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The Effect of GeoGebra-Assisted Problem-Based Learning on Students' Mathematical Literacy Skills and Learning Motivation

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ABSTRACT

This study aimed to examine the effect of GeoGebra-assisted problem-based learning on vocational high school students' mathematical literacy and learning motivation. Thirty-three students of one chemical industry class in grade 11 of vocational high school were chosen as the subjects for this study period. Simple random sampling was employed for the sampling process. This study was quantitative research and used a quasi-experimental design in the form of one-group pretest-posttest design. In this study, tests, questionnaires, and documentation were used as data collection methods. Descriptive and inferential analyses using paired sample t-tests were performed on the test data. In the study's findings, mathematical literacy students got a p-value of 0.000 < 0.05 as a significant level, and learning motivation students got a p-value of 0.006 < 0.05 as a significant level, indicating a difference between the study's average before and after treatment. Because p-value < 0.05, H_0 is rejected. So, there is an average difference between the two test results. Based on those results, GeoGebra-assisted problem-based learning affects mathematical literacy and learning motivation of vocational high school students on financial mathematics material. Teachers can use Geogebra as one of the media that can develop students' mathematical literacy and learning motivation.

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1. INTRODUCTION

Every human activity contains mathematics since it is a component of human activity. Sammons (2018) asserts that, in addition to comprehending mathematical concepts, one also needs to be able to work out situations that arise in daily life. Learning must be relevant to students' lives to accomplish that goal (Reyes et al., 2019). Practical problem-solving instruction is closely tied to vocational institutions that place an emphasis on practice. For students in vocational high schools, math is crucial in mastering their profession (Ozdemir & Onder-Ozdemir, 2021). Mathematical issues relating to the activities in their disciplines are familiar to students in vocational schools. However, because teachers frequently utilize direct learning, pupils are less engaged and feel bored when learning mathematics (Al-azawi et al., 2016). Additionally, without understanding the difficulties in the context of real-life, students merely remember mathematical principles (Manoy & Indarasati, 2017). In addition, mathematics teaches pupils how to think critically and creatively to help people solve difficulties in daily life.

The ability to think critically and innovatively is a basic component of mathematical literacy (Junianto & Wijaya, 2019). Therefore, pupils must possess adequate mathematical literacy skills in order to address everyday situations. The ability to formulate, apply, and interpret mathematics in order to solve issues in the actual world is the definition of mathematical literacy put out by The Organisation for Economic Co-operation and Development (OECD) (OECD, 2018). The ability of pupils to conceptualize, apply, and interpret mathematics in a variety of circumstances is known as mathematical literacy (OECD, 2013). Making wise decisions requires mathematical literacy, which aids in understanding the function and application of mathematics in daily life (Hayati & Kamid, 2019). Therefore, according to Anggoro et al. (2019), one of the skills people need to possess in the 21st century is mathematical literacy. According to Bappenas (2019) and Grotlüschen et al. (2020), one of the abilities needed to attain the Sustainable Development Goals by 2030 is mathematical literacy. According to the different definitions of mathematical literacy that have been given, mathematical literacy is the capacity of an individual to formulate, apply, and interpret mathematics to solve problems in various real-life contexts with the appropriate judgment. Three process indicators make up mathematical literacy: framing problems conceptually, using mathematical concepts, facts, and reasoning, and interpreting, using, and assessing mathematical findings (OECD, 2018). It is important for students to familiarize themselves with mathematical literacy by applying those indicators in learning.

Indonesian students' abilities in mathematical literacy can be seen from the latest PISA results in 2022. In PISA 2022, Indonesia's mathematics literacy score fell thirteen points from 379 in 2018 to 366 in 2022 (OECD, 2022). There were also poor outcomes in mathematical literacy for study in a smaller location, like Yogyakarta. Sari and Wijaya's research (Sari & Wijaya, 2017), involved 813 students of 10th-grade junior high school aged 15 years with questions given according to the content of number, geometry, algebra, statistics and probability. The results obtained showed that students were in the very low category. Then Nisa and Arliani's research on junior high school students with the subject of 8th grade students as many as 436 students, was reviewed from the students' self-efficacy (Nisa & Arliani, 2023). The results showed that mathematical literacy skills were still low, and self-efficacy was still moderate. Apart from that, Wulandari and Jailani's research with subjects in grades 9 and 10 who were 15 years old by giving mathematical literacy questions similar to PISA, found that students' mathematical literacy was still at a low level (Wulandari & Jailani, 2018). Based on previous research, it can be concluded that students' mathematical literacy skills are still low, especially in Yogyakarta.

