on this, to improve students' High Order Thinking Skill (HOTS) abilities, there is a need for development that is oriented towards students' thinking skills through changes in learning methods and media (Naimah et al., 2019). Students more easily understand the material and basic concepts with visual media-assisted learning (Widiyawati, 2017). This underlies the need for the development of learning media in the form of educational games that can implement effective learning activities to improve students' problem-solving skills that prioritise High Order Thinking Skills (HOTS) (Fahlevi & Yuliani, 2021).

Educational games are game-based interactive learning media that have knowledge content in the form of learning materials and quizzes that increase and provide positive stimulation to students' knowledge and learning outcomes with an interesting and fun learning process. In addition, the interactive learning approach can overcome students' boredom in the learning process and can increase curiosity and critical thinking skills (Fahlevi & Yuliani, 2021; Mardhotillah & Rakimahwati, 2021; Sari et al., 2023). The need for integration of science and technology in classroom learning is very important to facilitate the learning process because science without technology will be difficult for students to accept and only possible for certain students (Aripin et al., 2020). Students will be more active in the learning process if the learning concept used is game-based (Suryawirawati et al., 2018). Educational game-based learning should be a tool for students to be more intrinsically interested and skilled in complex problem-solving activities (Hamari et al., 2016).

The objectives of this study are how the effect of the Discovery Learning model based on the CERMAT educational game in terms of students' problem-solving ability on the concept of Trigonometry. The reason for conducting this research is as an alternative solution to the problems of the teachers that have been described previously to provide an overview and validation of effective and interesting learning for students in understanding mathematical concepts, especially on the concept of Trigonometry. In this study, the authors developed and used the Discovery Learning model based on the CERMAT educational game which can be used as an alternative solution to overcome and solve current problems, especially for teachers. The application is called CERMAT (Cerdas Matematika). CERMAT application is an android-based interactive learning media that belongs to the type of RPG (Role Playing Game) game, with the content in it in the form of missions that students must do to complete it. In scientific aspects, the game applies levels or missions that each student must go through gradually which can train problem-solving skills that affect the improvement of students' cognitive thinking (Sumartini, 2016). Of course, this is in line with the Discovery Learning model, which develops a way of learning for students who actively discover and investigate on their own with the teacher's function as a learning facilitator to match the learning outcomes and objectives. (Ningsih & Pramaeda, 2020). So that the effect of learning models and learning media on problem-solving skills can be seen and analyzed for their relationship. In addition, this

CERMAT application can be changed according to the needs of the teacher and this CERMAT application is also designed like an RPG (Role Playing Game) game that is familiar to children and adolescents today. So that students can use it easily and increase their confidence when they can pass the mission and answer all the questions in the game.

METHODS

This research analyses the effect of the Discovery Learning model assisted by CERMAT educational game media on the concept of Trigonometry using Experimental Design. The implementation of this research began on 9 October to 21 November 2024 at SMKN 12 Bandung with class X research subjects. This study used The Nonequivalent Pretest-Posttest Control Group Design which in the implementation of the research was conducted in two groups of class X. The first class is the experimental class that uses the Discovery Learning model assisted by CERMAT educational game media. The second class is the control class which only uses the Discovery Learning model without the help of the CERMAT application. This study uses learning media in the form of an educational game called CERMAT which is based on an Android application and has been tested and used in research by Reza Fahlevi and Anik Yuliani (Fahlevi & Yuliani, 2021).

Data collection in this study was carried out using the Simple Random Sampling Technique, namely conducting tests and administering questionnaires. According to Arikunto (in Naimah et al., 2019) Measuring the achievement of learning in the use of media can be seen through student learning outcomes. In this study, quantitative data were obtained from the results of the problem-solving ability test assessment which was used as the final mission content in the CERMAT educational game media in the form of a description question (essay). While supporting data in the form of qualitative data obtained from student response questionnaires to trigonometry learning with the Discovery Learning model assisted by the CERMAT educational games. The effectiveness of the CERMAT educational game media in the Discovery Learning model learning process on the concept of trigonometry was measured using the effectiveness and practicality instruments from the material and media aspects obtained from the data collection in the form of a Likert scale (interval 1 to 5). Then the percentage index of effectiveness and practicality of all aspects was calculated. The calculation of the effectiveness and practicality index can be calculated using the following formula (Abdullah & Yunianta, 2018):

$$P(s) = \frac{S}{N} \times 100\% \qquad (1)$$

Description: P(s) = percentage of sub-variables; S = number of scores per sub; N = maximum number of scores.

