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The Effect of Problem Based Learning (PBL) Model with Desmos Visual Media Assistance on Mathematical Problem Solving Ability and Self Regulated Learning of High School Students

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Abstract

One of the goals of learning mathematics is to improve problem solving skills. However, problem solving skills in Indonesia are still relatively low. Low problem solving ability is also influenced by an active and independent attitude in learning that must be owned by students. This study aims to determine and describe the effect of Problem Based Learning (PBL) with the help of Desmos visual media on students' problem solving skills and self-regulated learning. This research is a quasi-experiment with pretest-posttest group design. The study population included all grade X students in one of the State High Schools in Wakatobi Regency. The sampling technique used was purposive sampling, with class XA as the experimental group that received Problem Based Learning learning assisted by Desmos visual media and XB as the control group that received learning with a scientific approach. Based on the results of data analysis, it shows that there is a significant average difference between the problem solving ability and self-regulated learning of students in the experimental and control classes. This shows that there is an effect of Problem-Based Learning assisted by Desmos visual media on students' problem solving and self-regulated learning simultaneously and partially.

Keywords: *PBL; Desmos; Problem Solving; Self-Regulated Learning*

Introduction

Problem solving ability is an important part that must be possessed by a student. Problem solving covers all the objectives of mathematics learning activities, namely effective learning and improving students' abilities (Jonassen, 2011). According to Polya (1985) problem solving is an action or effort towards a discovery and investigation by describing the abilities needed to be able to achieve success in solving new problems.

The importance of problem solving in learning is also conveyed by NCTM (2000), namely the thinking process in learning mathematics includes five main standard competencies, namely problem solving ability, reasoning ability, connection ability, communication ability, and representation ability. Low problem solving skills can result in the low quality of human resources. Polya (1985) says that there are four steps that must be taken in solving math problems, namely: 1) Understanding the problems, refers to understanding what is known and what is stated. 2) Planning a solution, leads to how the strategy of solving the problem. 3) Completing the plan that leads to a completion of the strategy that has been prepared. 4) Re-examining, leading to activities related to student activities in checking answers and making final conclusions. These four steps will be used to measure students' mathematical problem solving skills in this study.

In addition, one of the important things is the attitude that students must have, namely *self-regulated learning* or student learning independence. *Self regulated learning* is recommended as an important competency for students in a student-centered learning environment which means students will be more actively involved in building and interpreting knowledge (Al-abdullatif, 2020). Sugiyana (2015) defines *self-regulated learning* as the readiness of an individual who has the willingness and ability to learn on his/her own initiative, with or without assistance from other parties regarding the determination of learning goals, methods used to learn, and evaluation of learning achievements. *Self regulated learning* is an active learning process where students set goals, and learning standards, after which students try to monitor the process and control aspects of cognition, motivation, and behavior and make the environment can support the learning process (Pintrich, 2000).

In an effort to improve students' problem solving skills and *self-regulated learning*, teachers can apply learning models that facilitate this. One of the mathematics learning models that can be applied by teachers is *Problem Based Learning (*PBL) (Zetriuslita et al., 2018). PBL is a learning model that presents contextual problems so as to provide a stimulus for students to learn. Classes that apply PBL model learning are expected to be able to solve problems in the real world, so that students have problem-solving skills (Chrisdiyanto et al., 2023).

Problems are the basis for students to reflect on a different way of thinking. Students will search for various information needed so as to find various solutions in solving the problem then compare and evaluate with ideas (Boye & Agyei, 2023). PBL is characterized by the problem as the driving force in learning, most students are asked to cooperate, directed by the teacher and involves student awareness (Schmidt et al., 2011). For this reason, the use of PBL or *Problem Based Learning* can be one of the solutions to improve students' problem solving and *self-regulated learning* in mathematics learning.

In the current era, the use of technology is very important, especially in education. According to Asiba (2021), one way to foster and increase students' interest in learning is by using technology in the learning process. The use of technology can create a learning atmosphere that is fun, not boring and creates a sense of excitement. One technology that is suitable for use in learning mathematics in this modern era is Desmos (Argarini et al., 2020). Desmos is an *online* free calculator that is accessed for free. Desmos allows students to discover concepts, be creative, check errors and think deeply on math learning (Orr, 2017). This platform can be used to improve the quality of math teaching and learning by facilitating students to perform authentic math activities (Kristanto, 2021). Although it is one of the easy-to-use tools for learning math, Desmos is one of the digital media that has not been widely used in math learning (Chorney, 2021).

