

Analysis of Ability Profile of Mathematic of Chemical Education Students' on Chemical Question Solving

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Abstract—The purpose of this study is to find correlation between mathematic ability to chemistry learning outcomes of students of Chemical Education Study Program. This research used mixed method (Quantitative-Qualitative Mixed Method) with quantitative descriptive research design. The population of this research was all students of Chemistry Education of UIN Sunan Gunung Djati Bandung Academic Year 2017/2018. Samples of the study were fifth semester students of study Program of Chemical Education. Technique of collecting data was using test. The tests used in this study were tests of mathematical ability and chemistry test. The results showed positive and significant correlation between mathematical ability and chemistry ability of students of Chemical Education Study Program of Tarbiyah and Teacher Training Faculty of UIN Sunan Gunung Djati Bandung. This meant that the higher the students' math ability the higher the students' chemical ability, and vice versa.

Keywords—ability of chemistry; mathematic ability

I. INTRODUCTION

Chemistry is one of the subjects other than dealing with everyday life, but there is a question solving that requires mathematical calculations. Question-solving abilities can be made if students can understand the question, create a question-solving plan, complete a solving plan and re-examine the completion result [1]. The ability to understand the concept becomes the basis for thinking in solving questions, so that learners will be able to explain a situation or action [2].

With good comprehension ability, the students will be able to translate sentences into other sentence forms and can determine the exact concept and apply in math calculations. In solving chemical calculation questions using mathematical understanding is not an objective but in this case mathematics as an instrumental used to achieve the desired goal [3]. With

the use of mathematics, the solving of chemical calculation questions can be simplified, and the presentation of the theory can be done more briefly. One of the chemical concepts that the solving of the calculation question requires mathematical ability is stoichiometry, reaction rate, acid base, buffer solution, thermodynamics, and core chemistry [4].

Mathematical ability is not born just like that. But it is through the process of learning and the desire to understand science to be able to change life for the better. Change can only be done by way of studying. This is in accordance with the word of God:

Meaning: ... Allah will not change the fate of a people except the people themselves who change what is in themselves (Surah Ar-Ra'd verse 11) [5].

Similar research results have been conducted by Hasim in general, students still struggle to answer stoichiometric questions [6, 7]. The low students' mathematical ability, especially algorithmic in solving stoichiometric questions is also low. The ability to solve mathematical questions positively correlated with student learning outcomes in the low group [8]. It is unlike the case with the above research. This study aims to find out correlation between mathematic ability to the chemistry learning outcomes of students of study program of Chemical Education.

II. RESEARCH METHODOLOGY

This study used mixed methods (Quantitative-Qualitative Mixed Method) with quantitative descriptive research design. The population of this research was all students of Chemistry Education UIN Sunan Gunung Djati Bandung Academic Year 2017/2018. While the samples of research were fifth semester students of chemistry education study program of Faculty of

Tarbiyah and Teaching Training UIN Sunan Gunung Djati Bandung School Year 2017/2018.

The instruments used in this research are mathematics ability test and chemical ability test. Before being tested, mathematical ability tests and chemical ability tests are pre-tested first by looking at validity, reliability, distinguishing and difficulty. After tested, 8 questions were obtained for mathematic ability test and 5 questions for chemical ability test.

Data in the form of math ability test and chemical ability test were analyzed by correlation test. Normality assumption test is done before the correlation test between mathematical ability with chemical ability. The following shows the normality test data in Table 1.

TABLE I. SUMMARY OF DATA NORMALITY TEST

Data	L _{count}	L _{table}	Decision of Test	Distributed Data
Math Ability	0.0679	0.1163	H ₀ is accepted	Normal
Chemical Ability	0.1025	0.1163	H ₀ is accepted	Normal
Posttest	0.2337	0.1419	H ₀ rejected	Abnormal

From Table 1, it is found that the data of mathematical ability and chemical ability were normally distributed. Therefore, the data of mathematical ability and chemical capability is continued by correlation test with product moment.

