Effect of problem based learning models on students’ analytical thinking abilities and scientific attitudes in chemistry

R Andriani*, YL I Supiah
Chemistry Education, Universitas Negeri Yogyakarta, Jl. Colombo No. 1, Sleman, Indonesia
*reniandriani836@gmail.com

Abstract. The ability of analytical thinking and scientific attitudes in the process of learning chemistry requires learning models that can enhance analytical thinking related to scientific attitudes used by students to solve complex and unstructured problems in the 21st century. Thus, this study aims to determine the ability of analytical thinking and scientific attitudes of high school students in learning chemistry. This study was carried out using a quasi-experimental with post-test only design. This research was conducted in senior high school in the rate reaction topic. The sample in this study consisted of two classes, namely Class XI Science 1 as an experimental class with a problem based learning model and Class XI Science 3 as a control class with direct instruction. A total of 63 students of class XI were determined as research samples and the sampling was done by random sampling techniques. The instrument used was a test in the form of essays and non-tests used in this study were students’ scientific attitude questionnaire. The MANOVA test was used to analyze differences in the abilities of analytical thinking and scientific attitudes of students in the experimental class and the control class. The results of this study indicate that the value of sig <0.05 ie 0.000 <0.05 is thus the application of the problem based model to the analytical thinking abilities and scientific attitudes of students of senior high school on the rate reaction topic.

1. Introduction
The learning process in every elementary and secondary education unit must be interactive, inspiring, enjoyable, challenging, actively participating, innovative, creative and independent in accordance with the talents and interests possessed by students. These objectives can be interpreted as a learning process in education including emphasizing on two aspects, namely aspects of scientific mastery and aspects of student attitudes. In the teaching and learning process in class need to apply a learning model that can help students to understand the material being taught and its application and its relevance in daily life such as in science lessons. The learning process is still a lot of applying the lecture method in delivering material, so that the development of students' knowledge in the discovery of concepts does not develop optimally. Students find it difficult to understand the concept of learning because the teacher is only limited to the lecture method, and students only accept the transfer of knowledge [1].

Students' analytical thinking skills are still low, Indonesian students are still weak in high-level cognitive skills such as reasoning, analyzing, evaluating so that the critical thinking skills of students are still relatively low, the initial ability and readiness of Indonesian students to learn are quite good but are still at a low level [2]. Based on the results of the 2015 PISA survey, Indonesian students are in 60th
place out of 74 countries (OECD, 2015). These results indicate that the ability of Indonesian students in mathematics and science is currently lacking.

During this time there is a tendency for teachers to view science learning only as a collection of products and forget about other aspects, one of which is the scientific attitude. In fact, in the process of teaching and learning of Natural Sciences, the development of concepts cannot be separated from the development of scientific attitudes. The nature of science is built on the basis of scientific products, scientific processes and scientific attitudes [3]. Scientific attitude is also very important because it can increase students' critical power towards the phenomenon at hand. But in reality, the teacher has not fully applied the scientific attitude in the learning process, so that the scientific attitude of students is still low. Research that has been conducted by [4] states that the low scientific attitude of students is due to lack of teacher and monotonous delivery so students are less motivated to learn and actively involved in teaching and learning activities.

To overcome these problems needed an interesting learning, making students active, creative and innovation. One of the learning-oriented achievement, we need a problem-based learning model, where problems can be obtained from the field or experience from students. The problem based learning model is very beneficial for students, because it is actively involved in their own learning process. Learning by doing is far more effective than passive reception of information because active participation allows students to experience the challenges involved in solving problems [5].

Problem-based learning is an innovation in learning because in problem-based learning students' thinking abilities are truly optimized through systematic group or team work processes, so students can empower, hone, test, and develop thinking abilities on an ongoing basis and demonstrate effective communication skills by conveying information to others [6]. Problem-based learning is a student-centered and curricular approach to learning that engages students to conduct research, integrate theory and practice and apply knowledge and skills to develop solutions that are feasible for defining problems [7].

