JPPIPA 8(1) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

The Critical Thinking Skills and Scientific Attitudes of Pre-Service Chemistry Teachers Through the Implementation of Problem-Based Learning Model

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DOI: 10.29303/jppipa.v8i1.1278

Article Info
Received: December 15, 2021
Revised: January 10, 2022
Accepted: January 14, 2022
Published: January 31, 2022

Abstract: This study aims to determine the effect of applying problem-based learning models on critical thinking skills and scientific attitudes of pre-service chemistry teachers in Basic Chemistry 1. This quasi-experimental research uses pre-test and post-test through an unequal control group design. This research has been carried out for 3 months from September-November in 2021 on pre-service chemistry teachers. The data were analyzed using Hotelling's T2 test and the Rasch model. Empirical evidence shows that based on Hotelling's T2 test results obtained a significance value of 0.001 < (0.05) with a partial eta squared value of 0.28 which means Ha is accepted. So, it can be concluded that there is a contribution of problem-based learning models on critical thinking skills and scientific attitudes of students with the contribution of 28%. Another finding also shows that based on the results of the Rasch model test, it shows that in the experimental class the indicators of critical thinking skills and scientific attitudes are mostly possessed the ability to synthesize attitudes towards scientific investigations. The indicators of critical thinking skills and scientific attitudes are least possessed the ability to analyze and chemistry learning experiences. The conclusions of this study include there is a significant effect of the application of the PBL model on students' critical thinking skills and scientific attitudes with a model contribution of 28%, as well as critical thinking skills and scientific attitudes that most students have in the experimental class are analytical skills and attitudes towards scientific investigations.

Keywords: Problem-based learning model; Critical thinking skills; Scientific attitudes; Pre-service chemistry teachers

Citation: Wahyudiati, D. (2022). The Critical Thinking Skills and Scientific Attitudes of Pre-Service Chemistry Teachers Through the Implementation of Problem-Based Learning Model. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 216–221. https://doi.org/10.29303/jppipa.v8i1.1278

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results. The purpose of chemistry learning in higher education cover three aspects, they are cognitive, affective, and psychomotor. Moreover, it consists of three domains namely macroscopic, microscopic, and symbolic (Sirhan, 2007; Johnstone, 2006). It is crucial to integrate these three domains within the learning process in order to understand the chemistry concepts. The affective domain is also important to be developed in the learning process including attitudes, values, motivation, and confidence (Cheung, 2011) so it must be included as the main component of the learning outcomes (Cheung, 2011; Calik, et al., 2014). However, the results of previous studies show that chemistry is often listed as the most difficult subject at all levels of education. It can be seen from many misconceptions, task difficulty, and lack of problem-solving skills that lower students' cognitive achievement, critical thinking skills, and scientific attitude (O'dwyer, 2012; Browman, et al., 2011). Based on these problems, teachers are

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expected to be able to create a learning environment that is able to facilitate students to construct understanding and develop scientific attitudes so that the goal of chemistry learning in higher education can be fully achieved.

According to Ramson (2010), passive learning processes have been a burden in developing students' thinking skills. It is relevant to the research results conducted by Singh (2016) and Taber (2011) that the monotonous learning process is due to the lack of variation in applying active and innovative learning models, as well as the low ability in developing constructivist instructional approaches. This kind of learning will also make the objectives of chemistry learning difficult to be achieved. The essence of constructivism learning theory refers that the knowledge obtained by students gained through both physically and mentally active involvement (Slavin, 1994). The knowledge is obtained from sensory experiences, such as seeing, listening, motoric activities, scientific thinking, and thought formulate as a knowledge (Suparno, et al., 2002). However, several previous research results revealed that the problems of chemistry learning were strongly influenced by monotonous learning activities because of the lack of application of active, innovative and constructivist-based learning models so that it negatively impacts on students' ability to understand scientific concepts, critical thinking skills, and scientific attitudes (Luvat, et al., 2011; Taber, 2011; Overton & Bradely, 2010; Wahyudiati, et al., 2019a). Thus, through the application of constructivism-based learning (active and innovative learning), it is expected to enable students to construct new knowledge through the process of scientific thinking that involves problem-solving skills in order to improve their scientific attitudes.

