The relationship between students’ problem solving skills and scientific attitude with students’ learning outcomes on stoichiometry at tenth grade at high school in Boyolali, Central Java, Indonesia

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Abstract. Student’s learning outcomes are influenced by several factors, both internal and external. Problem solving skills and scientific attitudes are internal factors affecting students’ learning outcomes. This was a quantitative research with the correlational approach and quantitative descriptive method. The populations were grade X science program students at SMA Negeri 1 (Senior high school) Boyolali, Surakarta, Central Java, Indonesia, academic year of 2019/2020. The data were analyzed with the correlation and regression analysis. The results showed the significant positive relationship between problem solving skills with students’ learning outcomes with the correlation coefficient value of 0.845 and determination coefficient of 71.4%; the significant positive relationship between scientific attitude with students’ learning outcomes with the correlation coefficient value of 0.926 and determination coefficient of 85.7%; and the significant positive relationship between problem solving skills and scientific attitude with students’ learning outcomes with correlation coefficient value of 0.936 and determination coefficient of 87.5%. The effective contribution of problem solving skills was 20.45%, and the scientific attitude was 67.05%. The relative contribution of problem solving skills was 23.4%, and the scientific attitude was 76.6%.

1. Introduction

To this day, the education sector has experienced various processes of development. These developments are expected to improve the quality of education in Indonesia. One development that occurred was the development of the curriculum. In the 2016/2017 academic year, the Ministry of Education and Culture (Kemendikbud) started reorganizing the revised edition of the National Curriculum of 2013 in Indonesia. The 2013 curriculum facilitates the students’ involvement in the learning process, and thus, the teachers are not required to directly provide knowledge to students. It means we expect the students to be independent in seeking, processing, and constructing their knowledge. The teachers play the role to encourage students to solve the problems, find solutions until finally, they can understand the concept of knowledge. It relates this to the ability that must be mastered by students. One of which is problem solving skills.

The ability to solve problems has an important role in process science skills, which these skills are part of the skills that are needed in the 21st century in Indonesia [1]. The problem solving skills are usually assessed as the ability to think critically and to reason analytically. Problem solving skills can
be defined as basic skills to identify problems and take steps to overcome them. It requires critical thinking to get these solutions [2].

Students are expected to solve the problems step by step so that the flow of students’ thinking and students’ conceptual understanding can be seen. Students build concepts to be applied in solving the related problems. In learning chemistry, students are not only required to understand the concepts but can also apply the concepts to solve the problems.

The steps of problem solving are (1) understanding the problem; (2) planning; (3) implementing the problem solving plans; and (4) evaluating. The step of understanding the problem and planning the plan requires students to find the relationship between the known data and the theory to be used in solving the problems [3].

Good problem solving skills allow students to be more objective in making decisions, more skilled in filtering information for analysis and carry out investigations based on the results of their analysis. Also, these skills encourage students to formulate the concepts and develop ideas in solving the problems. However, poor problem solving skills hamper the students to process information and make solutions to the problem, because students will have difficulty collecting relevant information and analyzing or reviewing the got hypotheses [4].

A problem can motivate the students to actively try to solve them. Problem solving is oriented toward a systematic approach in conceptualizing and understanding the problem, designing strategies for problem solving, and evaluating the applied strategies [5]. One's performance will increase only if the required knowledge and problem-solving skills applied to tasks [6]. Students will be required to develop the solution themselves and solve the problems. Therefore, students should have the skills and attitudes to learn problem solving.

The issues of the motivation of students in education and the impact on academic performance are considered as an important aspect of effective learning [7]. Students' motivation towards science learning has a high impact on scientific attitudes and student achievement [8]. Ali et al. explained that in the world of education, especially in field of science, a scientific attitude is an important aspect because this attitude can increase good learning achievement [9].