Reaction rate is material that is still considered difficult by students because it is complex [8], requires good analysis in understanding the concepts, so students need analytical skills and good scientific attitude. Difficulties in understanding scientific concepts are rooted in misconceptions that students bring to class before being taught [9], so that it requires methods or models of learning, media and appropriate teaching materials. Based on the description above, one of the suitable chemicals used to measure students' analytical thinking abilities and scientific attitudes is the rate of reaction, especially the factors that affect the rate of reaction. The aim of this study is to determine differences in analytical thinking abilities and scientific attitudes of students using problem-based learning models and direct instruction at the level of the reaction topic.

2. Method
This research was conducted at SMA Negeri 1 Magelang in the odd semester of the 2019/2020 school year. This research is a quasi experiment with the research design used is post-test only design. The sampling technique used in this study was random sampling, where the sample was taken by means of randomization taken from a specified population of 6 classes. The class condition can be randomized for sample selection. The research sample came from two classes, namely XI IPA 1, which was an experimental class of 31 students and XI IPA 3 was a control class of 32 students. The study was conducted quantitative data collection techniques using analytical thinking skills tests conducted at the end of the research activity. The questionnaire used in the study was a student's scientific attitude questionnaire given after the implementation of learning using the problem-based learning model in the experimental class and the direct instruction model in the control class. Data on students' analytical thinking skills were collected using 10 essay test questions (descriptions) for the reaction rate material. The scientific attitude instrument was carried out using a questionnaire technique consisting of 25 statements. The data analysis technique used in this study is the MANOVA technique with a significance level of 0.05 with the help of SPSS 16.0 software.
3. Result and Discussion
In this study, each student’s answers were analyzed according to the scoring rubric having been made in the previous stage. The analysis of the students’ answers is done by using descriptive approach, by giving a score of each stage of correct answers given by each student. The measurement results are then analyzed descriptively to determine the level of students' achievement on analytical thinking ability and scientific attitudes.

Manova test was conducted to determine differences in analytical thinking abilities and scientific attitudes of students who use problem-based learning and learning using direct instruction. Manova hypothesis test results with the Hotelling’s Trace test can be seen in Table 1 as follows:

| Testing Analysis | F   | Sig. | Conclusion |
|------------------|-----|------|------------|
| Hotelling’s Trace| 4.335| 0.000| H0 rejected |

Based on Table 1, the MANOVA test results with Hotelling's Trace analysis show a significance value of 0.000 less than 0.05 (H0 rejected) so it can be concluded that there are differences in analytical thinking abilities and scientific attitudes of students who are taught by using problem-based learning models (experimental class) and use direct instruction learning (control class). The study was also conducted by [10] with PBL models effective in increasing analytical thinking skills and scientific attitudes.

3.1. Differences in Analytical Thinking Ability in Problem Based Learning and Direct Instruction Learning
Based on the test results of analytical thinking skills obtained through the post-test test after learning is given in the learning process by using problem-based learning models and direct instruction. Comparison of the average post-test of students' analytical thinking skills between the experimental classes using problem-based learning and control classes with learning using direct instruction can be seen in Figure 1.

![Figure 1. Average Posttest Analytical Thinking Ability](image)

Based on Figure 1 students in the experimental class who use problem-based learning have higher analytical thinking skills compared to students in the control class who use direct instruction. There is a difference in the ability of analytical thinking in the second class. The difference between the two classes that shows the experimental class with problem-based learning has a higher analytical value compared to the control class in which learning uses direct instruction on the reaction rate material. In line with research conducted by [11] which shows that the application of the problem based learning model influences the ability to improve analytical thinking and science process skills of students.