The aspects that make it hard for students to find solutions to mathematical literacy problems include students not used to solving math ability problems (Wijaya et al., 2014), few teachers use math problems based on problem-solving skills (Zulkardi & Kohar, 2018), few sources such as library books and bookstores provide problems to develop mathematical skills (Wijaya & Heuvel-panhuizen, 2015), students' basic knowledge of mathematics is low (Faozi et al., 2020), and the difficult of students to answer narrative questions, understand them and translate them into mathematical models (Blum & Ferri, 2009). Interviews revealed that vocational students are unfamiliar with non-routine issues such as mathematical literacy. Problems that are given routinely make students less motivated to learn mathematics because they do not know the direct impact of mathematics on life.

Lack of motivation is one of the factors that influences learning. That is the same as the statement by Ryan & Williams (2007) that low motivation can also have an effect on student achievement in facing exams. Positive emotions on motivation and self-regulated learning support improving students' academic abilities (Mega et al., 2014). For students in a lesson, motivation is something fundamental and important because it can influence actions in learning and ways of thinking (Cook & Artino, 2016). It can influence students' mindsets when dealing with easy to difficult problems. Students will always develop their mindset and abilities by trying to organize their learning strategies because they believe that knowledge will always develop and not be fixed. Based on interviews with mathematics teachers, vocational school students were less motivated to studied mathematics compared to subjects appropriate to their major.

To address these challenges, it is essential to tailor educational materials to real-life problems that are relatable to students, thereby enhancing the relevance and impact of the content. One effective approach is Problem-Based Learning (PBL), which can significantly improve mathematical literacy and learning motivation by engaging students with problems pertinent to their everyday experiences (Fery et al., 2017; Syafitri et al., 2021). PBL is a pedagogical model that introduces problems at the beginning of the learning process, focusing on solving complex, unstructured issues from daily life. This method not only fosters enthusiasm for learning but also enhances various student competencies, including mathematical literacy. According to Syafitri et al. (2021), PBL positively influences students' mathematical literacy, particularly in relation to their visual and verbal abilities. Additionally, Fukuzawa et al. (2017) found that PBL boosts students' motivation to learn. The ultimate aim is to cultivate students into individuals capable of problem-solving, critical thinking, innovation, and self-monitoring, thereby advancing their higher-order thinking skills.

Media can help students in problem-solving and increase learning motivation during PBL implementation (Rosmilasari & Adoe, 2021). One of the media that can be utilized as a computer-based tool is GeoGebra. Markus Hohenwarter developed GeoGebra software in Austria between 2001 and 2002 and later expanded it in the United States. GeoGebra, according to Bu and Schoen (Bu & Schoen, 2011), is essential for the development of mathematical models. Everyone has access to GeoGebra as a tool to study many areas of mathematics where users can run simulations and models. Algebra, calculus, statistics, trigonometry, and geometry are just some of the many areas covered by GeoGebra. According to Arbain & Shukor (2015) and Zengin et al. (2012), GeoGebra can improve student achievement levels. Student achievement that can be improved with GeoGebra, for example, is mathematical literacy (Pradana et al., 2020). GeoGebra also affects student learning motivation, based on Putra et al. (2020). GeoGebra can simplify calculations, especially in financial maths calculations. Students only enter the formula in the space provided, and then, by using the slider tool, they can directly find the modal in n period according to the slider displacement. Geogebra makes learning more effective and efficient.

Until now, to the best of the researcher's knowledge, research on the use of PBL and GeoGebra learning models to increase mathematical literacy is still limited to the use of metacognition-based local culture (Dwidayati et al., 2020). There has been no research on the use of PBL and GeoGebra learning models to improve mathematical literacy and learning motivation in financial mathematics. Financial mathematics is very important to learn because it is related to financial literacy which is part of mathematical literacy (Sagita et al., 2022). In the learning outcomes of the *Merdeka* Curriculum, students are expected to be able to apply arithmetic and geometric rows and series in problems related to single interest and compound interest.

