12(2), 2023, 1-10 DOI: 10.23960/jppk.v12.i2.2023.01
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-ISSN 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

The Relationship of Mathematical Ability and Self- Efficacy to Chemistry Learning Outcomes of Class XI High School Students on Buffer Solution Material

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Received: May 24th, 2023 Accepted: June 17th, 2023 Online Published: August 1st, 2023

Abstract: The Relationship Between Mathematical Ability and Self-Efficacy on the Learning Outcomes of Grade XI High School Students in Buffer Solution Material. This study aims to determine whether there is a relationship between mathematical ability and self-efficacy on chemistry learning outcomes of high school class XI students on buffer solution material. The population of this study were all students of class XI MIA SMA Negeri 10 Medan and the research sample was class XI MIPA 2 which was selected using purposive sampling technique. Based on the regression test, linearity and hypothesis I obtained a linear and significant relationship between math ability and chemistry learning outcomes with a correlation value of 0.61. From the results of hypothesis II obtained there is a linear and significant relationship between self-efficacy and chemistry learning outcomes with a correlation value of 0.63. Furthermore, from hypothesis III It is obtained that there is a linear and significant relationship between math ability and self-efficacy with students' chemistry learning outcomes with a contribution of 75.69%.

Keywords: Math Ability, Self-efficacy, Learning Outcomes, Buffer Solution

Abstrak: Hubungan Kemampuan Matematika Dan Self- Efficacy Terhadap Hasil Belajar Kimia Siswa Kelas XI SMA Pada Materi Larutan Penyangga. *Penelitian ini bertujuan untuk mengetahui apakah ada Hubungan Kemampuan Matematika Dan Self- Efficacy Terhadap Hasil Belajar Kimia Siswa Kelas XI SMA Pada Materi Larutan Penyangga. Populasi penelitian ini adalah seluruh siswa kelas XI MIA SMA Negeri 10 Medan dan sampel penelitian adalah kelas XI MIPA 2 yang dipilih menggunakan teknik purposive sampling. Penelitian ini menggunakan dua instrumen tes yaitu tes kemampuan matematika dan tes hasil belajar kimi, Berdasarkan uji regresi, linieritas dan hipotesis I diperolah hubungan yang linier dan signifikan antara kemampuan matematika dan hasil belajar kimia dengan nilai korelasi 0,61. Dari hasil hipotesis II diperoleh ada hubungan yang linier dan signifikansi antara self-efficacy dan hasil belajar kimia dengan nilai korelasi 0,63. Selanjutnya dari hipotesis III diperoleh ada hubungan yang linier dan signifikansi antara kemampuan matematika dan self-efficacy dengan hasil belajar kimia siswa dengan kontribusinya sebesar 75,69%.*

Kata kunci: *Kemampuan Matematika, Self-efficacy, Hasil Belajar, Larutan Penyangga*

- **INTRODUCTION**

In the 2013 curriculum, chemistry is one of the science subjects that must be taught at the senior high school level. The concepts of learning materials in chemistry are mostly abstract so that many students have difficulty in understanding them.

According to Woldeamanuel, et al (2013) many students are afraid of chemistry subjects because students have a bad perception of chemistry subjects so that the material taught is difficult to understand. According to Ristiyani & Bahriah (2016), one of the factors causing chemistry learning difficulties in students is psychological factors with a contribution of 69.78% (moderate category).

Chemistry learning material is a combination of theory and calculation, so students who study it need good math skills in solving problems. According to Fahyuddin, et al (2012) the structure of mathematics and quantitative chemistry has many similarities such as abstract nature and strong connections between concepts, so that math skills are related to the development of abstract thinking skills.

According to Mann (2006) math skills can develop and answer problems that are solved using calculations. The important role of mathematics in chemistry can be used as a basis for calculations in learning activities, for example in calculating pH, poH, pKw and buffer solutions in acid-base (Sappaile, 2019).