III. RESULTS AND DISCUSSION

A. Mathematic Ability

On the question of no 1 about the comparison that there were 39 students were high in working on questions number one, 2 students of medium category, and 17 students of low category.

Analysis of student errors as follows.

- Misinterpretation of cross product so $\frac{2}{3} \times \frac{4}{x}$ when it should be $\frac{2}{3} = \frac{4}{x}$
- Some students only give answers directly without writing down the steps to get the answer.
- The concept of comparison is not understood by students so that many students are reversed in comparison

While on the mathematic question number 2 found that students with high category as many as 24 students, low category as many as 8 students, and 26 students were categorized as low in doing question number 2.

From the question that has been given, it was obtained analysis of students' error in doing question number two as follows.

- Some do not yet understand the logarithmic nature of $\log 7^2 = (0.4771)^2$ which should be $\log 7^2 = 2 \times \log 7$.
- Some already understand the logarithmic properties but the log value 7 is not replaced with 0.4771, log 2 is not replaced with 0.3010 already stated in the question.
- Some students write logs $(8 \times 100 + 12 \times 7) = \log (2^3 \times 10^{10} + 3 \times 2 \times 2 \times 7)$. In the answer, the student actually already understood about fact number 882 but the location of student error is 100 considered 10^{10} whereas $100 = 10^2$. So, the students are still less precise in terms of ranking the number.
- 3 students write $\log 882 = \log 21 \times 3 \times 2 \times 7$. The student forgot to give parenthesis which should $\log 882 = \log (21 \times 3 \times 2 \times 7)$.

At number three it was found that students in high categories in as many as 28 students, middle category 9 students, and 21 students of low category. Analysis of students' error i.e.

- Not much understanding of rank because it does not know the value of $(\frac{1}{4})^{-2}$.
- Misinterpretation of the nature of rank as the student

has done $\frac{x^{\frac{2}{3}} + (\frac{1}{y})^{-2}}{z^2}$ equated with how to move the

numerator $(\frac{1}{y})^{-2}$ Moved to denominator become

$z^2 + (\frac{1}{y})^2$ but cannot from the numerator is moved to

the denominator because the numerator operation is the sum.

- Less careful in the work when already understand the nature of rank like $3^3(\frac{2}{3}) = 2^3$ should be 3^3 .

- Less careful in such a division operation $\frac{9+16}{25} = 9,64$.

The correct answer is 1.

- Do not understand the fractional nature of rank as

student's answer $(\frac{1}{4})^{-2} = \frac{1}{16}$. The correct answer 16

should not be $\frac{1}{16}$. There are also students who answer

$$(\frac{1}{4})^{-2} = 1^{-2} \times 4^{-2}.$$

After the analysis of students' answers to the number 4 of the square root materials, 22 students with high category and 36 students with low category. Analyses of students' answer errors as follows.

- Lack of accuracy in operating the root form. In the

student's answer that is $(3 - \sqrt{2})(3 + \sqrt{2}) = 11$. The correct answer is 7 instead of 11.

- Lack of accuracy in outlining the form of rank. In the

student's answer is $(3 - \sqrt{2})^2 = 7 - 6\sqrt{2}$. The correct answer

$$\text{is } (3 - \sqrt{2})^2 = 9 - 2\sqrt{2} + 2 = 11 - 2\sqrt{2}.$$

- Students do not understand about the opposite roots so that the selection of opposite roots to multiply of the root fraction is not appropriate.

From the results of answers on the question number 5 then got 1 high category student, 52 students of medium category, and 5 students of low category. A analyze student errors as follows.

- Work on derivative material, but students do it in an integral way.
- Lack of accuracy in operating when the derivative concept is correct, such as miscalculating the end result, less careful in multiplication operations.

In question number 6, it was obtained 23 high category students, 13 medium category students, and 22 low-category students. Analysis of student errors for integral materials as follows.

- Lack of accuracy in operating the reduction operations

on fractions i.e. $\frac{48}{2} - \frac{3}{2} = \frac{51}{2}$. In the student's answer,

the numerator should be reduced but due to lack of accuracy then the students work on the sum.