Multivariate test results Test of between Subject Effect is used to analyze the differences in the analytical thinking ability of students who take learning with problem based learning models and direct instruction. This can be seen in Table 2 which shows that a significant value of 0.006 is smaller than 0.05. Univariate test results can be displayed in Table 2.
Table 2. Test of Between Subject Effect Results on Analytical Thinking Ability

| Factor                     | Dependent Variable | F     | Sig.  | Conclusion   |
|----------------------------|--------------------|-------|-------|--------------|
| Problem-based learning models | Analytical thinking ability | 7.994 | 0.006 | H₀ rejected  |

Table 2 shows that there are differences in each of the abilities of analytical thinking that apply problem-based learning and direct instruction learning on the rate reaction topic. The research results conducted by [12] show that there are significant differences between pre-test and post-test of students in the experimental class who are treated with problem based learning. These results prove that problem based learning has a significant positive effect. This is in line with [13] stating the results of the study showed that there was a significant increase in analytical thinking ability between the experimental classes using the Problem Based Learning (PBL) model and the average score of the experimental class was higher than the control class. The results of students' analytical thinking skills in the experimental class using Problem Based Learning models are greater than the results of students' analytical thinking skills using conventional learning models [14]. The benefits of problem-based learning are also conveyed in the results of research conducted by [15] which shows the difference between the experimental class taught by problem-based learning and the control class taught by conventional methods.

3.2. Differences in Scientific Attitudes in Problem Based Learning and Direct Instruction Learning

Comparison of the average posttest of students' scientific attitudes between the experimental classes using problem based learning and the control class with learning using direct instruction can be seen in Figure 2.

![Figure 2. Average Post-test Scientific Attitudes](image_url)

Based on Figure 2 students in the experimental class who used problem based learning had higher scientific attitudes compared to students in the control class who used direct instruction. The results of [16] stated that the average percentage of scores obtained, the experimental class was better than the control class or the increase in scientific attitude of the experimental class was higher than the control class, this was due to learning using PBL models on motion material can stimulate students' scientific attitudes, so students are more active and enthusiastic in responding to lessons.

Multivariate test results Test of between Subject Effect shows that there are significant differences between the scientific attitudes of students who take part in problem-based learning and students who take lessons using direct instruction. This can be seen in Table 2 which shows that a significance value of 0.041 is smaller than 0.05. The results of the Manova test can be shown in Table 3.
Table 3 shows the significant differences between the attitudes of students who use problem-based learning and students who learn to use direct instruction. The difference in scientific attitudes between the two classes shows that the scientific attitude of students in the experimental class is better than the control class applying problem-based learning has a positive impact on students' scientific attitudes. In this study shows the scientific attitude of good students after being taught with problem-based learning. The difference in scientific attitudes between groups of students who learn to follow problem-based learning models and groups of students who learn to use expository learning models. Furthermore, research conducted by [18] states that there are significant differences due to grade level and there is a high correlation between scientific attitude and science teaching attitude. In this context it is recommended that a learning environment that positively influences scientific attitudes and the attitude of teaching science must be regulated. The difference in the scientific attitude of the control class is only centered on the teacher. While in the experimental class students learn to be active, and are required to understand new concepts to a problem whose truth needs to be proven, this is what can help students learn scientifically, structured, and independen [19]. Problem-based learning does not only affect learning in the classroom but, it does affect the learning of chemistry in the laboratory.

4. Conclusion
Based on the data analysis of the results of research and discussion it can be concluded that there are differences in the application of problem-based learning models and direct instruction learning on the ability of analytical thinking and scientific attitudes of students on the reaction topic. The results of this study indicate that the value of sig <0.05 ie 0.000 <0.05 is thus the application of the problem-based model to the analytical thinking abilities and scientific attitudes of students in chemistry.