In general, the success of students in learning is strongly influenced by various factors, namely external factors such as family environment, parents' economic level and others. In addition to external factors, the success of learners is also influenced by internal factors, both physiological and psychological. Psychological factors that affect learning outcomes include learner intelligence, motivation, learning independence, self-efficacy, interest, attitude, and talent (Andriana & Leonard, 2017). Internal factors that can affect learning outcomes include self-efficacy, learning activities, learning independence and critical thinking skills (Suryani, Pendi, & Seto, 2020).

Bandura suggests that self-efficacy is people's beliefs about their ability to produce a level of performance and master situations that affect their lives, then self-efficacy will also determine how people feel, think, motivate themselves and behave (Bandura, 1997).

A person's self-efficacy can be seen based on three aspects. First, Level/Magnitude: This aspect refers to the degree of difficulty of the task at hand. People's acceptance and belief in a task is different. The perception of each individual will be different in viewing the level of difficulty of a task. The perception of a difficult task is influenced by the competence of the individual. Some consider a task to be difficult while others may feel it is not. This belief is based on their understanding of the task. Secondly Generality: This aspect refers to the extent to which individuals believe in their abilities in a variety of task situations, ranging from performing a commonly performed activity or a specific situation that has never been done to a series of difficult and varied tasks or situations. Third Strength: this aspect is the strength of a person's beliefs about their abilities when facing the demands of a task or problem (Bandura, 1997).

According to Jamal & Suraya (2017) that self-confidence in students can help complete tasks and produce something best according to their respective abilities. Based on the results of Bembenutty's research (2011) there is a positive relationship between homework assignments given by teachers with self-confidence and a sense of responsibility in students. This can help students to realize a learning system with better academic quality, increase high self-confidence and maximum chemistry learning outcomes.

According to Cholifah, et al (2019), one of the materials considered difficult by students

when studying chemistry in class XI SMA is buffer solution material. In learning buffer solutions, students are required to understand concepts and be able to solve mathematical equations correctly. Based on the results of research by Orgill & Sutherland (2008) revealed that in buffer material, students struggle / work hard to understand the concept of buffer solutions and calculations because the concepts in buffer material will also be applied to biochemistry, basic chemistry and analytical chemistry.

According to Rahayu, et al (2014) the concept of buffer solution is one of the essential materials that most of the concepts are abstract and microscopic. In studying buffer solutions, students often have difficulty in doing chemical calculation problems, especially in determining the pH of the solution. Calculating the pH price in buffer solution material requires mathematical concepts, especially related to logarithms. Students must master the concept of logarithms well so that when they have to find the pH price of a solution students can operate the numbers to get the pH price. Students' understanding of exponent numbers will greatly affect their learning development in chemistry teaching materials, especially buffer solution materials. In addition, solving problems also requires mathematical concepts such as multiplication, division, addition and subtraction. The ability to understand mathematical concepts makes students able to utilize what has been understood into learning activities and connect one teaching material with other teaching materials in other subjects. If students have a good understanding, then these students are ready to give definite answers to statements or problems in learning.

Based on the results of research observations with chemistry teachers in grade XI at SMA Negeri 10 Medan, the learning process at school still uses conventional methods such as lecture and question and answer methods, where this method is more dominated by the teacher, causing students to be passive during the learning process. In addition, the chemistry teacher of grade XI SMA Negeri 10 Medan also said that students' interest in learning chemistry is also still lacking.

Various studies have been conducted by researchers to see the extent of the relationship between students' ability in mathematics and their achievement in other subjects. Based on the results of Merdekawati's research (2013), the average cognitive achievement of students who have high mathematical ability is higher than the cognitive average of students who have low mathematical ability. The data obtained that the average cognitive achievement of students who have high mathematical ability is 67.05 while the average cognitive achievement of students who have low mathematical ability is 57.6. Furthermore, based on the results of Sari's research (2017) suggests that the contribution of mathematical ability to chemistry learning outcomes is 29.3% while 70.7% is the contribution of other factors.