- Already understand the concept of integral but on the calculation only until the middle does not continue until completed.

- The answer is correct but in the calculations obtained decimals, the possibility of students using the calculator in the calculation.

- On the question $\int_{-1}^4 (2x^2 + 3x - 10) dx$, students directly substitute -1 and 4 on the matter, when it should look for the integrals first and then substituted the values -1 and 4.

In the analysis of student answers from question number 7, it was obtained 20 high category students and 38 students of low category. Analysis of the students' error as follows.

- The students do not understand the question or do not understand the concept if the concept of derivatives and integrals used in the question.
- The student directly substitutes $x = 1$ in $f(1)$ and $x = 2$ at $f(2)$ whereas known in the question the derivative is $f'(x) = 2ax + (a-1)$.

From the student's answer at number 8, there were 12 high category students, 17 medium category students, and 29 low category students. Analysis of student answer errors as follows.

- Students have understood the concept of limit, but have not understood about factored quadratic equation so directly substituted value $x = 1$.
- Students do not understand in changing the form $9x^2 - 6x - 3$ to $3(3x^2 - 2x - 1)$.
- The lack of accuracy of students in doing factoring, as in the students' answer $(3x - 1)^2$ was equated with $6x^2 - 6x - 3$.
- Directly substituted the value of $x = 1$ without altered and simplified the first algebraic form on the question of limit number 8.

B. Chemical Ability

There are 6 questions that students do to know the students' chemical capabilities. On number one, there are students who do it as follows.

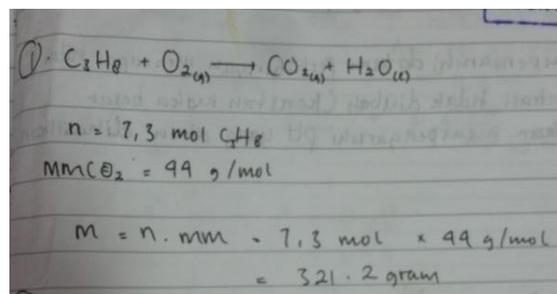


Fig. 1. Solving the question of the number 1 of medium group.

Based on Figure 1, the students did not equalize the reaction and the mole of the propane compound was not calculated, but it was directly obtained 7.3 mole of propane. Similarly, the molar mass of propane 44 grams/mole without

calculation. So it does not match the answer key contained in the grid. There are also students who answered as follows.

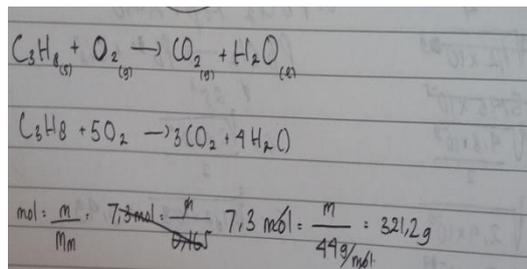


Fig. 2. Completion of the number 1 of low group.

According to Fig. 2 shows that the student performs reaction equalization and mole is calculated, but it is directly obtained 7.3 moles of propane. Similarly to the molar mass of propane 44 g/mole without calculating. Mathematical calculations of students were less accurately so that the results are not as expected.

The ability of students to solve chemical questions number two about counting the number of particles of an unreacted metal and calculating the mass of one of the gases formed from the propane gas combustion reaction. In the high group the students had the highest average score of 40.26 with sufficient category. This suggests that the high group has the ability to solve chemistry questions not yet in accordance with the stages of question solving. However, there are still many students who still solve the questions as shown in Figure 3.

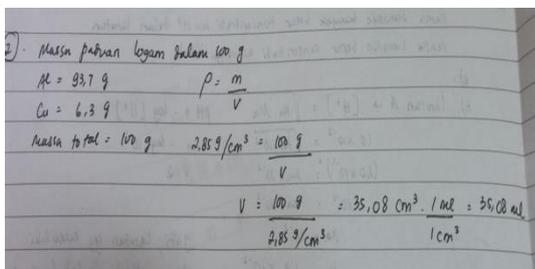


Fig. 3. Solving the question of the number 2 of high group.

