JPPIPA 9(6) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effect of Problem Based Learning on Students' Critical Thinking Ability and Scientific Attitude

Zulfa Yulia [1*], Das Salirawati[2]

[1] Program Studi Magister Pendidikan Kimia, FMIPA, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[2] Program Studi Pendidikan Kimia, FMIPA, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

Received: January 30, 2023
Revised: May 12, 2023
Accepted: June 25, 2023
Published: June 30, 2023

Corresponding Author:
Zulfa Yulia
zulfayulia.2018@student.uny.ac.id

DOI: 10.29303/jppipa.v9i6.3026

Abstract: This study aims to determine differences in critical thinking skills between students who apply the problem-based learning model and students who apply the direct instruction model; Differences in scientific attitudes between students who apply the problem-based learning model and students who apply the direct instruction model. This study uses a quasi-experimental research type with a posttest only design. This research was conducted at SMA Negeri 2 Nisam Aceh Utara. The sample in this study consisted of two classes, namely class XI-IPA1 as the experimental class with the Problem based learning model and class XI-IPA 2 as the control class with the direct instruction learning model. A total of 50 students as the research sample were taken by cluster random technique. The instrument used is in the form of multiple-choice questions to measure students' critical thinking skills and scientific attitude questionnaires. The MANOVA test is used to analyze differences in critical thinking skills and scientific attitudes of students in the experimental class and the control class. The results of the study show that there are significant differences in the ability to think critically between students who apply the problem-based learning model and students who apply the direct instruction model; there is a significant difference in scientific attitude between students who apply the problem-based learning model and students who apply the direct instruction model.

Keywords: Critical Thinking Ability; Direct Instructions; Problem Based Learning; Scientific Attitude.

Introduction

Seeing the development of the science world of students in Indonesia based on the results of TIMSS and PISA shows that while students excel in answering theoretical and routine questions. They struggle to answer questions that reveal high-level concepts and require application and thought (Salirawati, 2012). This fact shows that education in Indonesia generally fails to encourage students to apply the ideas they learn as a basis for logic and reasoning in dealing with problems. The role of schools in Indonesia, especially schools in rural areas, in efforts to improve critical thinking skills is still relatively low. Students are only required to provide correct answers in solving problems, so they do not inspire the students themselves in producing new concepts. As a result, students who graduate are only able to solve problems superficially, do not have the ability to solve problems that require logic and reasoning.

Education not only requires intellectual abilities, but also teaches how to process emotions and strengthen the spiritual. Students who have high skills and talents are not enough to carry out tasks properly, they need motivation in dealing with various problems in everyday life. Festus & Ekpete (2012) suggested that problem-solving-based learning can increase students' positive attitudes to become active and self-learning individuals. It is further said that there is a fairly strong positive correlation between students' attitudes towards problem solving skills.

How to Cite:
Yulia, Z., & Salirawati, D. (2023). The Effect of Problem Based Learning on Students' Critical Thinking Ability and Scientific Attitude. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4211–4217. https://doi.org/10.29303/jppipa.v9i6.3026

One that plays an important role in supporting the success of student learning is their attitude towards the subject matter they follow. According to Sajjad Kabir (2013) attitude is defined as a mental position that represents the level of one's likes or dislikes for something. Attitude is not a talent, it requires a skill that can be learned and practiced. A positive attitude leads to happiness, success and can change lives. Research conducted by Lilian (2012) proves that attitude, self-efficacy, effort, and academic achievement are positively correlated with one another. Therefore, learning outcomes, especially chemistry subjects, especially cognitive aspects that are supported by good attitudes or behavior need to be pursued, so that the measurement of learning outcomes in the attitude aspect needs to be done in addition to cognitive learning outcomes. Scientific attitude is one of the factors that influence learning outcomes. Scientific attitudes such as curiosity, respect for data or facts and open-mindedness and cooperation in research relate to the way they act and solve problems. The scientific attitude used in solving problems, the learning outcomes obtained are maximized (Sa'adah & Kusasi, 2017).