Related to self-efficacy, based on the results of Hairida & Astuti's research (2012) there is a positive and significant relationship between self-efficacy and chemistry learning achievement. Students who have high self-efficacy also get high learning achievement, while students with low self-efficacy show low learning achievement. Furthermore, based on the results of research by Majidah, et al (2014) there is a positive relationship between self-efficacy and knowledge domain learning outcomes, where students who have good self-efficacy will provide better learning outcomes.

Although research on the relationship between math ability and chemistry learning achievement has been widely done, as well as the relationship between self-efficacy and learning achievement, research that reveals the simultaneous relationship between math ability and self-efficacy on chemistry learning outcomes is still rarely done.

• METHOD

The research method used is one of the research methods according to (Arikunto, 2010), Correlational Studies is a study to determine whether there is a relationship between two or more

variables. The characteristics of this correlational research do not demand too many research subjects.

The population in this study were all students of class XI IPA SMA Negeri 10 Medan in the school year 2022/2023. The sample used was only one class, namely class XI IPA 2 SMA Negeri 10 Medan with a total of 32 students. By using Purposive sampling technique. The type of data used is primary data which is test result data (pretest and posttest scores) besides that there is also secondary data in the form of a self-efficacy questionnaire.

The feasibility test of the test instrument (pretest and posttest questions) uses validity, reliability, difficulty level, and distinguishing power tests. The test was carried out by giving pretest and posttest questions to students who had received or studied buffer solution material before. To find out the question is valid or feasible to use at the time of research. The validity of the question is determined by comparing the r-table and r-count values. The criterion is if r-table> r-count then the question is said to be valid. Reliability is determined using Cronbach's Alpha. The criteria for the degree of reliability (r11) according to Guilford are shown in table 1.

Table 1. Criteria for Degree of Reliability

Reliability Coefficient	Reliability Level
0,800 – 1,000	Very High
0,600 – 0,799	High
0,400 – 0,599	Fair
0,200 – 0,399	Low
0,00 – 0,199	Very Low

To calculate the value of the math ability test results and the results of the self-efficacy questionnaire and student learning outcomes obtained. Analysis of the test instrument is done by calculating the number of scores obtained by students with the formula:

$$\text{Score} = \frac{\text{number of correct questions}}{15} \text{ x } 100$$

And the analysis of non-test instruments is done by calculating the number of scores obtained by students with the formula:

$$\text{Score} = \frac{\text{number of correct questions}}{100} \text{ x } 100$$

Hypothesis testing is done by calculating manually using Microsoft excel. For hypothesis tests I and II were carried out with simple regression. Simple linear regression analysis is used to test whether there is a linear relationship between math ability (X1) and chemistry learning outcomes (Y) and whether there is a linear relationship between self-efficacy (X2) and student chemistry learning outcomes (Y). The simple correlation analysis (Product Moment from Pearson) is done using the formula:

$$\boldsymbol{r} = \frac{N\sum XY - (X)(Y)}{\sqrt{\{N\sum X^2 - (\sum X)\}\{N\sum Y^2 - (\sum Y)^2}}$$

The simple correlation significance test is carried out by comparing the obtained r value (r-hit) with the r table at a certain significance level, with the criteria: if r hit ≥ r - table then Ho is rejected, which means that there is a significant positive / negative correlation between variable X and variable Y.

Hypothesis III was tested with multiple linear regression which was used to test whether there is a significant relationship between math ability and self-efficacy with students' chemistry learning outcomes. Multiple correlation is a number that shows the direction and strength of the relationship between two or more independent variables together (simultaneously) with one dependent variable. The formula for multiple correlation of two variables is shown in the formula below:

$$r_{y.x1x2} = \sqrt{\frac{r_{yx1}{}^{2} + r_{yx2}{}^{2} - 2r_{yx1}r_{yx2}r_{x1x2}}{1-r_{x1x2}}}$$

To calculate the multiple correlation coefficient, the simple correlation must first be calculated through Pearson's product moment correlation. Testing the significance of the double correlation coefficient or seeing if there is a significant relationship between math ability and self-efficacy with chemistry learning outcomes can use the following formula, namely the F test:

$$F_{hitung} = \frac{\frac{r^2}{k}}{\frac{(1-r^2)}{n-k-1}}$$

The Fcount is then compared with the Ftable price with k is the numerator and (n-k-1) the denominator with a significance level of 5%. If Fhitung > Ftabel then the hypothesis is significant. If Fcount < Ftable then the hypothesis is not significant. (Silitonga, 2014).