Because there has been no research on the use of PBL and GeoGebra learning models to improve mathematical literacy and learning motivation in financial mathematics and many previous studies support that the use of GeoGebra and PBL is effective in developing various student abilities, the researchers were interested in conducting a study that examined the effect of GeoGebra-assisted PBL on mathematical literacy and learning motivation of vocational high school students in financial mathematics material. The research aimed to examine the effect of GeoGebra-assisted PBL on mathematical literacy and learning motivation on vocational high school students' mathematical literacy and learning motivation. It is expected that by using the PBL learning model assisted by GeoGebra in financial mathematics, vocational students can improve their mathematical literacy skills and learning motivation without being left behind by technological advances.

2. METHODS

In this study, a quasi-experimental was used. A quasi-experimental approach was chosen because not all components outside the variables are fully considered (Campbell & Stanley, 2015). The design for this study is one-group pre-test-post-test design because it only uses 1 group class with pre-test and post-test (Sugiyono, 2018). Teaching and learning activities were conducted via offline in the classroom for 5 meetings. 33 students of one chemical industry class at grade 11 of vocational high school were chosen as the subjects for this study period. A straightforward random sampling methodology was utilized in the sampling method. The class that will serve as the experimental class was chosen at random. Mathematical literacy and learning motivation are the dependent variables in this study, whereas the PBL model supported by GeoGebra is the independent variable. For this study, tests, questionnaires, and documentation were used as data collection methods. Pre-test and post-test mathematical literacy questions on financial mathematics material, as well as pre-questionnaire and post-questionnaire questions on learning motivation, were employed as instruments in this study. Documents were used as support for the information gathered from research observation. Documents in the form of images showing the application of learning and student activities throughout the learning process, as well as documents containing lists of student grades and evidence of the results of their work. Figure 1 is an example of using GeoGebra in financial mathematics material to find future modal in n period in simple interest topic.

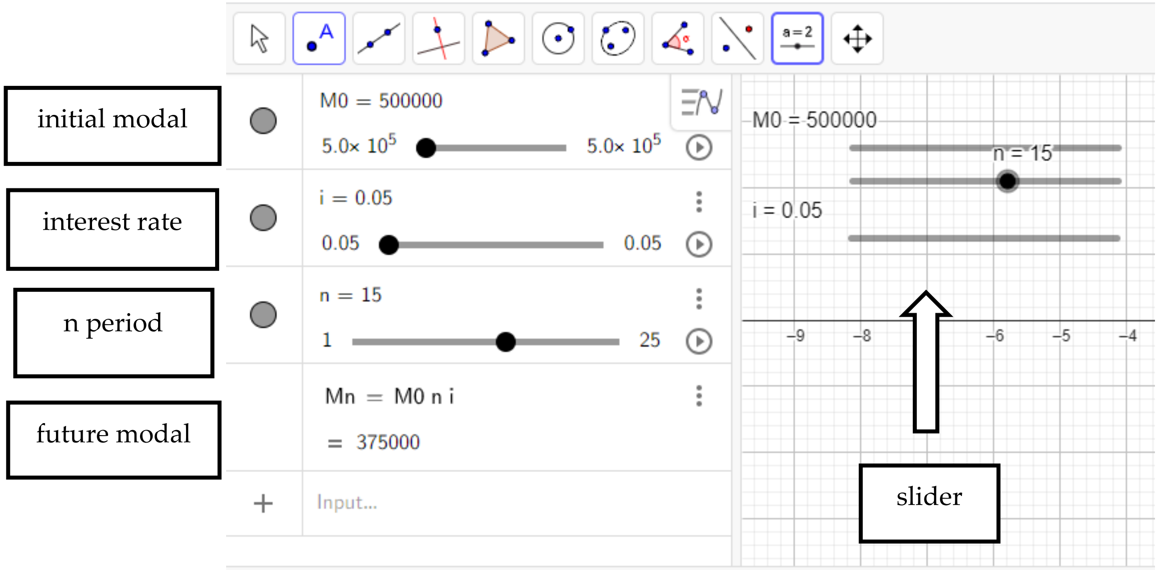

Figure 1. An example of using GeoGebra in financial mathematics material

The experimental class was given a pre-test to measure students' mathematical literacy and a pre-questionnaire to measure students' learning motivation so that researchers knew students' mathematical literacy abilities and learning motivation before the students were given treatment. Then after the last lesson, the experimental class was given a post-test to measure students' mathematical literacy and a post-questionnaire to measure students' learning motivation so that researchers knew students' mathematical literacy abilities and learning motivation after the students were given treatment. Five description questions are included in the financial math literacy test and 32 statements for questionnaires. They were made following the indicators. Indicators for mathematical literacy is shown in Table 1 based on OECD (2018) and indicators for learning motivation is shown in Table 2 modified based on Sardiman (2008).