Furthermore, the calculation results are classified according to the categories in the following table.

Table 1. Assessment Criteria

No.	Interval	Description
1	$84\% \leq$ score $\leq 100\%$	Highly Effective
2	$68\% \leq$ score $\leq 84\%$	Effective
3	$52\% \leq$ score $\leq 68\%$	Simply
4	$36\% \leq$ score $\leq 52\%$	Ineffective
5	$20\% \leq$ score $\leq 36\%$	Very ineffective

Meanwhile, to test the effectiveness of the CERMAT educational game media and students'

problem-solving skills, they used pretest and posttest. The pretest and posttest questions each amounted to 5 questions of trigonometry material with varying and balanced difficulty levels. After that, the analysis of the cognitive level of students is measured from the pretest and posttest results using normalized gain (N-Gain) as a measurement guideline. The effectiveness test results were analysed using the normalized gain (N-Gain) proposed by Hake (in Nissen et al., 2018) to measure the achievement and improvement of student learning outcomes before and after learning activities on students' problem-solving skills on trigonometry material with the Discovery Learning learning model assisted by the CERMAT educational games. The following is the N-Gain formula used in this study along with the N-gain category guidelines in **Table 2.**

$$g = \frac{postest\ score - pretest\ score}{maximum\ score - pretest\ score} \quad (2)$$

Table 2. N-Gain Category Guidelines

Skor N-*gain*	Category
$g \geq 0{,}70$	High
$0{,}3 \leq g < 0{,}7$	Medium
$g < 0{,}3$	Low

Meanwhile, the division of the N-Gain category in the form of percent (%) can refer to the picture in the table below:

Table 3. N-Gain Effectiveness Interpretation Category

Percentage (%)	Category
< 40	Ineffective
40 – 55	Less Effective
$56 - 75$	Quite Effective
> 76	Effective

Then the effect of using the CERMAT Educational Game Media on Discovery Learning Model learning on Trigonometry Material in improving the mathematical problem-solving skills of class X students of SMKN 12 Bandung can be seen from the Mann-Whitney Difference Test.

The independent variable (X) consists of two variables, namely the Discovery Learning Model assisted by the CERMAT educational game (X_1), and the Discovery Learning Model (X_2). While the ability to solve mathematical problems as the dependent variable (Y).

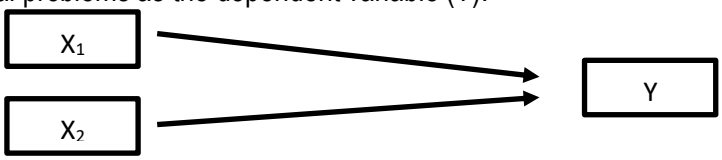

Figure 1. Discovery Learning Model Chart

Description:

X_1 : Discovery Learning model assisted by the CERMAT educational game

X_2 : Discovery Learning model

Y : Mathematical problem-solving ability

RESULTS AND DISCUSSION

The results of the study obtained data such as **Table 4.** below.

Table 4. N-Gain Data Description

Group	X_{max}	X_{min}	Measures of Central Tendency	
			$\bar{x}$	M_e
Experiment	83,87	25,00	67,95	77,14
Control	70,88	-10,89	32,96	38,73

Based on the results of the N-Gain test calculation above, it shows that the average value of the N-Gain score for the experimental class (Discovery Learning Model assisted by the CERMAT Educational Game) is 67.9511 or 67.95% included in the moderately effective category with a minimum score of 25% and a maximum of 83.87%. Meanwhile, the average N-Gain score for the control class (Discovery Learning Model) was 32.9623 or 32.96%, including the ineffective category with a minimum score of -10.89% and a maximum of 70.88%.

Thus, it can be stated that the use of the Discovery Learning Model assisted by the CERMAT Educational Game is effective enough to improve the mathematical problem-solving skills of class X students of SMKN 12 Bandung in the Mathematics subject of Trigonometry. The use of the Discovery Learning Model is not effective for improving the mathematical problem-solving skills of students in class X SMKN 12 Bandung in the subject of Mathematics Trigonometry.