- **RESULT AND DISCUSSION**

Before the test instruments (pretest and posttest questions) are given to students, validity and reliability tests are carried out. This test aims to determine whether the question is feasible or not to be used when conducting research. In testing the test instrument in this study, it was tested on students who had studied buffer solution material. After obtaining the data from the pretest and posttest results, it was analyzed using Microsoft excel. After being calculated, the results are obtained in the form of numbers which will be analyzed according to the criteria.

The results of the validity and reliability test of multiple choice math ability test questions can be seen in table 2 below.

Table 2 Results of Validity and Reliability of Math Ability Tests

No	Question Number	Valid	Reliability
1	1	0.44125633	0,911
2	3	0.547367	
3	7	0.645813	
4	8	0.447106	
5	9	0.650875	
6	10	0.469552	
7	11	0.578424	
8	13	0.658072	
9	14	0.480148	
10	16	0.448246	
11	18	0.528681	
12	21	0.361591	
13	22	0.507644	
14	24	0.671089	
15	26	0.638342	

The results of the validity and reliability test of multiple choice chemistry learning outcomes test questions can be seen in table 3 below.

Table 3. Validity and Reliability Results of the Chemistry Learning Outcomes Test

No	Question Number	Valid	Reliability
1	2	0.5128024	0,8512

No	Question Number	Valid	Reliability
2	3	0.576590308	
3	8	0.4931297	
4	9	0.453784	
5	10	0.403057	
6	12	0.65824	
7	13	0.4341115	
8	14	0.476301	
9	16	0.7354687	
10	17	0.41269	
11	19	0.4535	
12	22	0.735469	
13	23	0.545001	
14	24	0.73547	
15	25	0.735469	

Based on table 2 and table 3, there are 15 questions that are valid and suitable for use in research to measure math ability tests and student learning outcomes tests with a reliability value on the math ability test of 0.911 and on the chemistry learning outcomes test of 0.8512.

Before the learning process is carried out, a math ability test is given first. Then the self-efficacy non-test and chemistry learning outcomes test were given at the end of the lesson. Based on 32 samples of class XI IPA 2, student scores were obtained with three instruments, namely two test instruments and one non-test instrument. Test instruments are used to measure students' mathematical abilities and students' chemistry learning outcomes. Non-test instruments are used to measure student self-efficacy. The average value of mathematical ability is 70.43, student self-efficacy is 84.18, and student chemistry learning outcomes test is 84.

From the data on the value of Mathematical Ability (X_1) and Student Chemistry Learning Outcomes (Y) above, it shows a linear graph as shown in Figure 1.