In the high group, students perform calculations by searching for volumes based on total mass and known volumes. However, the calculation process has not been completed until just looking for volume. Meanwhile the group is having an average score of 13.25, with low category. It showed that moderate group has the ability to solve the questions of chemistry has not yet been according to the stage of completion of question and still a lot of students who still solve the questions as shown in Figure 4.

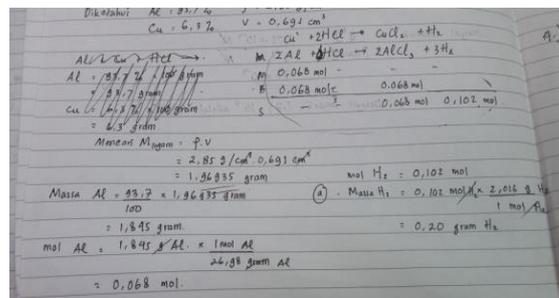


Fig. 4. Solving the question of number 2 medium group.

Students in the middle group is completing the second question is in accordance with the stages in solving questions in chemical calculations, because the less accuracy as to the multiplication of 0.102 multiplied by 0.068 equals 0.0069 then multiplied by the mole ratio of the equation for the present. This causes the calculation of the final result is not correct. The low group has an average of 18.42 with low category. This suggests that the low group has the ability to solve chemical questions not yet in accordance with the stages of question solving. And there are students who still solve the questions as shown in Figure 5.

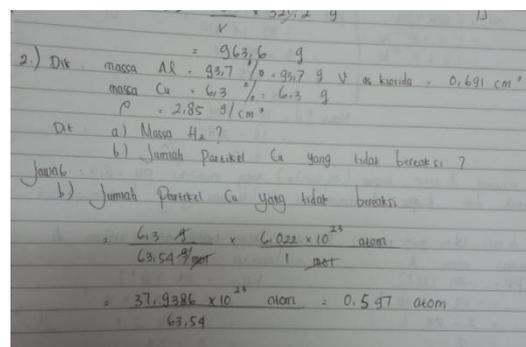


Fig. 5. Solving the question number 2 of low group.

Based on Figure 5 shows that students in solving the question of number two is not in accordance with the stages in solving the question of calculation in chemistry, because this student misconception. It is characterized that the required component is the mole of the hydrogen compound, but what is sought here is the number of atoms. And when viewed from the mathematical ability there are errors in doing calculations.

The ability of students to solve the question of number three is about the effect of the difference of K_a value on the concentration of H^+ ion in solution and compare $[H^+]$ acid solution A and C, determining the solution which has the value $pH = 2$, and prove it through the calculation. In the high group the students had the highest average score of 77.63 with good category. However, there were still students in high groups who solve the questions not appropriately.

Most of high group students in solving the question number three as if the answer is true but when viewed the sequence in completing the answer there is missed one step that is $pH = 2 - \log 1$ then $pH = 2$. Student groups are having an average score of 68.75 with good category. But there were still students that solves the question of number three not yet traced that is known $[A] = 0,01 M$, $[C] = 0,01 M$. $[H^+] = 1,0 \times 10^{-2}$, and

the value of K_a , but the students directly using the formula to find the pH value without being resolved to completion, then compared from both the pH value. Students of low group had average score of 42,11 with category fair. But still there were students who solved the questions as shown in the following Figure 6.

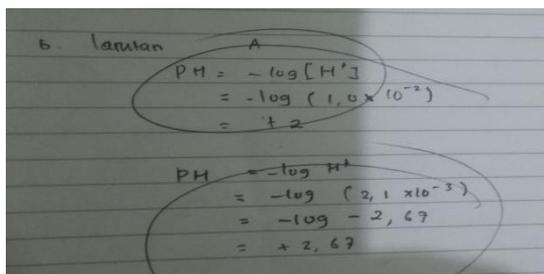


Fig. 6. Solving the question number 3 of the low group.