The use of Desmos application in mathematics *learning* with *problem-based learning* (PBL) model is a consideration in helping students in the exploration process to find concepts. Several studies have been conducted related to the use of Desmos applications such as research conducted by Chechan et al. (2023) which obtained results during learning, which showed students were more independent in managing their own learning and showed a significant increase in understanding. In addition, research by Cooper et *al.* (2024) showed that the use of Desmos increased student understanding and motivated students in learning.

Some of the facts that have been stated above, the researcher considers it necessary to find out more about "the effect of learning with PBL assisted by Desmos visual media on students' problem solving and *self-regulated learning*". The findings are expected to be a reference for teachers in determining the choice of teaching and learning materials that are suitable to further improve students' problem solving skills and simultaneously encourage students to learn more initiative so as to improve students' *self-regulated learning*.

Method

The type of research used is a *quasi experiment* or pseudo experiment consisting of two research groups, namely the experimental class group whose learning applies *Problem Based Learning* assisted by Desmos visual media and the control class group with scientific learning. This research was conducted at MAN in one of the State High Schools in Wakatobi Regency where the population was all class X with the selected sample of class XA totaling 30 as the experimental class and XB totaling 29 as the control class. The lesson taught was quadratic function material.

Data collection for hypothesis testing was carried out for six meetings in the experimental and control classes. The research design used is a group design (Putra & Sari, 2016) which is presented in Table 1.

Table 1. Pretest-Posttest Nonequivalent Group Research Design

Group	Pretest	Treatment	Posttest
KE	P_{E1}	X_1	P_{E2}
KK	P_{K1}	X_2	P_{K2}

In Table 1, the KE code is PBL learning assisted by Desmos visual media while KK is scientific learning. The implementation of the research was carried out by giving a *pretest* before treatment where to find out the initial condition of students on problem solving skills and *self-regulated learning* questionnaires in both experimental and control classes. At the end of the meeting after the treatment is given a *posttest* where to see the results of the treatment that has been given. This research design is used to determine whether there is an effect of PBL learning assisted by Desmos visual media on students' problem solving skills and *self-regulated learning*.

The types of instruments used in this research are tests and questionnaires. The questionnaire used is a *self-regulated learning* questionnaire consisting of 25 questions, this questionnaire uses a Likert scale. The instrument in the form of a test is a test of students' mathematical problem solving ability consisting of 4 questions. The material given is quadratic function material.

Prior to the inferential test, validity and reliability were conducted. The research instruments that have been prepared must meet the valid and reliable requirements before being tested (Allen & Yen, 1979). The validity of the instrument is done to see the accuracy of the instrument in measuring what the instrument wants to measure. After preparing test instruments and questionnaires for research based on a theory, to obtain evidence of content validity, it is done by asking for consideration from several experts (*expert judgment*) to assess the suitability of the grids and items of problem solving ability and *self-regulated learning* questionnaire. The experts in question are lecturers from Yogyakarta State University (UNY) to test whether the instruments that have been prepared previously are valid or not. Based on the results of content validity, it is known that both instruments were declared valid by both validators.

Instrument reliability is used to see whether an instrument that has been prepared can be used to measure the same thing consistently over time. Estimation of instrument reliability is carried out after the instrument is declared valid and has been tested on a number of respondents. The following are the results of the reliability of the two instruments as follows.

Table 2: Reliability Results of Test Trials of Problem Solving Ability Test and Self Regulated Learning Questionnaire

Category	Reliable Coefficient (α)	Critical Value (α)	Description
Problem Solving	0,68	0,5	Medium
Self Regulated Learning	0,90	0,5	High

Based on Table 2, it can be seen that the reliability coefficient for the problem solving ability test is 0.68 which is in the medium category and the student *self-regulated learning* questionnaire is 0.90 which is in the high category. Based on the reliability category, it can be concluded that the problem solving ability test and *self-regulated learning* questionnaire are reliable (Ebell & Friesbie, 1991).

The data analysis technique in this study consists of descriptive and inferential analysis. Descriptive analysis includes maximum value, minimum value, mean, variance, and standard deviation (Christensen et al., 2015). Inferential analysis in this study uses multivariate analysis with Hotelling's test statisticT^2 and *independent t-test*. Before conducting hypothesis testing, assumption tests will first be carried out. The assumption test performed is normality test and homogeneity test (Jhonson & Whichern, 2007).