Yacoubian et al., (2011) explained that considering a scientific attitude internalizes attitudes which include habits of mind discipline, persistence, risk taking, curiosity, inventory, openness, skepticism, ability to overcome doubts, a positive approach to failure, flexibility, respect for facts, and effectiveness. In line with other research conducted by Ali & Awan (2013) entitled attitude towards science and its relationship with students' achievement in science. This study was to examine the relationship between high school students' attitudes toward science and achievement in Physics, Chemistry, Biology and Mathematics. The results showed that attitudes toward science had a significant positive relationship with student achievement at the secondary level.

Research on non-cognitive factors such as students' scientific attitudes towards chemistry studies has been widely carried out as a predictor of chemistry achievement. Kahveci (2015) concluded that meaningful alignment between curriculum development and pedagogical practice is very important to improve students' attitudes towards chemistry subjects.

Furthermore, from the results of the research analysis conducted by Susilowati et al. (2017) showed that the average percentage of students' critical thinking skills was 52.28% (low category). Furthermore, based on the results of the interviews in this study, it was found that 70% of students easily forgot the material they were studying, because they tended to use rote learning methods. This indicates that students' critical thinking skills need to be trained and accustomed, so that they are able to solve various problems in social life. Students' critical thinking skills and scientific attitudes can be improved in various ways and strategies. One of the appropriate models to be applied to students if the teacher wants to improve these two things is the learning style that is often carried out by the 2013 Curriculum, namely Problem-Based Learning.

Problem Based Learning (PBL) is a learning model that provides individual opportunities for independent learning and lifelong learning, develops critical thinking skills, and helps them find alternative solutions to problems they face in everyday life (Tosun & Senocak, 2013). Research conducted by Aizikovitsh-Udi & Cheng (2015) entitled Developing Critical Thinking Skills from Dispositions to Abilities: Mathematics Education from Early Childhood to High School. They examine how teaching strategies that are oriented towards the development of higher-order thinking skills affect students' critical thinking abilities. The results showed that there was a significant increase in the disposition of secondary mathematics students towards critical thinking and critical thinking skills.

The problem of critical thinking skills is faced by many schools in urban areas, especially for schools in rural areas. However, for schools in urban areas where school facilities are generally relatively adequate and teachers have more opportunities to attend training, this problem can slowly be overcome. Unlike the case with schools in rural areas, let alone attending training or teaching material by uncovering critical thinking skills, the number of students can be counted on one hand and they are not always present at school. A number of studies on education in rural areas show that rural education problems, one of which is the lack of skilled teachers, is a serious problem (Mulken & Chen, 2008). One characteristic of instructors in rural locations is their metrocentric outlook. Living in cities and avoiding rural places is a metrocentric attitude (Campbell et al., 2011). Therefore, students in rural areas tend to be less motivated to learn than children in urban areas.

Problem Based Learning Model students are trained to find solutions to problems in groups or alone, encourage students to collaborate with friends or individually using logic and reasoning, and argue with each other to defend their opinions. PBL is very different from the direct instruction model which is still commonly used, especially in rural schools, where it is not yet effective in developing students' critical thinking skills and positive attitudes.

There are many issues that can be discussed to uncover students' critical thinking skills and form a scientific attitude towards students' interest, especially in colloidal material. The characteristics of the colloid topic are contextual (Novilia et al., 2016). The colloid system discusses the types of colloids such as milk, mayonnaise, dust, fog, air pollution, and hydrophilic and hydrophobic colloids. The substances previously mentioned were directly involved in the lives of students, but in their implementation, the colloid topics tended to be memorized by the participants (Chittleborough, G., Treagust, 2007). Students have difficulty connecting learning colloid material with practical applications. Colloidal material tends to be memorized so that the learning objectives of colloidal material have not been achieved. An investigation by Aidoo et al. (2016) in their research results show that PBL is an effective way to teach chemistry in order to improve students' critical thinking skills and problem solving. Therefore, in this study this material was selected as research material that would be taught through the application of a problem-based learning model in rural schools.