Table 1. Indicators of the mathematical literacy process for each problem

Indicators of the mathematical literacy process	Sub-indicators of mathematical literacy	Score
Formulate the situation mathematically	Identify the mathematical components of problems found in contexts relevant to the real world and highlight important variables. Use variables, symbols, diagrams, and common models to mathematically depict situations. Determine the components of the issue that match up with already-known data or mathematical concepts, facts, or techniques.	5
Use mathematical concepts, facts, procedures, and reasoning	Make the proper decision. Apply techniques for solving mathematical problems. Determine solutions, use mathematical principles, laws, algorithms, and structures.	10
Interpret, apply, and evaluate mathematical results	Reconcile mathematical findings with the real world. Analyze mathematical answers in light of practical issues.	5

Table 2. Indicators of learning motivation

Indicators	question item number	
	Positive	**Negative**
Strong will to act	1,2	3,4
The amount of time provided for studying	5,6	7,8
Willingness to abandon other obligations or duties	9,10	11,12
Diligence in carrying out tasks	13,14	15,16
Tenacious in facing difficulties	17,18	19,20
Shows interest in various adult problems	21,22	23,24
Prefer to work independently	25,26	27,28
Can defend the opinion	29,30	31,32

Before being tested, researchers conducted validity and reliability estimation to ensure that the instruments made were suitable for measuring what was measured and consistent. The mathematics literacy test and learning motivation questionnaire before treatment and after treatment were made the same so that validity and reliability could be tested using 5 mathematical literacy questions and 32 learning motivation questionnaire statements. The validity proof using expert judgment containing content validity and face validity was conducted by 4 graduate students of mathematics education. The validators gave descriptive suggestions and assessed the instrument, which contained valid and invalid columns. Valid results were obtained for 5 mathematical literacy questions. Several notes from validators such as errors in using symbols, errors in using words, writing effective sentences, and conformity with mathematical literacy indicators. For 32 learning motivation questionnaire statements, valid results were obtained from the validator. Some suggestions from the validator include the appropriateness of word use to the student's level and simplifying sentences. For reliability used the Cronbach alpha coefficient, 0. 798 was obtained for the mathematical literacy test and 0,876 for learning motivation questionnaire which was > 0. 6. The results were said have been reliable because, based on Ghozali (2013), the data was reliable if the Cronbach alpha coefficient > 0. 6. The mathematical literacy test outline in this study is shown in Table 3. Each mathematical literacy question has a value of 20 with the first indicator having a value of 5, the second indicator having a value of 10, and the third indicator having a value of 5.

Table 3. Mathematical literacy test outlines financial mathematics

Topic	Question Number	Score
Growth	1	20
Decay	2	20
Simple interest	3	20
Compound Interest	4	20
Annuities	5	20

The highest score used to measure mathematical literacy is 100 and the lowest is 0. Mathematical literacy ability is said to be adequate if it meets the minimum KKM score of 70. The formula for determining the length of the score interval is based on Kementerian Pendidikan dan Kebudayaan (2017) as follows.

$$Score\ interval = \frac{maximum\ score - KKM\ score}{3}$$

The results of the categorization of mathematical literacy abilities can be seen in Table 4 as follows.

Table 4. The score criteria of mathematical literacy

Score	Criteria
$90 \leq x \leq 100$	Very high
$80 \leq x < 90$	High
$70 \leq x < 80$	Middle
$x < 70$	Low

The finding of the pre-questionnaire and post-questionnaire data were transformed into score Likert scale 1-5 with (1) strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree. Here is Table 5 for the score criteria of motivation to learn mathematics modified based on Azwar (2010).

Table 5. The score criteria of motivation to learn mathematics

Score (X)	Criteria
$132 < X \leq 160$	Very high
$107 < X \leq 132$	High
$82 < X \leq 107$	Middle
$57 < X \leq 82$	Low
$32 < X \leq 57$	Very low

Both descriptive and inferential analytics were used to analyze test data. Data were needed on the scores of students' mathematical literacy and the scores of students' learned motivation questionnaire. Converted the data results before and after the test to the results of the math literacy test, ranging from 0 to 100. Results described include maximum and minimum results, as well as average and standard deviation. Inferential analysis used statistical tests that researchers need to draw conclusions from researched findings. Inferential analysis used normality tests, homogeneity tests, and paired t-tests. Normality tests were used to determine whether the studied data followed a normal distribution. To ascertain whether the data went from a homogeneous population, the homogeneity test was carried out. Widyanto (2013) states that a paired t-test was chosen to evaluate whether there was an average difference between the experimental group's pre-test and post-test results in order to assess the influence of learning. The following is the hypothesis for the prerequisite test for normality and homogeneity, then the hypothesis for the t test for two dependent samples.