Results and Discussion

Description of Problem Solving Ability and *Self Regulated Learning*

The following is the data description of students' problem solving ability and *self-regulated learning*.

Table 3. Pretest and Posttest Data of Students' Problem Solving in Experimental Class and Control Class

	PBL+Desmos		**Scientific**	
Subject	***Pretest***	***Posttest***	***Pretest***	***Posttest***
Average	27,33	77,1	27,68	70,55
Variance	60,12	47,95	44,87	17,40
Maximum Value	43	90	50	90
Minimum Score	13	60	15	60
Theoretical Maximum Score	100	100	100	100
Minimum Value	0	0	0	0

Table 4. Pretest and Posttest Data Self-Regulated Learning of Experimental Class and Control Class Students

	PBL+Desmos		**Scientific**	
Subject	***Pretest***	***Posttest***	***Pretest***	***Posttest***
Average	83,37	87,9	82,62	85,79
Variance	39,28	25,81	19,32	56,38
Maximum Value	90	94	90	94
Minimum Score	70	74	70	73
Theoretical Maximum Score	100	100	100	100
Theoretical Minimum Value	0	0	0	0

Based on Table 3, it can be seen that the value of students' problem solving skills has increased. The average value in the experimental class with an initial average of 27.33 increased by 47.76 so that the final average value in the control class became 77.1. Meanwhile, the control class experienced an increase of 48.67 with an initial average of 27.68 increasing to 70.55. By comparing the average *posttest* score of mathematical problem solving ability, it can be concluded that the problem solving ability of PBL class assisted by Desmos is higher than the scientific class.

Based on Table 4, it is known that the average score of students' *self-regulated learning* in the control class and experimental class has increased. In the control class, it increased by 3.17 from the initial average of 82.62 to 85.79. While in the experimental class it increased by 4.53 from the initial average of 83.37 to 87.9 The variance and standard deviation decreased after being treated, this means that the distribution of the range of values before treatment is more diverse than after treatment. It can be concluded that the *self-regulated learning of* PBL class students assisted by Desmos is higher than the scientific class.

Research Data Test Results

Before analyzing the data, researchers first conducted an assumption test, namely a normality test using a *scatter plot* and a homogeneity test using Box'm. Based on the normality test, the *scatter plot* tends to form a straight line, thus indicating that the data is normally distributed. Based on the correlation coefficient value of the experimental class and control class based on *pretest* and *posttest* data. In the experimental class, *the* correlation coefficient is 0.987 and 0.962 while in the control class based on *pretest* and *posttest* data, the correlation coefficient is 0.985 and 0.982. This shows a strong linear relationship between the two variables in both experimental and control classes. Thus, it can be concluded that the data comes from a normally distributed population.

The assumption of homogeneity of the covariance matrix is met if the *p-value* or significance value is greater than 0.05. Based on the results of *Box's M* test, the significance value of *pretest* and *posttest* data is 0.211 and 0.220, which means it is greater than 0.05. This indicates that both classes have a homogeneous covariance matrix, so the assumption of homogeneity of the *pretest* and *posttest* data covariance matrix is met. After all assumption tests are met, the next step is to test the effect of the *Problem-Based Learning* model assisted by Desmos visual media on problem solving ability and *self-regulated learning*.

Table 5 below presents the results of *Hotteling's* testT^2 based on the *pretest* scores of students' problem solving ability and *self-regulated learning* in the experimental and control classes.

Table 5. Hotteling's Test Results$\boldsymbol{T^2}$ Pretest Data

Effect	F	Sig	Decision
Hotteling's T^2	0,140	0,280	H_0 Accepted

The significance value of *Hotteling's*T^2 is 0.280, where the value is greater than 0.05 or can be written$p - value > 0,05$. This shows thatH_0 is accepted, meaning that there is no significant average difference between the problem solving ability and *self-regulated learning of* students in the experimental class and control class based on *pretest* data. Based on this explanation, it can be concluded that the problem solving ability and *self-regulated learning of* students in both classes are relatively the same, so it can be said that both classes have the same initial conditions.

Table 6 below presents the results of *Hotteling's* testT^2 based on *posttest* data of students' problem solving ability and *self-regulated learning* in experimental and control classes.