One of the learning models based on a constructivism approach that is able to increase student activity in constructing attitudes, knowledge, and experiences of student chemistry learning is the problem-based learning model. Problem-based learning model that can be used to improve students' scientific attitudes. The development of problem-solving skills in learning can provide a positive influence on students'scientific attitudes where it consists of 5 phases namely; (1) problem orientation; (2) problem identification; (3) group investigation; (4) class discussion; (5) evaluation & concensus. The advantage of applying the problem-based learning model lies in the experience-based scientific inquiry process that is often experienced and found in student life as a reference in providing learning experiences that are directly related to students' daily lives so that learning can be more interesting and meaningful. This condition is very relevant to previous studies that have proved that the learning process which is oriented to the problem-solving process can improve students' scientific attitudes (Tosun & Taskesenligil, 2013; Orhan, 2008). Moreover, the learning experience and scientific attitude possessed by students are positively correlated with their academic achievement (Ferrel & Barbera, 2015).

Another advantage of implementing a constructivism-based PBL model is that it is expected not only to improve scientific attitudes and critical thinking skills, but also as an effort to integrate chemical concepts that are relevant to students' daily experiences so that learning becomes more meaningful and student-centred (Wahyudiati, et al., 2020; Wahyudiati, 2021; Sumardi, et al., 2020; Sumardi & Wahyudiati, 2021) Thus, researchers believe that through the application of the PBL model it will have a positive effect on students' scientific attitudes in the Basic Chemistry 1 course. In addition, the findings of this study can provide benefits for lecturers and researchers in practicing new innovative learning models in order to improve cognitive achievement, scientific attitudes or other 21st century skills at the primary, secondary, and tertiary levels.

Method

The research design used a quasi-experimental pretest posttest design with a non-equivalent control group design (Campbell & Stanley, 1963). In the experimental group, a problem-based learning model was applied, while the control group used a conventional learning model. The research was carried out for 3 months from September-November in 2021 consisting of face-to-face activities in class and practical activities in the laboratory. The research design is shown in Table 1.

Table 1. Pretest Posttest Non-Equivalent Control Group Design

Group	Pre-Treatment	Treatment	Post Treatment
Experiment	S, C	X	S, C
Control	S, C	Y	S, C

Where:
S : Students' scientific attitude
C : Critical thinking skills
X : The problem-based learning model
Y : The conventional method

The research samples were 80 students of pre-service chemistry teachers from one universities in Mataram city. In the experimental group, there were 40 people (6 men and 34 women) and the control group consisted of 40 people (12 men and 28 women). The determination of the sample group was done through cluster random sampling techniques with the characteristics of the two groups that were almost the same, the average age of 19 years (18-20 years).

The instruments for data collection of students' critical thinking skills and scientific attitude (SA)) on the Problem-based learning developed by researchers that had been through the expert judgments and the empirical tests. The validity value for Aiken's V of 0.96 was a scientific attitude instrument that included 10 indicator items with Cronbach's alpha value of 0.89. Based on Cronbach alpha values, the two instruments were above the acceptable limit of 0.70 (Yadav & Argawal, 2013; Vaske, et al., 2016), and the V value ranged from 0.94 to 0.97, so it can be categorized as high (Penfield & Giacobbi, 2004). After the expert validation test, it was followed with the empirical validity test of the instruments through the items analysis by using the Rasch test model. Based on the results of the Rasch model test, 34 questionnaire items of critical thinking skills and scientific attitude were declared valid and reliable referring to goodness-of-fit indicators for all items as shown in Table 2 (Boone et al., 2014).

Table 2. Indicators of Goodness-of-Fit

Out Fit		Pt-Measure
Outfit Means Square	Outfit Z-Standard	Point Measure Correlation
0.5 <MNSQ < 1.5	-2.0 <ZSTD <+2.0	0.4 <Pt Measure Corr < 0.85

The analysis of research data used Hotelling's T2 test and the Rasch model. The Hotelling's T2 test test was conducted after all Hotelling's T2 test assumption tests were fulfilled as the prerequisite test before the test (Stevens, 2002) with the significance level of 5%. The Rasch Model analysis was carried out to analyze the critical thinking skills and scientific attitudes that students most possessed and lacked after the PBL model was applied.

Result and Discussion

The data analysis results showed that all assumption tests of Hotelling's T2 tes have been fulfilled. The test of the contribution of the PBL model to the critical thinking skills (CA) and scientific attitude (SA) of students is based on the partial eta squared value. Based on the results of the study, the partial eta squared value was 0.28 with a significance value of 0.001 as shown in Table 3.

Table 3. The results of Effect Test between Model Subject of the Problem-based learning model on CA and SA

Dependent Variable	df	Mean Square	sig	Partial eta squared
CA and SA	1	537.920	0.001	0.28

The measurement of critical thinking skills and students' scientific attitudes includes 34 statement items with 12 indicators, namely; (1) understanding, (2) synthesis, (3) analysis, (4) application, (5) evaluation, (6) attitude towards scientific investigation, (7) application of scientific attitude, (8) attitude towards chemistry, (9) chemistry learning experience, (10) curiosity attitude, (11) open-minded attitude, and (12) behavioral tendency to study chemistry. The results of student questionnaires in the experimental class and in the control, class were analyzed using the Rasch model test which aims to identify the type of statement items that are most approved or owned by students. Based on the results of the Rasch model test, it shows that in the experimental class the items that students lack the least are numbers 20 & 8, while the items that are mostly owned are numbers 1 & 25 as shown in Table 4.