Based on figure 6 above the average of low-group students in solving the question of number three has not been traced to begin to be known $[A] = 0.01 \text{ M}$, $[C] = 0.01 \text{ M}$. $[H^+] = 1.0 \times 10^{-2}$, and K_a value, but students directly use the formula to find the pH value. One of the lower group students had poor math ability. So when calculating $\text{pH} = -\log 2,1 \times 10^{-3}$, $\text{pH} = 3 - \log 2,1$. The error can be called an operation error. In accordance with the theory expressed by that one of the errors that occur when students solve a question is an operation error, occurs when the student is not careful or less ability in the calculation.

Students' ability to solve number four is to calculate lime concentration at $\text{pH} = 8.3$. Compare the limestone pH of A and B, which land will have the lowest acidity. In the high group the students had the highest average score of 82.89 with very good category. However, there were still students in high groups who solve the questions not in appropriate. As shown in the following Figure 7.

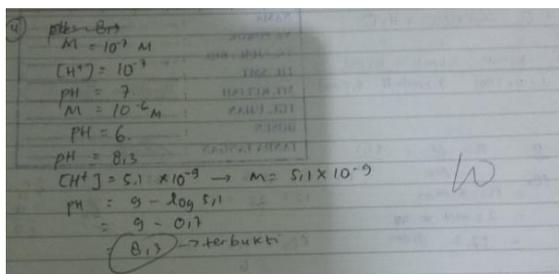


Fig. 7. Solving for the question number 4 of high group.

In high group students in solving the question of number four has not been traced, that was not done the stage of exposing the components in question. Student of moderate group had an average score of 51.75 with sufficient category. But there were still students who solved this question were still confusion in operating numbers in mathematics, especially for logarithms. This is apparent from the count operation performed by the students. Whereas in the question already known pH of material a using calcium hydroxide with a concentration of 10^{-7} M and material B using calcium

hydroxide with a concentration of 10^{-6} M . Students were instructed to choose which concentrations produce pH 8.3.

The analysis of the error of the low group students in working on question number 4 was misinterpretation of the given question should look for pH of both concentrations of 10^{-7} M and concentration of 10^{-6} M . Then choose from both concentrations that produce pH 8.5. Some students only give answers directly without writing down the steps to get the answer. Steps to do the question, especially about the essay is necessary because to know about the way students think about answering the given questions and know the extent to which the concept owned by students.

The ability of students in solving the question of number five is given a discourse about the phenomenon in everyday life "of course we are familiar with acidic solutions, such as hypochlorite acid (HOCl) added to pool water to kill bacteria and nitric acid (HNO₃) used in the manufacture of explosives. In the high group to the low group students had the average successive scores of 26.32; 1.25; and 5.00 with low and very low category. It showed that students do not understand the concept of ionization degree determination. This was indicated by the number of students did not write the answer of number five, either for high, medium and low students.

Analysis of high student group errors in working on question number five as follows: False use of formula for looking for ionization degree $\text{HOCl} = \frac{[M]}{[H]^+}$ should be $\text{HOCl} = \frac{[H]^+}{[M]}$. Analysis of student's ability of medium and low groups in working on number five was several students just write answers by writing a known component in the question as showed at Figure 8 as follow.

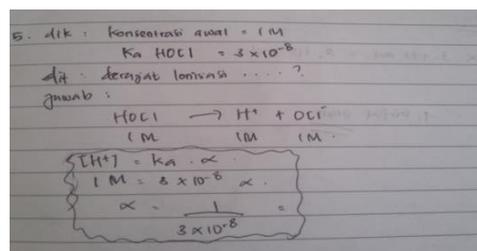


Fig. 8. Completion of question number 5 of medium group.

Based on the Figure 8 over a few students did not understand the concept and nature of the rank so that only wrote the question without answering. There were 3 students whose ways of doing the stages were correct but without being given any information, the magnitude of the ionization enzyme obtained for HOCl compounds or HNO₂ compounds. On the question asked between the two solutions which have the value of degree of ionization 1.73×10^{-4} .