Based on this description, this study wanted to know empirically the extent of students' critical thinking skills and scientific attitudes after being given the treatment of applying PBL to colloid material. This research is focused on class XI high school students in rural areas of Aceh which are indeed far from cities to show that students in rural areas can also improve their critical thinking skills and scientific attitude after being given the application of the PBL model.

Method

This study uses a quasi-experimental research type with a posttest only design. This research was conducted at SMA Negeri 2 Nisam Aceh Utara. The sample in this study consisted of two classes, namely class XI-IPA1 as the experimental class with the PBL model and class XI-IPA 2 as the control class with the direct instruction learning model. A total of 50 students as the research sample were taken by cluster random technique. The instrument used is in the form of multiple-choice questions to measure students' critical thinking skills and scientific attitude questionnaires.

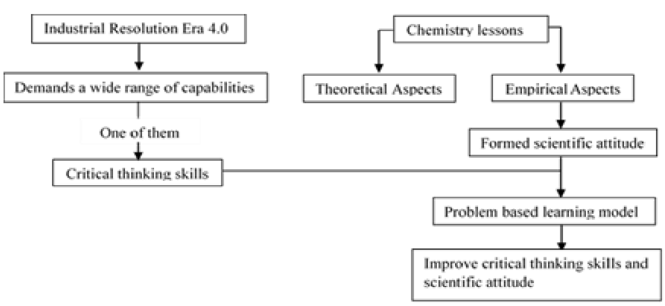

Figure 1. Research Stages Chart

The MANOVA test is used to analyze differences in critical thinking skills and scientific attitudes of students in the experimental class and the control class. The stages in this study can be seen in Figure 1.

Result and Discussion

Data on the results of critical thinking skills were obtained through the posttest which was given after the students were given the learning treatment using the Problem Based Learning model and the direct learning model. Data from the posttest results of critical thinking skills in the experimental class and control class can be seen in Table 1.

Table 1. Results of Data Analysis of Students' Critical Thinking Ability

Classes	description				
	N	Mean	Min. Value	Max. Value	Dev. Stand
Experiment	25	87.20	80.00	93.33	5.06
Control	25	76.00	66.67	86.67	6.09

The posttest average comparison of students' critical thinking skills between the experimental class and the control class can be seen in Figure 2.

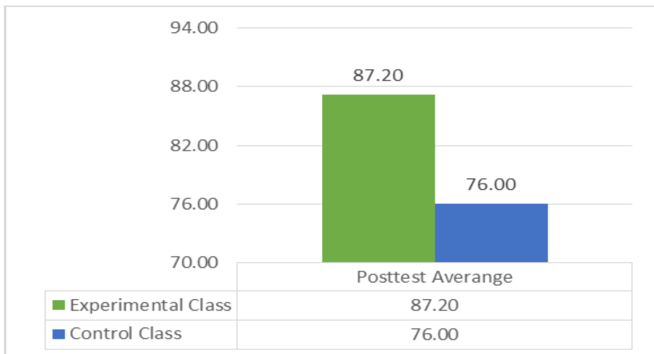

Figure 2. Average Students' Critical Thinking Ability

Based on Figure 2, it shows that students in the experimental class who use the PBL model have higher critical thinking skills than students in the control class who use the direct instruction model. Data from the answers to the scientific attitude questionnaire of students in the experimental class and control class can be presented in Table 2.

Comparison of the average scientific attitude questionnaire results of students between the experimental class and the control class can be seen in Figure 3.