Table 4. The Most and Less CA dan SA Questionnaire Items Owned by Students in the Experimental Class

Questionnaire Items		
No	Least Owned Questionnaire Item by Student	Indicator type
20	I feel that it is enough to study chemistry during lectures.	Chemistry learning experience
8	I have difficulty in relating chemistry concepts to everyday life	Analyze
Questionnaire Item Most Owned by Student		
1	I feel interested in carrying out scientific investigations	Attitudes towards scientific investigations
25	I feel very interested in deducing chemical concepts based on experimental results	Synthesize

This study aims to determine the effect of the application of the problem-based learning model on the critical thinking skills and scientific attitude of pre-service chemistry teachers in the Basic Chemistry 1 course. The results of the study showed that there were differences in CA and SA among students from both classes in which the significance value of 0.001 <α (0.05) was obtained. The difference was caused by the characteristics of the Problem-based learning that emphasizes the students' active participation and independence in identifying problems, formulating hypotheses, designing and carrying out experiments to give students wide opportunities to develop their critical thinking skills and scientific attitudes that will also positively impact to their cognitive achievement. The findings of this research are consistent with the results of previous studies which also prove that the application of learning-oriented to the problem-solving process can improve the students' cognitive achievement, critical thinking skills, and scientific attitudes (Tosun & Taskesenligil; 2013; Orhan, 2008). Furtherly, it is stated that the learning model will be effective if there is an increase in the students'ability before and after the treatment (Duran & Dokme, 2016).

The application of learning models oriented to problem-solving has a positive influence on students' critical thinking skills, and scientific attitudes and it is relevant to the syntax characteristics of the Problem-Based Learning Model. This syntax reflects based scientific inquiry process as the foundation of the learning activities. Through the implementation of this model, it provides students with meaningful learning experiences in conducting scientific inquiry including the experience of identifying problems, formulating goals and hypotheses, designing and conducting independent experiments, and making conclusions. The development of various problem-solving skills is needed by students so that they are able to practice critical thinking skills, self-confidence, scientific attitudes, and science processing skills which can significantly affect their comprehensive understanding ofthe concepts. This condition is matching to previous studies which prove that students' learning experiences, scientific attitudes, and self-confidence are positively correlated with their cognitive achievement (Ferrel & Barbera, 2015). Thus, the application of the Problem-based learning can have a positive influence on the scientific attitudes and critical thinking skills among students.

The implementation of the Problem-based learning begins with problem orientation. The problem orientation activities are performed through the submission of various phenomena or problems originating from everyday life which are relevant to Basic Chemistry 1 material. The advantage of this phase is that students are trained to be actively involved in analyzing, and predicting a problem that comes from their daily experience to give a more positive impact on the students' scientific attitudes and critical thinking skills. The students'active participation in problem-solving can enhance their motivation, persistence, and perseverance during classroom learning and practicum activities so it positively impacts to improve their scientific attitudes, critical thinking skills, processing skills, and academic achievement (Villafane & Lewis, 2016).

The second and the third phases of the Problem-based learning are the problem identification and the group investigation. At the problem identification stage, each student analyzed the issues which were urgent and relevant to the material of Basic Chemistry 1. This phase can attract students' curiosity and improve their identification skills as well as their logical and critical thinking to identify a problem for creating a solution. This finding supports the previous researches which has proved that the ability of problem-solving skills among students can influence their critical thinking skills, scientific attitudes and scientific processing skills to boost their cognitive achievement (Dalgety, et al., 2003). In the group investigation, the students and their group members arranged an experimental design based on the student worksheet to conduct experimental activities in answering the formulated problems. This phase is beneficial for students to design and carry out experiments that have a positive impact on their ability to observe problems, formulate research variables, and prove hypotheses in order to develop their scientific attitudes and cognitive achievement. It is in line with the study from Grangeat (2016) which shows that the students have positive outcomes on their scientific attitudes and concepts mastery through experimental activities.