Table 6. Hotteling's Test ResultsT^2 Posttest Data

Effect	F	Sig	Decision
Hotteling's T^2	9,441	0,000	H_0 rejected

The significance value of *Hotteling's*T^2 is 0.000, where the value is less than 0.05 or can be written$p - value < 0,05$. This shows that there is a significant average difference between the problem solving ability and *self-regulated learning of* students in the experimental class and the control class based on *posttest* data.

Based on the explanation above, it can be concluded that there is an effect of *Problem-Based Learning learning* assisted by Desmos visual media on students' problem solving ability and *self-regulated learning*. Furthermore, testing will be carried out with the *Independent Sample T-test* test to determine the effect on each variable of students' problem-solving ability and *self-regulated learning*.

Because there is an effect of *Problem-Based Learning learning* assisted by Desmos visual media, then further tests are carried out, namely testing with the *Independent Sample T-test* test to determine the effect on each variable of students' problem solving ability and *self-regulated learning* which is presented in Table 7 below.

Table 7. Results of Independent Sample T-test of Problem Solving Ability

Class	Mean	t	Sig
Experiment	77	3,630	0,001
Control	71,83		

Table 8. Independent Sample T-test Results of Self Regulated Learning

Class	Mean	t	Sig
Experiment	88,30	2,068	0,043
Control	84,97		

Based on Table 7, the results of the *independent t-test of* problem solving ability obtained a significance value of$0,001 < 0,05$ which means that there is a significant average difference in problem solving ability between the experimental and control class groups. In other words, the experimental class group that applies *Problem-Based Learning* assisted by digital learning media has a significant effect on students' problem solving ability.

Based on Table 8 of *the independent t-test* results of *self-regulated learning, a* significance value of$0,043 < 0,05$ is obtained. This means that there is a significant average difference in *self-regulated learning* between the experimental and control class groups. In other words, the experimental class group that applies *Problem-Based Learning* assisted by digital learning media has a significant effect on students' *self-regulated learning*.

Discussion

1. There is an Effect of *Problem-Based Learning* Assisted by Desmos Visual Media on Problem Solving Ability and *Self Regulated Learning of* Students

Based on the results of the multivariate test of the *posttest* value of problem solving ability and students' *self-regulated learning*, there is a significant average difference between the experimental class and the control class. This can be seen from the value of *Hottelings's* test statistics which obtained a value of $p - value\ 0{,}000 < 0{,}05$ with a significance level of 0.05 so that H_0 was rejected. This means that there is a multivariate significant difference between the experimental and control class groups. This shows that *Problem-Based Learning* assisted by digital learning media has an effect on students' problem solving ability and *self-regulated learning* simultaneously.

This finding is in line with the results of Achsin's research (2016), which revealed that learning with PBL contextual approach can improve mathematical problem solving skills. In addition, research conducted by Harapit (2018) shows that the PBL model has an important role in improving students' problem solving skills. PBL model learning has a role in increasing learning motivation and student learning independence.

The influence on students' problem solving ability and *self-regulated learning* can be seen from the learning process, where students are trained to understand the problem thoroughly, design and implement solution strategies and critically evaluate the results. Desmos learning media support strengthens conceptual understanding by presenting interactive graphical representations, thus helping students in identifying patterns in learning, verifying solutions and reflecting on their thought processes. In addition, students became more engaged and asked many questions and were more enthusiastic about learning mathematics. Abu-Tineh et al. (2019) support the statement that the use of technology makes students excited, so they become more motivated in learning.

2. There is an Effect of *Problem-Based Learning* Assisted by Desmos Visual Media on Students' Problem Solving Ability

From the results of the *independent sample t-test* test which obtained a significance value of $0{,}001 < 0{,}05$, which shows that there is a significant average in problem solving ability between students who follow *Problem-Based Learning* assisted by Desmos visual media and students with scientific learning. Thus, it can be concluded that *Problem-Based Learning learning* assisted by Desmos visual media has a significant effect on students' problem solving ability.

After being given treatment, the *posttest* results showed an increase in students' problem solving skills in both studies. The average score on each problem solving indicator, both in the experimental and control classes, has increased. Students showed a better understanding in solving problems, such as understanding the problem by identifying important information and making strategies to solve the given problem, namely determining the right formula or strategy. In addition, students are also more careful in performing calculations and providing clear interpretations and reasons for the answers presented. The following is the *posttest* problem solving ability.