One important factor in science teaching is students’ attitudes which determine their behavior [10]. Scientific attitude can be defined as the pattern to think and behave scientifically. Being scientific means, they have specific attitudes such as curiosity, rationality, willingness to defer judgment, open-mindedness, critical thinking, objectivity, honesty, and humility [11]. In addition to metacognitive skills, scientific attitude is also believed to play an important role in students' academic success [12]. The scientific attitudes describe how students should behave in learning, respond to the problems, carry out the tasks, and develop their understanding. It implied that scientific attitudes can affect students’ problem solving skills and influence their learning outcomes in a positive direction. It closely relates the scientific attitude to science learning, especially in chemistry learning, which requires a high level of understanding to shape students’ conceptual understanding and knowledge.

Scientific attitudes contain two aspects, the attitude toward science, and the attitude of science. Attitude toward science refers to attitudes toward science such as like or despise toward science. Meanwhile, the attitude of science refers to the attitudes inherited by students after studying science, such as curiosity, openness, objectivity, honesty, and so on [13].

The observations on students in tenth grade at high school in Boyolali, Central Java, showed the students are passive in seeking additional knowledge. They only rely on what has been explained by the teachers. During the learning process, students were less enthusiastic about responding to teacher questions regarding the topics in the previous meeting. Also, when the teachers explain the topic, students are passive and unenthusiastic about asking questions. Only a few students can answer the questions asked by the teacher. Students feel they cannot answer the questions before they try to do it. These showed that students’ curiosity, critical thinking, open mindedness, and learning motivation was low. These attitudes are part of scientific attitudes.

Stoichiometry is a topic that requires problem solving skills, calculation, and mastery of concepts related to the topic such as the connection of one chemical measurement unit to another
(the mole concept). Also, solving stoichiometric problems requires a proper understanding of previous topics such as the basic laws of chemistry, reaction volume, reaction products, molarity, and so on. Thus, students need to have good problem solving skills to obtain good learning outcomes in stoichiometry.

2. Research Method

The research was a quantitative study. The multiple correlations were used to show the direction and strength of the relationship between two or more variables with one other variable. The independent variables were the students’ problem solving skills (X1) and scientific attitude (X2) while the dependent variable was student learning outcomes (Y).

The population in this study were all class X students of SMA Negeri 1 Boyolali in the academic year 2019/2020 (n = 252). The sampling was carried out by using the cluster random sampling technique. It took only one class for the study. The class homogeneity test was conducted before selecting the class for the experiment. The selected class as the sample is class X MIPA 2 with a total of 36 people.

Data were collected by using tests and non tests (observation, interviews, documentation reviews, and questionnaires) methods. The test to get data on students’ problem solving skills and students’ learning outcomes. The questionnaires were used to get data on students’ scientific attitudes. Data were analyzed in several steps, such as the normality test, linearity test, and multicollinearity test. After fulfilling those prerequisite tests, we continue it with the hypothesis testing using correlation and regression tests. The tests were carried out using SPSS.

3. Results and Discussion

Before the hypothesis test, the prerequisite tests such as normality, linearity, and multicollinearity tests were conducted. The results were shown in Table 1.

| Variable                  | Kolmogorov-Smirnov | Shapiro-Wilk |
|---------------------------|--------------------|--------------|
|                           | Statistics | df | Sig. | Statistics | df  | Sig. |
| Problem solving skill     | 0.136      | 36 | 0.088 | 0.950      | 36  | 0.103 |
| Scientific Attitude       | 0.123      | 36 | 0.186 | 0.961      | 36  | 0.224 |
| Learning outcomes         | 0.112      | 36 | 0.200 | 0.947      | 36  | 0.081 |

Based on Table 1, it can be seen that the results of the normality test using the Shapiro-Wilk test produce the Sig. values of the three variables were > 0.05, so the data were normally distributed.

| Variable | Sig. |
|----------|------|
| X1-Y     | 0.967|
| X2-Y     | 0.415|

The linearity test between the problem solving skill (X1) and the learning outcomes showed the value of Deviation from Linearity Sig. was 0.967 > 0.05, showing that the data for the variables X1 and Y were linear. The test between the scientific attitude variable (X2) and learning outcomes (Y) also got Sig. value of 0.415 > 0.05. Thus, the relationship between variables X2 and Y was linear.