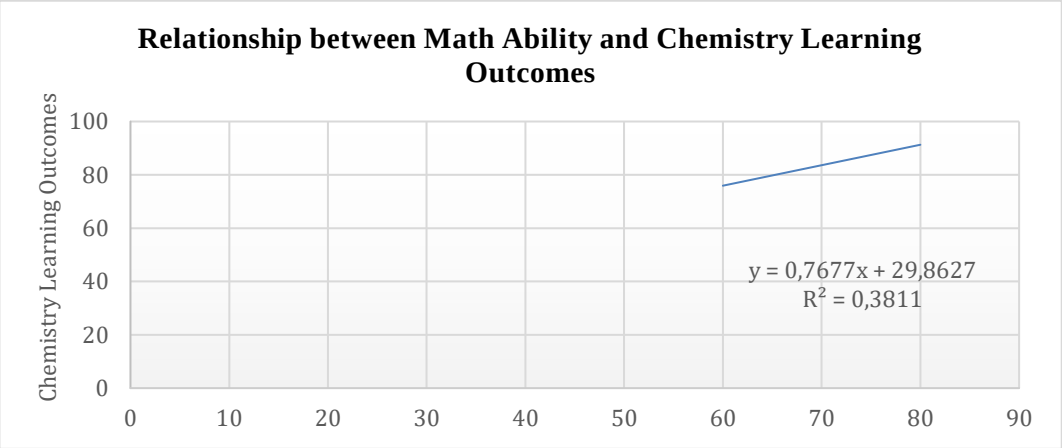

Figure 1. Graph of the Relationship between Mathematics Ability and Student Chemistry Learning Outcomes.

Based on the graph above, the highest math ability score is 80 and the lowest is 60. As for the chemistry learning outcomes test, the highest score is 93 and the lowest is 73. The equation from the graph above is Y = 0.7677x + 29.8627 this equation is in accordance with the simple linear regression equation, namely Y = a + bx. where a (29.8627) states the constant number and the value of b (0.7677x) states the regression coefficient.

From the data score of Self-efficacy (X2) and Student Chemistry Learning Outcomes (Y) above, shows a linear graph as in Figure 2.

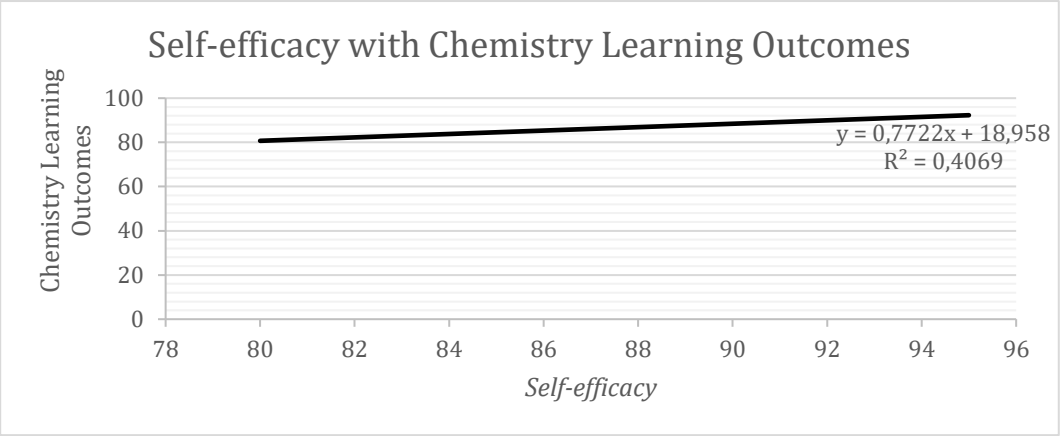

Figure 2. Graph of the Relationship between Self-Efficacy and Student Chemistry Learning Outcomes

Based on the graph above, the highest self-efficacy value is 95 and the lowest is 80. As for the chemistry learning outcomes test, the highest value is 93 and the lowest is 73. The equation from the graph above is Y = 0.7722x + 18.958 this equation is in accordance with the simple linear regression equation, namely Y = a + bx. where a (18.958) states the constant number and the value of b (0.7722x) states the regression coefficient.

After conducting research and collecting data, hypothesis testing is carried out using statistical tests, namely regression and correlation tests with the aim of whether the hypothesis in this study can be accepted or rejected. Regression testing criteria Fcount> Ftabel and correlation testing criteria rcount> rtable. If the test meets both criteria, the hypothesis in this study can be accepted.

Hypothesis I in the regression linearity test is used to test whether there is a linear relationship (causal relationship) that is significant between math ability (X_1) and student chemistry learning outcomes (Y). linearity test is carried out by analysis of variance (variance analysis) based on calculations obtained data on the results of hypothesis I test as follows:

Table 4. List of Variance Prints of Math Ability with Chemistry Learning Outcomes

Source of variation	Db	JK	KT	F_{hitung}	F(0,05)(1)(30)
Regression	1	332,30	332,30	18,46	4,17
Residuals	30	539,575	17,98		
Total	31	871,875			

Thus obtained Fhitung = 18.46, while Ftabel = 4.17. Because Fcount> Ftable means Ho is rejected and Ha is accepted. That is, there is a linear and significant relationship between math skills and student chemistry learning outcomes on the subject of buffer solutions. From the calculation obtained the correlation coefficient rcount = 0.61 and rtable = 0.396 so rcount> rtable means there is a positive correlation between math skills and student chemistry learning outcomes.