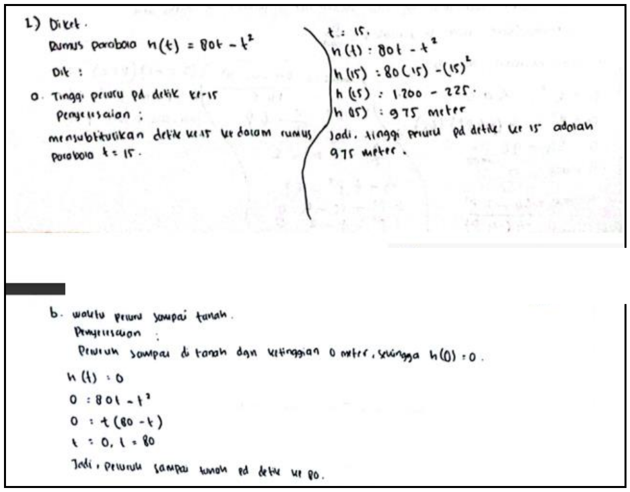
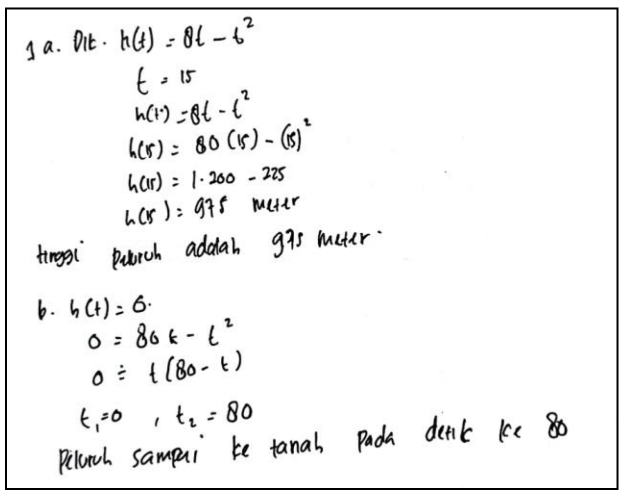


Figure 1. Answer Number 1 of Experimental Class students



Answer Number 1 of Control Class Students

Figure 1 and Figure 2 are the results of student answers in the experimental class and control class in working on *posttest* question number 1. Based on the results of student work, it can be seen that *Problem-Based Learning learning* assisted by Desmos visual media has a positive impact on improving aspects of students' problem solving skills. Based on students' answers, it can be seen that the aspects of problem solving ability are different in the group that received *Problem-Based Learning learning* assisted by Desmos visual media in the experimental class compared to scientific learning in the control class.

In this aspect of problem solving, improvements were seen in all indicators. Indicators of understanding the problem, designing strategies, implementing strategies and evaluating solutions or checking back. Desmos Learning Media which presents interactive visualization of learning concepts is proven to help students in understanding the problem more concretely, especially in identifying important information and understanding the relationship between mathematical concepts. In learning, when designing a solution strategy, students were helped by the explorative features of Desmos that allowed them to try different approaches and get immediate feedback. In strategy execution, students showed better accuracy and efficiency as they could verify each step using the visual graph on Desmos. Re-examination skills also improved as students could directly match the results of their thinking with the visual representation on Desmos, making it easier to identify errors, make corrections and draw a conclusion.

This indicates that the application of PBL learning can affect problem solving skills. This is in line with Fadilah & Ardiawan's research (2023) which states that *Problem-Based Learning* is effective in improving further mathematical problem solving skills. *Problem-Based Learning learning* assisted by digital learning media is considered better than scientific learning. Research by Aulia, et al (2019) also said that *Problem-Based Learning learning* is one of the learning models that directs students to have a desire to understand, learn good learning needs so that they want to use and find the best learning resources in order to solve the problems faced.

3. There is an Effect of *Problem-Based Learning* Assisted by Desmos Visual Media on Students' *Self Regulated Learning*

The results of univariate analysis show that *Problem-Based Learning learning* assisted by Desmos visual media has an effect on students' *self-regulated learning*. This can be seen from the results of the *independent sample t-test* test obtained a significance value of $0{,}043 < 0{,}05$, which shows that there is a significant average difference in the *self-regulated learning of* students who follow *Problem-Based Learning learning* assisted by Desmos visual media compared to scientific learning. Thus, it can be concluded that *Problem-Based Learning* assisted by Desmos visual media has a significant effect on students' *self-regulated learning*.