The multicollinearity test with SPSS showed the tolerance value for the problem solving skill (X1) and scientific attitude (X2) is 0.308, which was greater than 0.10. The VIF value for variables X1 and X2 was 3.250 <10.00. Thus, no multicollinearities between the independent variables were found. Furthermore, the correlation test and linear regression were carried out between the problem solving skill and scientific attitudes toward students learning outcomes on stoichiometry.
Table 3. Results of Regression Test and Simple Correlation between X1 and Y

| Variable               | Coef. Regression (B) | t count | Sig. t | Descriptions |
|------------------------|-----------------------|---------|--------|--------------|
| Constant               | 18.492                | 3.032   | 0.005  |              |
| Problem Solving Ability (X1) | 0.773                | 9.209   | 0.000  | Significant  |
| R                      | 0.845                 |         |        |              |
| R Square               | 0.714                 |         |        |              |

The simple regression test analysis in table 3 above can be written into the regression equation in equation (1):

\[ Y = 18.492 + 0.773X1 \]  

Equation (1) showed a constant value of 18.492. It means that the learning outcome value was 18.492 if the problem solving skill was equal to zero. It explained that students’ learning outcomes will be decreased if the students didn’t have good problem solving skills. The problem -solving skill (X1) has a positive influence on learning outcomes (Y) with a regression coefficient of 0.773. It explained that if the problem solving skill increased by one percent, learning outcomes will increase by 0.773 points assuming the other independent variables were constant. The sig value of 0.000 < 0.05 showed the students’ problem solving skills have no significant influences on their learning outcomes.

The coefficient of determination for R2 was 0.714. It means that 71.4% of the variations in the dependent variable on learning outcomes can be explained by variations in the independent variable (problem solving skill), while the rest (28.6%) was influenced by other variables not covered in the research. The results of the simple correlation analysis showed the correlation between problem solving skills and learning outcomes is 0.845. These indicated a very strong relationship between problem solving skills and learning outcomes in chemistry. Also, the relationship was unidirectional, as seen from the positive correlation value. It means the higher students’ problem solving skills resulted in the higher the students’ learning outcomes in chemistry.

Those results agreed with the opinion by Uno that students should have the ability to control and organize what they have learned. These abilities were problem solving skills. If these abilities were developed and mastered by students, their learning outcomes will be improved [14]. These results are also in accordance with the research results of Kavitha, there is a high positive correlation between problem-solving abilities and mathematics learning achievement of high school students [15]. Gurudeva also stated the positive and significant relationship between problem solving skills and academic achievement in both male and female, rural and urban, private, and public middle school students [16]. Research by Kanmani and Nagarathinam also found a positive correlation between problem solving skills and students’ learning outcomes in mathematics [17].

Moshirabadi et al. stated that the students’ problem-solving skills have had an effect on both on the motivation of school success and individual relationships [18]. Training students’ analytical skills can be achieved by applying problem solving steps. It will help students find solutions. Students are expected to understand the concepts and link them to the problems through problem solving steps so students’ involvement and learning outcomes improved [19]. Problem solving skills support students’ scientific understanding and help them make connections between their previous knowledge and new knowledge [20]. The results proved the connection between students’ problem solving skills and learning outcomes. It can be said the higher the students’ problem solving skills, the higher their learning outcomes.

Table 4. Results of Regression Test and Simple Correlation between X2 and Y

| Variable              | Coef. Regression (B) |
|-----------------------|-----------------------|
| Constant              | 21.079                |
| Scientific Attitude (X2) | 0.696                |

| Variable              | Coef. Regression (B) |
|-----------------------|-----------------------|
| Constant              | 21.079                |
| Scientific Attitude (X2) | 0.696                |

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Table 4 showed the results of $R^2$ (R Square) in the simple regression analysis was 0.857. It can be interpreted as the contribution of the scientific attitude (independent variable) toward the learning outcomes (dependent variable) was 85.7%, and the other 14.3% was influenced by other factors.

The simple regression analysis for the scientific attitude ($X_2$) with learning outcomes ($Y$) showed the regression coefficient of 0.696, and the constant was 21.079. Thus the obtained regression equation was:

$$Y = 21.079 + 0.696X_2$$  (2)

Table 4 also showed sig. value of 0.000, which showed the regression of $Y$ on $X$ was significant. Equation (2) explains that every one-point increase in scientific attitude score will cause an increase of 0.696 in chemistry learning outcomes scores at a constant of 21.079. The Pearson Bivariate correlation showed the correlation between scientific attitudes and learning outcomes at 0.926. It showed a very strong relationship between scientific attitudes and learning outcomes. The relationship was unidirectional because the results were positive. It showed that the higher the student’s scientific attitude, the higher the student’s learning outcomes in chemistry.