5. References
[1] Aderhold J Davydiv V Y Fedler F Klausung H Mistele D Rotter T Semchinova O Stemmer J and Graul J 2001 InN thin films grown by metalorganic molecular beam epitaxy on sapphire substrates Journal of crystal growth 222 4 pp.701-705.
[2] Hackathorn J Solomon E D Blankmeyer K L Tennial R.E and Garczynski A M. 2011 Learning by Doing: An Empirical Study of Active Teaching Techniques Journal of Effective Teaching 11 2 pp.40-54.
[3] Widayati W Suyono S and Rahayu W 2018 Pengaruh Model Pembelajaran Berbasis Penemuan Terhadap Kemampuan Berpikir Kritis Matematis Dan Self Concept Dengan Mengontrol Kemampuan Awal Peserta Didik Kelas VII SMP JPPM (Jurnal Penelitian dan Pembelajaran Matematika) 11 1
[4] Trianto 2013 Model Pembelajaran Terpadu (Jakarta, Indonesia: PT. Bumi Aksara)
[5] Tryas IA and Pathoni H 2014. Upaya Meningkatkan Sikap Ilmiah Dan Hasil Belajar Dengan Menggunakan Model Pembelajaran Problem Based Learning Di Kelas X SMA Negeri 8 Kota Jambi.
[6] Chin C and Chia LG 2006 Problem-based learning: Using ill-structured problems in biology project work Science Education 90 1 pp.44-67.
[7] Duch B J Groh S E and Allen D E 2001 The power of problem-based learning: a practical" how to" for teaching undergraduate courses in any discipline Stylus Publishing.LLC.
[8] Kirik Ö T and Boz Y 2012 Cooperative learning instruction for conceptual change in the concepts of chemical kinetics Chemistry Education Research and Practice 13 3 pp.221-236.
[9] Kaya E and Geban O 2011 The effect of conceptual change based instruction on students’ attitudes toward chemistry Procedia-Social and Behavioral Sciences 15 pp.515-519.
[10] Lestari D I and Projantsosoto A K 2016 Pengembangan media komik IPA model PBL untuk meningkatkan kemampuan berfikir analitis dan sikap ilmiah Jurnal Inovasi Pendidikan IPA 2 2 pp.145-155.
[11] Ware K and Rohaeti E 2018 Penerapan Model Problem Based Learning dalam Meningkatkan Kemampuan Berpikir Analitis dan Keterampilan Proses Sains Peserta Didik SMA J Tadris Kim 3 pp.217-226.
[12] Prastiwi M N B and Laksono E W 2018 The ability of analytical thinking and chemistry literacy in high school students learning In Journal of Physics: Conference Series 1097 1 p. 12061).
[13] Üce M and Ates I 2016 Problem-Based Learning Method: Secondary Education 10th Grade Chemistry Course Mixtures Topic. Journal of Education and Training Studies 4 12 pp.30-35.
[14] Assegaff A and Sontani U T 2016 Upaya Meningkatkan Kemampuan Berfikir Analitis Melalui Model Problem Based Learning (PBL) Jurnal Pendidikan Manajemen Perkantoran (JPManper) 1 1 pp.38-48.
[15] Yulianti E Rosani M and Nuranisa N 2018 Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Berpikir Analitis Siswa Sma Negeri 2 Banyuasin 1. JURNAL SWARNABHUMI: Jurnal Geografi dan Pembelajaran Geografi 3 2 pp.89-93.
[16] Orji C T and Ogbuanya T C 2018 Assessing the effectiveness of problem-based and lecture-based learning environments on students’ achievements in electronic works. International Journal of Electrical Engineering Education 55 4 pp.334-353.
[17] Israfiddin I Gani, A. and Suminan S 2016 Penerapan Model Problem Based Learning Untuk Meningkatkan Sikap Ilmiah Dan Hasil Belajar Peserta Didik Pada Materi Gerak Di SMP Negeri 2 Delima Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education) 4 1
[18] Astika I K U Suma K and Suastra I W 2013 Pengaruh Model Pembelajaran Berbasis Masalah (Problem Based Learning) Terhadap Sikap Ilmiah Dan Ketrampilan Berpikir Kritis. Jurnal Pendidikan dan Pembelajaran IPA Indonesia 3 1
[19] Erdogan S C 2017 Science Teaching Attitudes and Scientific Attitudes of Pre-Service Teachers of Gifted Students. Journal of Education and Practice 8 6 pp.164-170.