2.1 Normality test

In this normality test, the Shapiro-Wilk test is used with the help of IBM SPSS statistics 26 software. The data tested for normality are pre-test and post-test data on mathematical literacy as well as pre-questionnaire and post-questionnaire data on learning motivation.

Hypothesis 1
H_0: pre-test of mathematical literacy came from a normally distributed population
H_1: pre-test of mathematical literacy did not come from a normally distributed population
Hypothesis 2
H_0: post-test of mathematical literacy came from a normally distributed population
H_1: post-test of mathematical literacy did not come from a normally distributed population
Hypothesis 3
H_0: pre-test of learning motivation came from a normally distributed population
H_1: pre-test of learning motivation did not come from a normally distributed population
Hypothesis 4
H_0: post-test of learning motivation came from a normally distributed population
H_1: post-test of learning motivation did not come from a normally distributed population

Significance level: $\alpha = 0.05$
Test statistic: $W = b^2/SS$
with $SS = \sum_{i=1}^{n}(x_i - \bar{x})^2$
if n is even then $m = n/2$, if n is odd then $m = (n - 1)/2$
$b = \sum m\ i{=}1\ ai\ (xn{+}1{-}i - xi)$
Decision criteria:
H_0 is rejected if $W < W_{\alpha(n)}$
or H_0 is rejected if p-value < a

2.2 Homogeneity Test

The homogeneity test uses the Box's M statistical test with the help of IBM SPSS Statistics 26 software. The data tested for homogeneity were pre-test and post-test data on mathematical literacy as well as pre-questionnaire and post-questionnaire on learning motivation in one experimental class.

Hypothesis
H_0: matrix variance-covariance came from a homogeneous population
$H1$: matrix variance-covariance did not come from a homogeneous population
Significance level: $\alpha = 0.05$
tested using Box's M statistical test which is compared with the p-value for each dependent variable.
H_0 s rejected if p-value < 0.05

2.3 T-test for two dependent samples

First hypothesis
$H0$: $\mu d = 0$ (There is no effect in mathematical literacy in GeoGebra-assisted problem-based learning model)
$H1$: $\mu d > 0$ (There is an effect in mathematical literacy in GeoGebra-assisted problem-based learning model)

Second hypothesis
$H0$: $\mu d = 0$ (There is no effect in learning motivation in GeoGebra-assisted problem-based learning model)
$H1$: $\mu d > 0$ (There is an effect in learning motivation in GeoGebra-assisted problem-based learning model)
The significance level is $\alpha = 0.05$

The test statistic is $t = \frac{\bar{d}-\mu_0}{s_d/\sqrt{n}}$ and $H0$ is rejected if p-value < 0.05

The following is a flowchart of the research steps in this article.