Scientific attitude is one that must be considered in science education because it has an important meaning correlation with academic achievement [21]. Those results echoing the finding by Mahanta about the positive correlation between students’ attitudes and their achievement in mathematics [22]. Kant also stated that achievement in science subjects is directly related to scientific attitudes. Students with scientific attitudes score higher in science subjects than their peers. Scientific attitude gives the students how to behave in learning, respond to problems, complete assignments, and develop their knowledge. It will increase their learning motivation and influencing their learning outcomes in a positive direction [23].

Scientific attitudes also play an important role in academic success. Scientific attitudes reflect the mindset that is following the rules or ethics of science. If a reaction is carried out according to the ethics of science, the reaction is considered a scientific attitude. Scientific attitudes are related to the scientists’ code of ethics. Thus, scientific attitudes are used to direct scientific actions. Any activity related to scientific thought deserves further caution. Attitudes such as curiosity, rationality, willingness to suspend judgment, open-mindedness, critical thinking, objectivity, honesty, and humility regulate the directed behaviors toward or away from the objects or situations [24].

| Variable                  | Coef. Regression (B) | t count | Sig. t | Descriptions  |
|---------------------------|----------------------|---------|--------|---------------|
| Constant                  | 16.683               | 4.071   | 0.000  |               |
| Problem Solving Ability (X1) | 0.222               | 2.185   | 0.036  | Significant   |
| Scientific Attitude (X2)  | 0.544                | 6.532   | 0.000  | Significant   |
| R                         | 0.936                |         |        |               |
| $R^2$                     | 0.875                |         |        |               |

Table 5 showed an $R$-value of 0.936. It showed the relationship between students’ problem solving skills and scientific attitudes toward their learning outcomes in chemistry. The relationship was strong because the $R$-value approached one. The relationship was unidirectional. The results of the regression analysis showed that the $R^2$ (R Square) value of 0.875. It indicated the independent variables (problem solving ability and scientific attitude) contribution to learning outcomes was 87.5%, while the rest was
influenced by other variables not covered in the research. The results showed the value of $a = 16.683$; $b_1 = 0.222$; and $b_2 = 0.544$.

The results showed the sig. value of $0.000 < 0.05$. Thus, it can be concluded that the Y regression on X12 was significant and the regression coefficient was real. The regression equation was shown in Equation (3) below:

$$Y = 16.683 + 0.222X1 + 0.544X2$$

Equation (3) showed that every increase of one point on problem solving skills gives an increase of 0.222 points in students’ learning outcomes if $X_2$ was assumed as fixed. For every one-point increase in scientific attitudes will increase the learning outcomes by 0.544 points with the assumption $X_1$ was fixed with a constant of 16.683. Changes will follow a one-point change in problem solving skill score and one-point change in scientific attitude score combined with 0.222 and 0.544 points in students’ learning outcomes.

If $X_1$ was 100 and $X_2$ was constant ($X_2 = 0$), then Y was:

$$Y = 16.683 + 0.222 (100) + 0.544 (0)$$
$$Y = 16.683 + 22.2$$
$$Y = 38.883$$

Meanwhile, if $X_1$ was constant and $X_2$ was 100, then Y was:

$$Y = 16.683 + 0.222 (0) + 0.544 (100)$$
$$Y = 16.683 + 54.4$$
$$Y = 71.083$$

Students’ learning outcomes are influenced by several factors, both internal and external. Problem solving skills and scientific attitudes are internal factors that influence students’ learning outcomes. Stages in the problem solving process can build and improve students’ scientific attitudes, such as critical thinking and curiosity. Problem solving skills and scientific attitudes encourage students to become independent learners who can face problems in life as the final process of learning. Nufus (2013) shows that in problem-solving students answer questions better, meaning that problem-based learning is better than learning the usual [25]. Meanwhile, someone with a good scientific attitude is free from assumptions and unverified opinions and has no clear basis [26]. If students are allowed to develop higher cognitive processes through problem-solving strategies, then their scientific attitude towards chemistry may change in a positive way [27].