The students' ability to solve question the number six was to determine and explain the highest salt solubility, based on K_w data for CaCO₃, AgCl and PbCl₂. In the high group to the low group of the students had average successive score of 78.95; 21, 75; and 7.37 with good, low, very low category. Figure of solving answer of high category student can be seen in Figure 9 as follow.

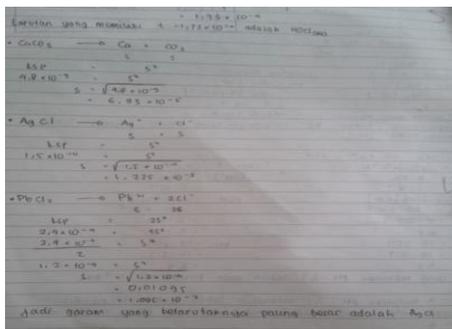


Fig. 9. Solving for the question number 6 of high group.

Based on the Figure 9 it can be seen that the high group students solved the question of determining the largest salt solubility of CaCO_3 , AgCl and PbCl_2 . Solving the question started from writing the equation of reaction $\text{CaCO}_3 \rightarrow \text{Ca} + \text{CO}_3$, then determining the solubility value of CaCO_3 , AgCl and PbCl_2 compounds based on K_{sp} value each until comparing the solubility value obtained, so based on the solubility value of each student can determine the largest solubility value.

The result of analysis of student answer of medium group generally they did not understand to this question so that from data of CaCO_3 , AgCl and PbCl_2 still many students did not write the expected answer. There were some students who simply wrote down the answers by writing down the known components in the question. There were even students who work without steps but the answer is correct.

The result of students' answer analysis in low group generally they understood this question so that from the data of CaCO_3 , AgCl and PbCl_2 there were still many students who only wrote some answers such as just looking for solubility of CaCO_3 and AgCl only, some were looking for solubility of CaCO_3 only and PbCl_2 only.

C. Relationship of Mathematical Ability with Chemical Ability

Data of mathematical ability and chemical ability are normally distributed using 5% significance level. Therefore, the correlation test used is *Product Moment* correlation test. Researchers used SPSS Windows 20 for correlation test. The results of the correlation test can be seen in the following table:

TABLE II. CORRELATION TEST OF MATHEMATICAL ABILITY WITH CHEMICAL ABILITY

	Math Ability	Chemical Ability
Math Ability	1	0,509 **
Sig. (2-tailed)		0,000
N	58	58
Chemical Ability	0,509 **	1
Sig. (2-tailed)	0,000	
N	58	58

Based on Table 2 above, obtained $r_{\text{arithmetic}} = 0.509$. The direction of the correlation is positive because r_{counts} positive value which means the higher the students' mathematical ability the higher the student's chemical ability, and vice versa. In addition, researchers also looked at the significance level of results from SPSS for Windows 20 is 0,000 which can be concluded that the relationship between the two variables is significant because the level of significance is less than 0.05 i.e. $0,000 < 0.05$. Therefore, it can be concluded that there is a positive relationship between mathematical ability and chemical ability of Chemistry Education students.

The correlation coefficient value in this study has a moderate relationship between the mathematical ability and chemistry ability of chemistry students. This is because the value of the correlation coefficient of 0.509 which shows the relationship medium/sufficient.

IV. CONCLUSION AND SUGGESTION

Based on the result of the research, it can be concluded that there is positive and significant relationship between the ability of mathematics and chemistry of students on the Study Program of Chemistry Education of Faculty of Tarbiyah and Teacher Training of UIN Sunan Gunung Djati Bandung.

It is expected to be improved students' understanding in solving questions of chemical questions. By looking at the positive correlation between students' mathematical ability in solving chemical questions, it is indispensable to cultivate students' mathematical concept. As for other researchers, is expected to develop more in its special chemical concepts that perform calculations and search for learning methods that can help solve the chemical questions so that student learning outcomes better.

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