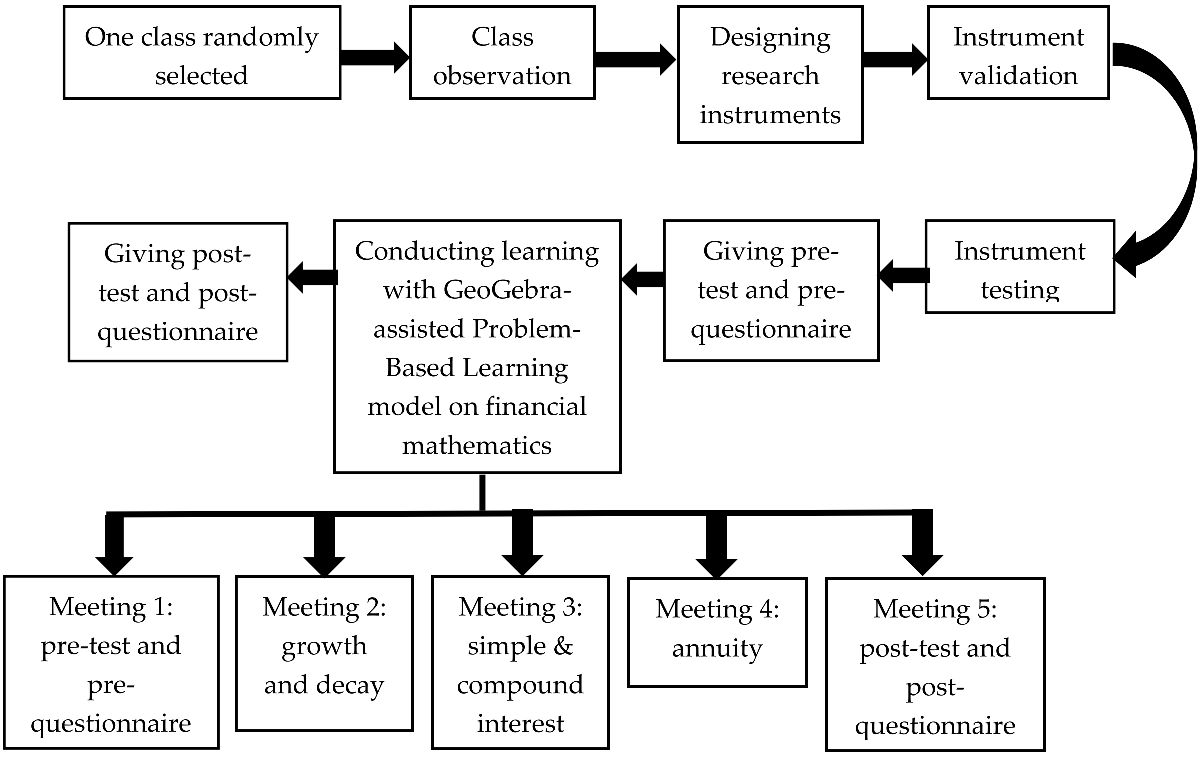

Figure 2. Flowchart the steps of research

3. FINDINGS AND DISCUSSION

3.1. Findings

This study aimed to examine the effect of GeoGebra-assisted PBL on vocational high school students' mathematical literacy and learning motivation. At the first meeting, students were given a pre-mathematical literacy test and a pre-learning motivation questionnaire. Then at the second meeting, students were introduced to geogebra to help calculate growth and decay materials. Then for the third meeting, students can calculate single interest and compound interest using geogebra. The same as the previous meeting, students at the fourth meeting were able to calculate annuities using Geogebra. In general, the existence of Geogebra can make it easier for students to calculate the nth savings by moving the slider on Geogebra. Finally, at the fifth meeting, students were given a post-test on mathematical literacy and a post-questionnaire on student learning motivation. The data that will be analyzed are pre-test and post-test data on mathematical literacy, as well as pre-questionnaire and post-questionnaire data on student learning motivation. To answer the research questions, prerequisite tests are needed, namely the normality test and homogeneity test, then test hypotheses to answer research questions.

3.1.1 Assumption Test before and after treatment

The assumption tests in this studied were the normality test and the homogeneity test. The normality test aims to determine whether data before treatment and after treatment were normally distributed or not. While the homogeneity test aims to determine whether data before treatment and after treatment came from a homogeneous population or not.

Normality Test

This test was carried out to determine whether the data under studied was normally distributed or not. In this normality test, the Shapiro-Wilk test was used with the help of IBM SPSS statistical software 26 using a significant level $\alpha = 0.05$.

Table 6. Normality test results

Shapiro-Wilk	Math literacy test (p-value)		Questionnaire (p-value)	
	Pre	**Post**	**pre**	**post**
Sig. (2-tailed)	0,065	0,060	0,987	0,807
Decision	Normal	Normal	Normal	Normal

Based on the data in Table 6, it can be seen that the p-value on the mathematics literacy pre-test is 0.065. 0.065 > 0.05 so H_0 is rejected and H_1 (alternative hypothesis) is accepted. It can be said that the mathematics literacy pre-test data is normally distributed. Furthermore, the p-value on the mathematical literacy post-test was 0.060. 0.060 > 0.05 so H_0 is rejected and H_1 (alternative hypothesis) is accepted. It can be said that the post-test data on mathematical literacy is normally distributed. Then for the questionnaire, the p-value on the pre-questionnaire for learning motivation was 0.987. 0.987 > 0.05 so H_0 is rejected and H_1 (alternative hypothesis) is accepted. It can be said that the pre-questionnaire data on learning motivation is normally distributed. The same decision also applies to post-questionnaire data on learning motivation of 0.0807 which is more than 0.05 so that H_0 is rejected and H_1 (alternative hypothesis) is accepted. It can be said that the post-questionnaire data on learning motivation is also normally distributed.