A strong positive correlation between students’ scientific attitudes and their problem solving skills were found [28]. Problem solving skills and scientific attitudes have positive influences on learning outcomes. The students with good scientific attitudes and problem solving skills can achieve better learning outcomes. The results of the regression test showed the effective contribution and relative contribution of each independent variable as shown in Table 6.

| Independent Variable | Effective Contribution | Relative Contribution |
|----------------------|------------------------|-----------------------|
| Problem solving skill | 20.45%                 | 23.4%                 |
| Scientific Attitude  | 67.05%                 | 76.6%                 |

Table 6 showed the effective contribution of the problem solving skill was 20.45%, while the scientific attitude was 67.05%. The relative contribution of problem solving ability was 23.4%, and the
scientific attitude was 76.6%. The effective contribution and relative contribution value of scientific attitude were greater than the problem solving skill. This means the scientific attitude makes a greater contribution to learning outcomes. A scientific attitude will greatly help the course of a more structured learning process so that the knowledge gained by students is more organized and conceptual [29]. It because scientific attitudes have several aspects such as curiosity, critical thinking, and open-mindedness. The students who have good scientific attitudes become enthusiastic in seeking knowledge, studying, and asking questions about what they do not understand. Other aspects, such as persistence, thoroughness, discipline, and responsibility, encourage the students to do the tasks more seriously and responsible for completing them. Scientific inquiry and critical thinking can develop science process skills that can be used in educational activities [30]. This helps students achieve good learning results.

4. Conclusion
A significant positive relationship between problem solving skills and student learning outcomes was found. The values of the correlation coefficient (0.845), the coefficient of determination (71.4%), and the significant value of 0.000. The level of the relationship was very strong. A positive and significant relationship between scientific attitudes and student learning outcomes have also been found. It was indicated by the value of the correlation coefficient of 0.926 and the coefficient of determination of 85.7% with a significant value of 0.000. The level of the relationship was very strong. A positive correlation between problem solving skills and scientific attitudes with students’ learning outcomes were found. It was indicated by the values of the correlation coefficient (0.936), the coefficient of determination (87.5%) with a significant value of 0.000. The linear regression equation is \( Y = 16.683 + 0.222X_1 + 0.544X_2 \). The effective contribution of the problem solving skill was 20.45%, and the scientific attitude was 67.05%. The relative contribution of problem solving skills was 23.4%, and the scientific attitude was 76.6%.

References
[1] Harefa, Nelius & Purba, Leony. 2020. Problem solving skills improvement and the impact on students’ learning outcomes: learning based e-project. *Journal of Physics: Conference Series*. 
[2] Altun, I. 2003. The perceived problem solving ability and values of student nurses and midwives. *Nurse Education Today*, 23, 575–584.
[3] Poly, G. 1957. *How to Solve It*. New Jersey: Princeton University Press.
[4] Rotherham, A. J., & Willingham, D. 2009. 21st Century Skills: The challenges ahead. *Educational Leadership, 67*(1), 16 – 21.
[5] Allen and Graden. 2002. Best practices in collaborative problem solving for intervention design. *National Association of School Psychologists Washington*, 565-582.
[6] Tan, H.-T., & Kao, A. 1999. Accountability effects on auditors’ performance: the influence of knowledge, problem-solving ability, and task complexity. *Journal of Accounting Research, 37*(1), 209.
[7] Tella, A. (2007). The impact of motivation on student’s academic achievement and learning outcomes in mathematics among secondary school students in nigeria. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(2), 149-156.
[8] Cavas, P. (2011). Factor affecting the motivation of turkish primary students for science learning. *Science Education International, 22*(1), 31-42.
[9] Ali, K., Shaqf, Shah, A., Makhdoom, S., Mahmood, Z., & Zareen, R. (2012). Scientific attitude development at secondary school level: A comparison between methods of teaching. *Language in India, 12*(9), 439–454.
[10] Amjad I. P. & Muhammad F. 2012. Measurement of scientific attitude of secondary school students in Pakistan. *Academic Research Internationa, 2 (2), 379-392.
[11] Munby, H. 1983. Thirty studies involving the scientific attitude inventory. what confidence can we in this instrument. *Journal of Research in Science Teaching, 20*(2), 141-162.
[12] Kristiani, N., Susilo, H., Rohman, F., & Aloysius, D.C. 2015. The contribution of students’
metacognitive skills and scientific attitude towards their academic achievements in biology learning implementing Thinking Empowerment by Questioning (TEQ) learning integrated with inquiry learning (TEQI). *International Journal of Educational Policy Research and Review, 2*(9), 113-120.