Table 2. Results of Data Analysis of Students' Scientific Attitudes

Classes	description				
	N	Mean	Min. Value	Max. Value	Dev. Stand
Experiment	25	84.43	75.20	95.20	7.70
Control	25	72.99	60.00	80.00	6.48

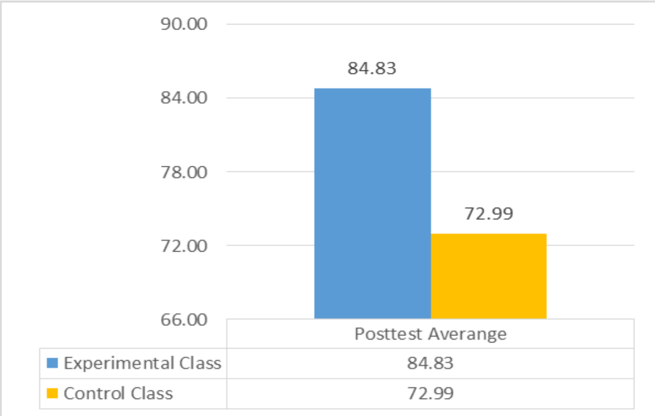

Figure 3. Average Scientific Attitude of Students

Figure 3 shows that students in the experimental class who use the problem based learning model have a higher scientific attitude than students in the control class who use the direct instruction model.

Hypothesis Test Results

The assumption of multivariate normality is met. The normality test aims to determine whether the data from each variable is normally distributed or not. This can be seen from the results of the Shapiro-Wilk test in Table 3.

Table 3. Shapiro-Wilk Test Results

Research Variable	Classes	Uji *Shapiro-Wilk*		Summary
		Df	Sig.	
Critical Thinking Ability	Experiment	25	0.758	Normal
	Control	25	0.862	
Scientific Attitude	Experiment	25	0.737	
	Control	25	0.921	

Table 3. shows that the significance value of scientific attitudes and students' critical thinking skills in experimental and control courses is more than 0.05, thus supporting the conclusion that Ho is accepted. As a result, it can be said that the data is regularly distributed. Furthermore, the assumption of homogeneity of the variance-covariance matrix is fulfilled. The homogeneity test was carried out using the Box's M test which can be seen in Table 4.

Table 4. Box's M Test Results

Box's M Test	F	df1	df2	Sign.
2.834	1.045	4	8.752E5	.437

Based on Table 4, it can be seen that H0 is accepted which proves that the data comes from a population with a homogeneous variance-covariance matrix. Box's M test result of 1.045 is greater than 0.05. The MANOVA test is carried out after the prerequisite test results are obtained. The MANOVA test is used to compare students' critical thinking skills and scientific attitudes taught by the direct teaching approach versus the problem based learning paradigm. The results of the MANOVA hypothesis test with Hotelling's Trace can be seen in Table 5.

Table 5. Hotelling's Trace Test Results

Test Analysis	F	Sig.	Summary
Hotelling's Trace	5.358	0.000	Ho is rejected

Based on Table 5, the results of the MANOVA test with Hotelling's Trace show a significance value of 0.000, which is less than 0.05 (Ho is rejected), so it can be concluded that there is a difference between critical thinking skills and the scientific attitude of students who are subjected to the problem-based learning model for class experiment with the direct instruction model for the control class. The multivarite test results of the Test of Between Subject Effects are used to analyze significant differences in the critical thinking abilities of students who take part in the Problem based learning model and the direct instruction model. This can be seen in Table 6 which shows that the significance value is 0.017 which is smaller than 0.05. Univariate test results can be presented in Table 6.

Table 6. Test Results of Between Subject Effects on Critical Thinking Ability

Factor	V.Dependent	F	Sig.	Summary
Problem Based Learn-ing	Critical Thinking	9.837	0.017	Ho is rejected

The results of the multivariate Test of Between Subject Effects showed that there were significant differences in the scientific attitude of students who took part in learning using the Problem based learning model and the direct instruction model. This can be seen in Table 7 which shows that the significance value is 0.038 which is smaller than 0.05. The MANOVA test results can be shown in Table 5.