Then supported by the Mann-Whitney difference test (MacFarland & Yates, 2016; Perme & Manevski, 2018) to determine whether or not there is an effect of using the CERMAT Educational Game Media on students' mathematical problem-solving skills in the Discovery Learning Model on Trigonometry Material. The following is a table of Mann-Whitney Difference Test results:

Table 5. Mann Whitney Difference Test Results

	Trigonometric Mathematical Problem Solving Ability
Mann-Whitney U	1,000
Wilcoxon W	562,000
Z	-6,859
Asymp. Sig. (2-tailed)	$< ,001$

In testing, a hypothesis is defined as a temporary conclusion in a study. The hypothesis proposed in this study is H_a = There is a difference in mathematical problem-solving ability between the Experimental Class and the Control Class. Based on the Mann-Whitney Difference Test Results above, it is known that the Asymp. Sig. (2-tailed) of < ,001 is smaller than (<) the probability value of 0,05. Therefore, as the basis for making the Mann-Whitney Difference Test decision above, it can be concluded that " H_a is accepted." Thus it can be said that there is a significant difference in the formulation of the research problem, namely "There is an effect of using the Discovery Learning Model Assisted by the CERMAT Educational Game on the Mathematical Problem Solving Ability of Class X Students of SMKN 12 Bandung on the Concept of Trigonometry" (Akcaoglu, 2014).

Based on the information above, it can be said that the CERMAT educational game helps the learning process and improves mathematical problem-solving skills which have an impact on improving students' learning outcomes on the concept of Trigonometry (Dindar, 2018; Ingram et al., 2018; Yu et al., 2020). In the app, there is a narrative (story) that intrigues each player through the words (Shi & Shih, 2015). Using games to tell a story is as much a challenge for designers as it is for creating an effective film. However, the level of importance of narrative in different game genres varies. Simulation and puzzle

games usually include the background of the game, but adventure games and RPGs include a full storyline. For educational games, narration is an important factor in providing declarative knowledge for the players. Kiili (Kiili, 2005) indicates storytelling is a key consideration before designing an educational game. Teaching content must match the narrative to create an effective educational game. Presenting a virtual world to the player, including audio and visuals adds to the aesthetics while giving each player a thrill. This is the concept proposed in RPG theory (Bowman, 2013; Cultures, 2019), which includes the fantasy and game sensation factors presented in this study. The CERMAT educational game genre uses stimulation that creates a sensation in every challenge or mission faced by the player that is adjusted to the cognitive level using Discovery Learning to improve the player's problem-solving skills (Cai & Li, 2006; Hooshyar et al., 2016; Hou & Li, 2014; C.-C. Liu et al., 2011). This is in line with research conducted by Fahlevi, Yuliani, Fitrianna, Purwasih and Aripin (Fahlevi & Yuliani, 2021; Fitrianna et al., 2018) the existence of attractive ICT learning media makes students highly motivated, more confident and confident in solving the problems they face. In its implementation, most students are interested and motivated and enthusiastic in facing every obstacle in the game (Baytak & Land, 2010; Erol & Çırak, 2022; Laamarti et al., 2014). In addition, the learning situation was conducive because students were busy with their work, creating effective and fun learning (Coutinho et al., 2015; Yılmaz & Griffiths, 2023). This CERMAT educational game is Android-based so it is easy to use and its portable nature can be used anywhere, making the learning process efficient and can improve students' basic competencies with problem-solving skills contained in the game and with games making students more active, motivated, brain nerves in students continue to develop because students enjoy the learning process without pressure, and effectively promote student learning achievement (Hwang et al., 2014; Irsa et al., 2015; X. Liu et al., 2024; Oyesiku et al., 2018; Ukobizaba et al., 2021; Zeng et al., 2020).

CONCLUSION

Based on the results of the study, it can be concluded that the Discovery Learning Model Assisted by the CERMAT Educational Game is very influential and quite effective in improving students' problem-solving skills, especially in the concept of Trigonometry. The improvement of students' problem-solving ability is also influenced by the presence of CERMAT educational game learning media with satisfactory learning outcomes. This shows that CERMAT educational games can be used as learning media that can solve current ICT-based learning problems.

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