[13] Harlen, W. 1996. *The Teaching of Science: Studies in Primary Education*. London: David Fulton Publisher Ltd.

[14] Uno, Hamzah B. 2008. *Teori Motivasi Dan Pengukurannya*. Jakarta: Bumi Aksara.

[15] Kavitha, Madhusudan. 2009. Interaction effect of mathematical creativity, intelligence and problem solving ability on achievement in mathematics of ix standard students of bangalore district. ph.d thesis, 2015, pp 283.

[16] Gurudeva B.R. 2019. A study of relationship between problem solving ability and academic achievement of ix standard students. *International Journal of Research in Engineering, IT and Social Sciences, 09*(01), 204-208.

[17] M. Kanmani and N. Nagarathinam. 2017. Problem solving ability and academic achievement of higher secondary students. *Int. J. of Adv. Res, 5*, 871-876.

[18] Moshirabadi Z, Hghani H, Borimnejad L. 2016. The perceived problem solving skill of Iranian nursing students: A cross-sectional study. *European Psychiatry, 33*, 651-652.

[19] Josef et. al. 2012. Implementation of inquiry-based science education in science teacher training. *Journal of Educational and Instructional Studies in the World, 2*(4), 23.

[20] Maxwell, Deborah. 2015. Effects of using inquiry-based learning on science achievement for fifth-grade students. *Journal of Asia-Pacific Forum on Science Learning and Teaching, 16*(1), 2.

[21] Zhyang D, Campbell T. 2010. The psychometric evaluation of a three-dimension elementary science attitude survey. *J. Sci. Teach. Educ. Advance online publication*

[22] Mahanta, D. 2014. Impact of attitude and self-concept of the students towards mathematics upon their achievement in mathematics. *Int. J. Theoret. Appl. Sci, 6*(1), 20-35.

[23] Kant, Ravi. 2015. Relationship between learning styles and scientific attitude of secondary school students and their achievement in science subject. *Journal of Educational Sciences and Psychology, 5*, 1-10.

[24] Pitafi AI & Farooq M. 2012. Measurement of scientific attitude of secondary school students in Pakistan. *J. Academic Res. Int, 2*(2), 379-392.

[25] Nufus. 2013. Upgrades mathematical problem solving and communication through application of problem based learning in class vii smp. Thesis. Field: PPS UNIMED

[26] Olatoye, R. A. & Aderogba, A. A. 2012. Harnessing the power of emotional intelligence, scientific literacy and problem-solving skills for successful living. *Pacific Journal of Science and Technology, 13*(1), 403-417.

[27] F.A. Adesoji. 2008. Managing students’ attitude towards science through problem – solving instructional strategy. *The Anthropologist, 10*(1), 21-24.

[28] Marchis, I. 2013. Relation between students’ attitude towards mathematics and their problem solving skills. *PedActa, 3*(2), 59-66.

[29] Astalini, Astalini & Darmaji, Darmaji & Pathoni, H. & Kurniawan, Wawan & Jufrida, Jufrida & Kurniawan, Dwi & Perdana, Rahmat. 2019. Motivation and attitude of students on physics subject in the middle school in Indonesia. *International Education Studies. 12*(9).

[30] B Utami, S Saputro, MM Ashadi, S Yamtinah, S Widoretno. 2017. Development of the science skills of lower secondary students in a chemistry laboratory experiment. *Pertanika Journal Of Social Science And Humanities, 25*, 41-50.