Based on the results of the experimental research, it shows that the implementation of *Problem-Based Learning* assisted by Desmos visual media has a positive effect on improving students' *self-regulated learning* ability. *Problem-Based Learning* naturally encourages students to become active learners who are responsible for their learning process, while Desmos acts as an interactive visual tool that supports independent and concrete exploration of concepts. In addition, *Problem-Based Learning* assisted by Desmos helps students visualize abstract mathematical concepts so that it supports a more independent and structured learning process (Oktaviane & Ekawati, 2022). The combination of the two creates a learning environment that allows students to develop independent learning skills in three aspects of *self-regulated learning*, namely motivation, metacognition and behavior. In line with Hidajat's research (2023) which states that *Problem-Based Learning* is effective in improving *self-regulated learning* skills in the aspects of planning, monitoring and self-evaluation.

On the motivation aspect, *Problem-Based Learning* encourages students to learn actively through the presentation of contextual problems. When this process is supported by Desmos, students become motivated because they can directly see the connection between mathematical concepts and their visual representations. Desmos provides an interactive and engaging learning experience, so students feel more involved and have clear learning goals.

In the metacognition aspect of the learning process, students plan, monitor and evaluate their own understanding. Desmos visual media-assisted *Problem-Based Learning* naturally encourages metacognitive activity through open-ended questions and group reflection, where Desmos reinforces this process as students can explore different possible solutions and visually test ideas.

Finally, the behavioral aspect, this aspect can be seen from how students manage time, look for additional learning resources and persist in facing difficulties. *Problem-Based Learning* assisted by Desmos visual media encourages students to be more active and independent in accessing materials, exploring graphics and discussing and working together in groups.

Conclusion

Based on the results of data analysis, there is a significant average difference between the problem solving ability and *self-regulated learning of* students in the experimental and control classes. This shows that there is an effect of *Problem-Based Learning* assisted by Desmos visual media on problem solving and *self-regulated learning* simultaneously. And based on further tests, it shows that there is an effect of *Problem-Based Learning learning* assisted by Desmos visual media on students' problem solving ability and *Problem-Based Learning learning* assisted by Desmos visual media affects students' *self-regulated learning*. This can be seen from the learning process that trains students to understand problems, design strategies, and critically evaluate results. Desmos media support strengthens concept understanding through interactive graphics, helps pattern identification, solution verification and thinking reflection. Students are more involved, enthusiastic and actively ask questions in learning mathematics. This shows that there is an effect of Problem Based Learning assisted by Desmos visual media on problem solving and self-regulated learning simultaneously and partially.

The suggestions that can be given based on the research results are *Problem Based Learning* with the help of Desmos visual media can be used as learning in improving problem solving skills and *self-regulated learning*. In addition, it can develop this research with other material coverage.

References

Abu-Tineh, A., Murphy, C., Calder, N., & Mansour, N.(2019). The Use of Webquets in Developing Inquiry-Based Learning Views if Teachers and Student in Qatar. International Journal of Educational an Pedagogical Sciences, 13(10), 976-983. https://doi.org/10.11591/IJERE.V1013.21771.

Achsin, M.(2016). Kemampuan Pemecahan Masalah Pada PBL Pendekatan Kontekstual dalam Tinjauan Inventori Kesadaran Metakognitif. *PRISMA, Prosiding Seminar Nasional Matematika,* (150),696-704. https://journal.unnes.ac.id/sju/index.php/prisma/article/view/21684.

Al-abdullatif, A. M. (2020). Investigating Sel-regulated Learning and Academic Achievement in E Learning Enviroment: The Case of K-12 Flipped Classroom. *Cogent Education, 7*(1), 1-18. https://doi,org/10.1080/2331186X.2020.1835145.

Allen & Yen. (1979). *Intoduction to Measurement Theory*. California: Wadsworth, Inc.

Argarini, D. F., Yazidah, N. I., & Kurniawati, A. (2020). The construction learning media and level of students' mathematical communication ability. *Infinity Journal*, *9*(1), 1–14. https://doi.org/10.22460/infinity.v9i1.p1-14.

1.1 Aulia, L. N., Susilo, Subali, B. (2019). Upaya Peningkatan Kemandirian Belajar Siswa dengan Model Problem-Based Learning Berbantuan Media Edmodo. Jurnal Inovasi Pendidikan. Diakses dari: https://journal.uny.ac.id/index/php/jipi.