To find out how much the contribution of math skills with student chemistry learning outcomes, the coefficient of determination (CD) test can be sought. Based on the calculation, the contribution of math skills to students' chemistry learning outcomes on buffer solution material is 37.21% while 62.79% is influenced by other factors.

Hypothesis II in the regression linearity test is used to test whether there is a linear relationship (causal relationship) that is significant between Self-Efficacy (X2) and student chemistry learning outcomes (Y). linearity test is carried out by analysis of variance (variance analysis) based on the calculations obtained the following hypothesis test data:

Table 5. List of Variance Prints of Self-efficacy with Chemistry Learning Outcomes

Source of variation	Sumber keragaman	Db	JK	KT	F_{hitung}	F(0,05)(1)(30)
Regression	Regresi	1	354,73	354,73	20,58	4,17
Residuals	Sisaan	30	517,14	17,23		
Total	Total	31	871,875			

Thus obtained Fhitung = 20.58, while Ftabel = 4.17. Because Fcount> Ftable means Ho is rejected and Ha is accepted. That is, there is a linear and significant relationship between self-efficacy and student chemistry learning outcomes on the subject of buffer solutions. From the calculation obtained the correlation coefficient rcount = 0.63 and rtable = 0.396 so rcount> rtable means there is a positive correlation between self-efficacy and student chemistry learning outcomes.

To find out how much self-efficacy contributes to students' chemistry learning outcomes, the coefficient of determination (CD) test can be sought. Based on the calculation obtained the contribution of self-efficacy with student chemistry learning outcomes on buffer solution material is 39.69% while 60.31% is influenced by other factors.

Hypothesis III correlation analysis is used to measure how close the relationship is between two or more variables. To calculate the multiple correlation, the simple correlation must first be calculated through Pearson's Product moment correlation. In this case, a correlation test is carried out to calculate the correlation between Mathematical Ability (X1) and student chemistry learning outcomes (Y); Self-efficacy (X2) with student chemistry learning outcomes (Y); then the double correlation between Mathematical Ability (X1) and Self-efficacy (X2) with student chemistry learning outcomes (Y). The data from the calculation of the correlation test can be seen in Table 6 below:

Table 6 Correlation Test Calculation Results

CorrelationAnalysis	r_{hitung}	r_{tabel}
r_{yx1}	0,61	0,349
r_{yx2}	0,63	
r_{x1x2}	0,424	
r_{yx1x2}	0,87	

Based on the table above, it can be seen that math ability and self-efficacy on student chemistry learning outcomes have a positive correlation. Based on the calculation of the contribution obtained, it can be concluded that the contribution of mathematical ability and self-efficacy to chemical learning outcomes on buffer solution material is 75.69% while 24.31% is influenced by other factors.

- **CONCLUSION**

After conducting research, calculating data and testing hypotheses, the research results are obtained as follows:

There is a linear and significant relationship between math ability and student chemistry learning outcomes with a correlation value of 0.61 with the contribution of math ability to student learning outcomes of 37.21% and the remaining 62.79% is influenced by other factors. There is a linear and significant relationship between self-efficacy and student chemistry learning outcomes with a correlation value of 0.63 with a contribution of self-efficacy to student learning outcomes of 39.69% and the remaining 60.31% is influenced by other factors. There is a linear and significant relationship between math ability and self-efficacy with student chemistry learning outcomes with a correlation value of 0.87 with the contribution of math ability and self-efficacy to student learning outcomes by 75.69% and the remaining 24.31% is influenced by other factors.

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