Table 7. Test Results of Between Subject Effects of Students' Scientific Attitudes

Factor	V.Dependen	F	Sig.	Summary
PBL	The Scientific attitude	3.267	0.038	Ho is rejected

Differences in Students' Critical Thinking Ability

The data used to determine differences in the critical thinking skills of students in the experimental class and the control class are the students' posttest scores which include 15 multiple choice questions. This test was carried out at the end of the meeting in both classes. Based on the results of data analysis using Hotteling's Trace and Test of Between Subject Effects, a significant value of <0.05 was obtained so that it could be stated that there was a significant difference between the critical thinking abilities of students who were subjected to the problem based learning model and the direct instruction model on colloid material.

Referring to the research by Üce & Ateş (2016) it shows that there is a significant difference between the pretest and posttest of students in the experimental class subjected to the problem-based learning model. These results prove that the problem-based learning model has a very significant positive effect. The benefits of problem-based learning are also conveyed in the results of research conducted by Orji & Ogbuanya (2018) which states that there are differences between the experimental class which is taught using the problem-based learning model and the control class which is taught using conventional learning models. Likewise, the results of research from Schmidt et al. (2011) showed that the problem-based learning model has a fairly strong effect on learning and achievement, compared to conditions where learning does not use problems. This research generally shows that the learning outcomes of students with the application of problem-based learning models in the experimental class are higher than the control class.

The application of the problem-based learning model makes students play an active role in the learning process, students actively work together in groups to find solutions to problems given by the teacher. The stages of learning in the problem-based learning model are the activities of students in applying critical thinking skills. Without this ability, students will experience difficulties in solving the problems they face. Critical thinking is the ability to solve problems through an investigation, resulting in a rational conclusion or decision.

Based on this, this has an effect on students at SMA Negeri 2 Nisam, North Aceh. Students who are in the control class with the application of the direct instruction model mostly experience difficulties when answering the questions given. Overall, students' mastery of critical thinking skills has not achieved the expected indicators of success. This is due to the ability of students to answer critical thinking skills questions on colloid material only to the extent of what they remember and read. Students still have difficulty in providing conclusions from each case of problems contained in the problem. Students only rely on their memory skills and sometimes many concepts are lost, because not all material can be remembered by students, especially if their attention during the learning process is lacking. This is inversely proportional to students who are in the experimental class with the application of the problem-based learning model.

The critical thinking skills of students who study using the problem-based learning model show a very significant increase. This happens because the PBL model provides opportunities for students to develop their critical thinking skills through complex problem solving processes in small discussion groups, so that students' analytical, interpretation, evaluation, inference, and explanation skills of the questions given are better.

Differences in Scientific Attitudes of Learners

Based on the results of the Hotteling's Trace data analysis and the Test of Between Subject Effects, a significant value of <0.05 was obtained so that it could be stated that there was a significant difference between the scientific attitudes of students who were subjected to the problem-based learning model and the direct instruction model. This is because students have carried out scientific activities that support changes in scientific attitudes, especially changes in the dimensions of attitudes towards cooperation and curiosity.

Student worksheets that have been compiled help foster the character of students to find out for themselves and use their ideas in solving a problem. The problem-based learning model is able to stimulate students' scientific attitudes so that they are more active and enthusiastic in responding to lessons. This is in accordance with the results of research conducted by Astika et al. (2013) which explains that there are differences in scientific attitudes between groups of students who learn to follow the problem-based learning model and groups of students who learn to use conventional learning models. This result was also reinforced by Israfiddin et al. (2016) which stated that there were significant differences in scientific attitudes in motion material between students who studied using problem-based learning models and conventional learning models.

Nursafiah et al. (2015) stated that the difference in the scientific attitude of the control class and the experimental class was due to the fact that the control class was only teacher-centered, whereas in the experimental class students learned to be active and required to understand new concepts about a problem whose truth needs to be proven. This is what can help students learn scientifically, structured, and independently. The problem based learning model not only influences classroom learning, but also influences chemistry learning in the laboratory. This is measurable based on the research that was conducted at the first meeting on colloid production. Students are given student worksheets and carry out activities in the laboratory. The results of observations on chemistry learning in the laboratory show the dimensions of the attitudes of students who respect the data obtained during practical activities, as well as the sensitivity of students in maintaining and paying attention to order, neatness, and cleanliness in the laboratory.