Boye, E. S., & Agyei, D. D. (2023). Effectiveness of problem-based learning strategy in improving teaching and learning of mathematics for pre-service teachers in Ghana. *Social Sciences and Humanities Open*, *7*(1), 1–7. https://doi.org/10.1016/j.ssaho.2023.100453.

Chechan, B., Ampadu, E., & Pears, A. (2023). Effect of using Desmos on high school students' understanding and learning of functions. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(10).

Chorney, S. (2022). Classroom practice and craft knowledge in teaching mathematics using Desmos: challenges and strategies. *International Journal of Mathematical Education in Science and Technology, 53*(12), 3203–3227. https://doi.org/10.1080/0020739X.2021.1931974.

Chrisdiyanto, E., Hamdi, S., Jailani, J., & Nur Cahyanti, M. (2023). Efektivitas problem-based learning dengan model NHT berbantuan sempoa untuk meningkatkan hasil belajar siswa SMP. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 669. https://doi.org/10.24127/ajpm.v12i1.6746.

Christensen, L. B., Johnson, B., & Turner, L. A. (2015). *Research methods, design, and analysis*. Pearson Education.

Ebell, R. L., & Friesbie, D. A. (1991). *Essentials of Educational Measurem 5th Ed.* New Delhi: Rajkamal Electric Press.

Fadillah, S., & Ardiawan, Y. (2023). Pengaruh Model Problem-Based Learning terhadap Kemampuan Pemecahan Masalah Matematis Ditinjau dari Self Confidence. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 12(1), 1178–1187. https://doi.org/10.24127/ajpm.v12i1.6737.

Harapit, S. (2018). Peranan Problem-Based Learning (PBL) Terhadap Kemampuan Pemecahan Masalah dan Motivasi Belajar Peserta didik. *Jurnal Pendidikan Tambusai, 2*(4), 912-917. Diambil dari https://www.jptam.org/index.php/jptam/article/view/41.

Hidajat, F. A. (2023). *A Comparison Between Problem-Based Conventional Learning and Creative Problem-Based Learning on Self-Regulation Skills: Experimental Study*. Heliyon, 9, e19512.

Johnson, Richard A., & Dean W. Wichern. (2007). *Applied Multivariate Statistical Analysis.* 6th Ed. New Jersey: Prentice-Hall, Inc.

Jonassen, D.H. & Hung, W. (2015). *All Problems are Not Equal: Implications for Problem-based Learning,* in Walker, A., H., Hmelo-Silvber, C.E. and Ertmer, P.A. (Eds) Essential Readings in Problem-based Learning pp 7-41.

National Council of Teachers of Mathematics. (2000). *Curriculum and Evaluation Standars for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Oor, J. (2017). Function Transformations and the desmos activity Builder. *NCTM*, *110*(7), 549-551.

Oktaviane, D., & Ekawati, R. (2022). *The Development of Problem-Based Learning Desmos Worksheet to Improve Students' Mathematical Communication Skills*. Journal of Innovative Mathematics Learning, 5(3), 18432.

Pintrich, P. R., & Groot, E. V. De. (1990). Motivational and Self-regulated Learning Components of Classroom Academics Performance. *Journal of Educational Phsycology, 82*(1), 33-40.

Polya, G. (1985). *How to solve it. A new aspect of mathematical method)2nd ed).* New Jersey: Princeton University Press.

Schmitdt, H. G., Rotgans, J.I., & Yew, E.H.J. (2011). The Process of Problem-based Learning:What Works and Why. Medical Education, 45, 792-806.

Sugiyana, S. (2015). Pengaruh self regulated learning, self efficacy dan perhatian orang tua terhadap prestasi belajar matematika siswa. *PSIKOPEDAGOGIA jurnal Bimbingan dan Konseling, 4*(1), 63-72. https://doi.org/10.12928/psikopedagogia.v4i1.4497.

Verschaffel, L., Dooren, W. Van, & Smedt, B. De. (2012). Mathematical learning. In *Encyclopedia of the Sciences of Learning*. Springer US. https://doi.org/10.1007/978-1-4419-1428-6.

Zetriuslita, Z., Wahyudin, W., & Dahlan, J. A. (2018). Association among mathematical critical thinking skill, communication, and curiosity attitude as the impact of problem-based learning and cognitive conflict strategy (PBLCCS) in number theory course. *Infinity Journal*, *7*(1), 15–24. https://doi.org/10.22460/infinity.v7i1.p15-24.