Homogeneity Test

The homogeneity test was conducted to determine whether the data came from a homogeneous population. The homogeneity test used Box's M statistical test with the help of IBM SPSS Statistic 26 software with a significance level of 0.05. The homogeneity results can be seen in the following table:

Table 7. Homogeneity test results

Box's M Statistic	df1	df2	p-value	Decision
1.186 (pre-test and post-test)	1	64	0,280	Homogenous

Based on the data in Table 7, the p-value is 0.280. o.280 > 0.05 so H_0 is accepted. It can be said that the variance-covariance matrix of mathematical literacy and student learning motivation in one experimental class comes from a homogeneous population.

3.1.2 The Effect Test of Geogebra-Assisted Problem-Based Learning

Data distribution

Based on the pre-test, post-test, and questionnaire results, the researcher analyzed the average score, standard deviation, maximum score, and minimum score. The average score is crucial to demonstrate the difference in improvement between the data obtained before and after the intervention. The standard deviation indicates the extent of data variability around the average. Additionally, the maximum and minimum scores highlight the range of the data. The results of the written tests and questionnaires before and after learning financial mathematics using Problem-Based Learning are presented in Table 8.

Table 8. Data distribution results

	Results of students' mathematical literacy test		Results of students' questionnaire	
	Pre	Post	Pre	Post
Many students	33	33	33	33
Average score	36,64	68,27	89,55	90,67
Std. Deviation	20,103	17,398	18,296	18,046
Max obs score	73	93	123	125
Min obs score	24	24	46	46
Max ideal score	100	100	160	160
Min ideal score	0	0	32	32

Table 9. The number of students per category for learning motivation

Category	pre-questionnaire	post-questionnaire
very low	1	0
low	14	12
middle	12	14
high	6	7
very high	0	0

Based on the Table 9, post-questionnaire results are better than the pre-questionnaire results in each section. For learning motivation, the mean score increased from 89.55 to 90.67, which fell into the category of having middle learning motivation, as shown in Table 4. Based on Table 9, it can also be seen that there is an increase in motivation for the high and very high categories. It can be seen that the learning motivation of students in 11^{th} grade of industrial chemistry using PBL model assisted by GeoGebra has increased and has a moderate category.

Table 10. The number of students per category for mathematical literacy

Category	pre-test	post-test
low	32	15
middle	1	8
high	0	8
very high	0	2

Similar to the questionnaire results, Table 10 shows that post-test scores are higher than pre-test scores. For mathematical literacy, the mean score increased from 36.64 to 68.27, which, despite the improvement, still falls into the category of low mathematical literacy skills according to Table 4. Table 10 also indicates an increase in motivation across the middle, high, and very high categories. This data demonstrates that while the mathematical literacy of 11th-grade industrial chemistry students using the PBL model assisted by GeoGebra has improved, the average literacy level remains in the low category.

For the indicator of formulating the situation mathematically, students were less correct. There were numerical errors in writing capital and symbol errors. Then, for the indicator of using mathematical concepts, facts, procedures, and reasoning, students made mistakes in the concept of logarithms. Students were less able to operate calculators to find the value of logarithms. Errors were also found in the indicators of interpreting, applying, and evaluating mathematical results. Students were less able to interpret the results in the real world. The conclusion did not make sense because the year for the solution of the problem was not round.

Hypothesis Test

After obtaining normal and homogeneous distributed data, the t-test was used to test the hypothesis. The test used is the paired sample t-test.

Table 10. The paired sample t-test results

Variables	p-value	Decision
Mathematical literacy	0	H_0 is rejected
Learning motivation	0.006	H_0 is rejected

Null hypothesis (H_0) for mathematical literacy is: there is no effect in mathematical literacy in GeoGebra-assisted problem-based learning model. The other side, alternative hypothesis (H_1) for mathematical literacy is there is an effect in mathematical literacy in GeoGebra-assisted problem-based learning model. Based on the hypothesis test carried out for mathematical literacy, a P-value of 0.000 was obtained. Because the P-value is less than 0.05 the significance level, so the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. So that, there is an effect in mathematical literacy in the GeoGebra-assisted problem-based learning model.