Conclusion

Based on the analysis of research data and discussion, it can be concluded that there is a significant difference in critical thinking ability and scientific attitude between students who are subjected to the application of the PBL model and students who are subjected to the application of the direct instruction model in colloidal material for class XI-IPA at SMA N 2 Nisam. There is a significant difference in the ability to think critically between students who are subjected to the application of the PBL model and students who are subjected to the application of the direct instruction model in class XI-IPA colloid material at SMA N 2 Nisam. There is a significant difference in the scientific attitude between students who are subjected to the application of the PBL model and students who are subjected to the application of the direct instruction model in colloidal material for class XI-IPA at SMA N 2 Nisam.

Acknowledgments

Thanks, are given to the lecturers and chemistry teachers who have supported the researchers and all the Nisam 2 Public High Schools who have given permission so that this research can be carried out properly and smoothly.

Author Contributions

This article was published thanks to the collaboration of writer 1, Zulfa Yulia, and writer 2, Das Salirawati. Author contributions to paper: author 1 is studying the conception and comprehensive discussion of statistical results; author 2 is methodology, data analysis, and instrument validation. All authors reviewed the results and approved the final version of the manuscript.

Funding

All funding for this research and publication was borne by the two authors.

Conflicts of Interests

The author's interest in publishing this article is for the needs of research output in the form of publication in scientific journals as proof of the required performance. There is no conflict of interest.

Reference

Aidoo, B., Boateng, S. K., Kissi, P. S., & Ofori, I. (2016). Effect of Problem-Based Learning on Students' Achievement in Chemistry. *Journal of Education and Practice*, *7*(33), 103–108. Retrieved from https://iiste.org/Journals/index.php/JEP/article/view/34135

Aizikovitsh-Udi, E., & Cheng, D. (2015). Developing Critical Thinking Skills from Dispositions to Abilities: Mathematics Education from Early Childhood to High School. *Creative Education*, *6*(4), 455–462. https://doi.org/10.4236/ce.2015.64045

Ali, M. S., & Awan, A. S. (2013). Attitude Towards Science and Its Relationship With Students ' Achievement in Science. *Interdisciplinary Journal of Contemporary Research in Business*, *4*(10), 707–718. Retrieved from https://journal-archieves28.webs.com/707-718.pdf

Astika, I. K. U., Suma, I. K., & 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), 1–10. Retrieved from https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/851/606

Campbell, A. M., & Yates, G. C. (2011). Want to be a Country Teacher? No, I am too Metrocentric. *Journal of Research in Rural Education*, *26*(4). Retrieved from http://sites.psu.edu/crec/wp-content/uploads/sites/6349/2013/11/26-4.pdf

Chittleborough, G., Treagust, D. . (2007). The modelling ability of non-major chemistry students and their understanding of the sub-microscopic level. *Chemistry Education Research and Practice*, *8*(3), 274. https://doi.org/10.1039/b6rp90035f

Festus, C., & Ekpete, O. A. (2012). Improving Students' Performance and Attitude towards Chemistry through Problem-Based-Solving Techniques (PBST) The impact of motivation and role modeling on female students View project. *Article in International Journal of Academic Research in Progressive Education and Development*, *1*(1), 156–163. https://doi.org/10.6007/IJARPED/v1-i1/10940

Israfiddin, Gani, A., & Saminan. (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*, *4*(1), 43–51. https://doi.org/10.52060/pgsd.v3i2.481

Kahveci, A. (2015). Assessing high school students' attitudes toward chemistry with a shortened semantic differential. *Chemistry Education Research and Practice*, *16*(2), 283–292. https://doi.org/10.1039/C4RP00186A

Lilian, L. (2012). A Study of the Attitude, Self-efficacy, Effort and Academic Achievement of CityU Students towards Research Methods and Statistics.

Discovery – SS Student E-Journal, *1*, 154–183. Retrieved from http://ssweb.cityu.edu.hk/download/RS/E-Journal/journal8.pdf

Mulken, A., & Chen, D. (2008).*Teachers for Rural Schools*. The World Bank. https://doi.org/10.1596/978-0-8213-7479-5

Novilia, L., Iskandar, S. M., & Fajaroh, F. (2016). the Effectiveness of Colloid Module Based on Guided Inquiry Approach To Increase Students' Cognitive Learning Outcomes. *International Journal of Education*, *9*(1), 17. https://doi.org/10.17509/ije.v9i1.3713

Nursafiah, Nurmaliah, C., & Rahmatan, H. (2015). Penerapan Model Pembelajaran Inkuiri Terbimbing pada Materi Fotosintesis untuk Meningkatkan Sikap Ilmiah Peserta Didik di SMP Negeri 8 Banda Aceh. *Jurnal EduBio Tropika*, *3*(1), 15–18. Retrieved from https://jurnal.usk.ac.id/JET/article/view/5270

Orji, C. T., & 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 and Education*, *55*(4), 334–353. https://doi.org/10.1177/0020720918773983

Sa'adah, & Kusasi, M. (2017). Menggunakan model pembelajaran inkuiri terbimbing (guided inquiry) pada materi kesetimbangan kimia increasing scientific attitude and concept understanding using guided inquiry model in chemical Equilibrium. *QUANTUM, Jurnal Inovasi Pendidikan Sains*, *8*(1), 78–88. Retrieved from https://ppjp.ulm.ac.id/journal/index.php/quantum/article/view/3861/3491

Sajjad Kabir, S. M. (2013). Positive Attitude Can Change Life. *Journal of Chittagong University Teachers Association. Department of Psychology University of Chittagong, Chittagong.*. https://www.researchgate.net/profile/Syed-Muhammad-Kabir/publication/325712867_Positive_Attitude_Can_Change_Life/links/5b1f9f28458515270fc4ea2b/Positive-Attitude-Can-Change-Life.pdf

Salirawati, D. (2012). Percaya Diri, Keingintahuan, Dan Berjiwa Wirausaha: Tiga Karakter Penting Bagi Peserta Didik. *Jurnal Pendidikan Karakter*, *3*(2), 213–224. https://doi.org/10.21831/jpk.v0i2.1305

Schmidt, H. G., Rotgans, J. I., & Yew, E. H. J. (2011). The process of problem-based learning: What works and why. *Medical Education*, *45*(8), 792–806. https://doi.org/10.1111/j.1365-2923.2011.04035.x

Susilowati, Sajidan, & Ramli, M. (2017). Analisis keterampilan berpikir kritis siswa madrasah aliyah negeri di Kabupaten Magetan. *Prosiding SNPS (Seminar Nasional Pendidikan Sains)*, *21*, 223–231. Retrieved from https://jurnal.fkip.uns.ac.id/index.php/snps/article/view/11417

Tosun, C., & Senocak, E. (2013). The effects of problem-based learning on metacognitive awareness and attitudes toward chemistry of prospective teachers with different academic backgrounds. *Australian Journal of Teacher Education*, *38*(3), 61–73. https://doi.org/10.14221/ajte.2013v38n3.2

Üce, M., & Ateş, İ. (2016). Problem-based Learning Method: Secondary Education 10th Grade Chemistry Course Mixtures Topic. In *Journal of Education and Training Studies*, *4*(12). https://doi.org/10.11114/jets.v4i12.1939

Yacoubian, H., Hur, S. J., Lei, Y., Freed, C., Phillips, L. M., & Norris, S. P. (2011). Teaching Scientific Inquiry Using Science Trade Books. *Alberta Science Education Journal*, *41*(1), 16–21. Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=759ec437458b07dffd572d73490e6fdb8b17bfda