The null hypothesis (H_0) for learning motivation states that the GeoGebra-assisted problem-based learning model has no effect on learning motivation. Conversely, the alternative hypothesis (H_1) posits that the GeoGebra-assisted problem-based learning model has an effect on learning motivation. The hypothesis test for learning motivation yielded a P-value of 0.000. Since this P-value is less than the significance level of 0.05, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). Therefore, it can be concluded that the GeoGebra-assisted problem-based learning model has a significant effect on learning motivation.

3.2. Discussion

In math lessons, it's essential to pick a learning model that fits the circumstances and requirements of the students. Students will become discouraged from learning mathematics if the selection is improper. Because Problem-Based Learning employs problems to learn, it is a good learning model for students who enjoy practicums, such as those at vocational high schools (Moust et al., 2021). The use of problem-based learning also makes learning meaningful since it prepares students to solve problems in daily life situations and adheres to student needs (Junianto & Wijaya, 2019). Media selection is just as important to learning as model selection. The chosen medium must be of a high standard, fit for the subject matter, and consider any particular student peculiarities or student characteristics (Susilana & Riyana, 2009). Since students can use technical tools to solve problems directly, GeoGebra is a good fit for vocational high school students who often learn best through kinesthetic experiences (Jacinto & Carreira, 2017). Students may find it simpler to calculate while using GeoGebra in financial mathematics because they are simply entering existing facts and formulas. By simply moving the slider to the desired number, students can use the slider to find the modal of the n period by changing what is already known. According to the calculations analysis, the average level of mathematical literacy among the pupils was 36.64 before treatment and 68.27 after treatment. It shows that there has been an increase in motivation from before being given treatment to after being given treatment. Besides that, for learning motivation based on Table 7, before receiving treatment, there were 1 student with very low criteria, 9 students with low criteria, 14 students with moderate criteria, 6 students with high criteria, and 4 students with very high criteria. After receiving treatment, the results of the student learning motivation post questionnaire were obtained with 1 student in the very low category, 5 students in the low category, 14 students in the medium category, 7 students in the high category, and 4 students in the very high category.

The hypothesis test, specifically the paired sample t-test, suggests that the average pre-test and post-test results for mathematical literacy using the GeoGebra-assisted PBL model are different**.** That difference occurred due to an increase in the average score from pre-test to post-test of 31.36. It can be concluded that learning using PBL, assisted by Geogebra, has an influence on students' mathematical literacy abilities. These findings are the same with studies conducted by Fery et al. (2017) and Syafitri et al. (2021). Mathematics literacy abilities are impacted by PBL (Syafitri et al., 2021). In urban, rural, and transitional settings, PBL is superior to the direct learning strategy for enhancing mathematics literacy (Fery et al., 2017). Additionally, GeoGebra is one of the tools that significantly contributes to fostering mathematical literacy (Pradana et al., 2020). The finding is supported by Dwidayati et al. (2020) that the implementation of GeoGebra and PBL methods can enhance students' mathematical literacy. Not only for mathematical literacy, the geogebra-assisted PBL model also influences student learning motivation. These results are in line with Fukuzawa et al. (2017), who state that students have high learning motivation when using PBL. GeoGebra also has an effect on increasing student learning motivation (Putra et al., 2020). Based on the results obtained and the explanation of the discussion, it can be concluded that GeoGebra-assisted problem-based learning affects on mathematical literacy and student learning motivation. Teachers can use GeoGebra as an alternative media to train students' mathematical literacy skills and increase students' learning motivation.

4. CONCLUSION

The results of the research showed that mathematics learned used GeoGebra-assisted problem based learned affects students' mathematical literacy skills and learned motivation. There was an increase in the average from pre-test results to post-test results for the mathematics literacy test and learned motivation questionnaire. Even though there had been an increase, some students still made mistakes when working on mathematical literacy questions, such as not being careful in calculating and not being appropriate in interpreting the results obtained to the problems given. The limitation of this research was that it used subjects from grade 11 students at vocational high schools that focus on industrial chemistry majors. Further research was needed to determine how geogebra-assisted problem-based learning influences students' mathematical literacy and motivation to learn at other levels and on different materials. Apart from that, further researchers were needed who could examine the mathematical abilities of other students by applying various approaches, models and methods that were different from this research. Teachers could use geogebra as an alternative media to train students' mathematical literacy skills and increase students' learned motivation.

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