The fourth and the fifth phase of Problem-based learning are the class discussion activities and the evaluation. The class discussion activities aimed at presenting, confirming, and discussing the results of the experiments that had been conducted by each group so that they can practice their communication skills and respect other's opinions. The advantages of class discussion are enabling students to be actively involved in exchanging ideas and opinions as well as constructing knowledge, attitudes, and skills to improve their academic achievements (Avsec & Kocijancic, 2014). The last phase of this model in the form of evaluation and feedback was done by students according to the lecturers'guidance. This phase is crucial for students to reflect on the constraints and the benefits in each learning process as a material for improvement in the subsequent learning activities. It agrees with a study conducted by Philip (2006) which evidencesthat the evaluation and reflection activities in the learning process truly support the optimal learning outcomes. Those various advantages of theintegrated learning model show that it can be a contextual learning model through problem-solving activities based on local wisdom that is very likely to the students'daily activities. This point positively influences the ability of critical thinking skills and scientific attitudes among students.

Based on research shows that the most critical thinking skills and scientific attitude possessed by students in the experimental class is feeling interested in carrying out scientific investigation activities and compiling their own Basic Chemistry 1 practicum report based on primary sources and the results of my own analysis which are included in the attitude indicators towards the scientific investigation. This means that the experimental class through the application of the PBL model has a positive effect on students' scientific attitudes, namely attitudes towards scientific investigations, where students are very enthusiastic in carrying out experimental or experimental activities. However, the questionnaire item that students lacked the least was that they always thought that the work of other groups was the result of maximum effort and felt that it was enough to study chemistry during lectures. This means that in the experimental class students feel it is enough to learn chemistry during class meetings so that the acquisition of chemical concepts outside the classroom is less attractive to students, such as obtaining information through print and electronic media is considered less important to do.

The interesting findings of this study prove that there are differences in the ability of scientific attitudes in the experimental and control classes, where attitudes towards scientific investigations are the statement items that are the easiest to answer for students in the experimental class, but are the most difficult statement items to answer in the control class. In the control class, students were taught using the direct learning model, while the experimental class was taught using the PBL model. The characteristics of the PBL model are oriented towards collaborative problem-solving activities as a reference in constructing attitudes, understanding, and skills, but on the contrary, the conventional learning model does not emphasize the mastery of problem-solving skills and the lack of student activation in constructing attitudes, understanding, and skills so that it has an impact on less developed attitudes towards scientific investigations of students in the control class. This condition is in line with research conducted by Taber (2011), Ismiani, et al., (2017), Wahyudiati, et al., (2019b), and Ramson (2010) prove that the monotonous learning process with passive learning situations and processes has an impact on not achieving the chemistry learning objectives optimally. The findings of this study are also supported by the results of research conducted by Jarjoura, et al., (2015) and Koksal & Berberoglu (2014) which prove that scientific investigation activities through teamwork make learning more enjoyable so as to improve scientific skills, critical thinking skills, scientific attitude, and student achievement compared with the application of conventional learning models. However, the application of the direct learning model is very effective in developing students' declarative and procedural knowledge (Barth, et al., 2019).

Conclusion

Based on the empirical evidence generated by the study, it can be concluded that; (1) there is a significant effect of the application of the PBL model on students' critical thinking skills and scientific attitudes with a model contribution of 28%; and (2) critical thinking skills and scientific attitudes that most students have in the experimental class are analytical skills and attitudes towards scientific investigations.

References

Avsec, S., & Kocijancic, S. (2014). Effectiveness of Inquiry-Based Learning: How Do Middle School Students Learn to Maximise the Efficacy of A Water Turbine? *International Journal of Engineerin Education*, 30(6A), 1436-1449. http://www.ijee.ie/latestissues/vol30-6a/10_ijee2982ns.pdf.

Barth, V, L., Piwowar, V., Kumschick, I, R., Ophardt, D., Thiel, F. (2019). The Impact of Direct Istruction in a Problem-Based Learning Setting: Effects of A Video-Based Learning Program to Foster Preservice Teacher's Profesional Vision of Critical Incident in the Classroom. *International Journal of Educational Research, 95*, 1-12. https://doi.org/10.1016/j.ijer.2019.03.002

Boone, W.J., Staver, J.R., & Yale, M.S. (2014). *Rasch Analysis in the Human Sciences*. Neterhlands: Springer.

Browman, K., Ekborg & Johnels. (2011). Chemistry in Crisis? Perspectives on Teaching and Learning Chemistry in Swedish Upper Secondaray Schools. *International Jornal of Science Education* 7(1), 43-53. https://doi.org/10.5617/nordina.245

Calik, M., Ultay, N., Kolomuc, A., & Aytard, A. (2014). A Cross-Age Study of Science Student Teachers' Chemistry Attitudes. *Chemistry Education Research and Practice.*

Campbell, D.T., & Stanley, J. (1963*). Experimental and Quasi-Experimental Designs for Research*. Chicago, IL: Rand McNally.

Cheung, D. (2011). Evaluating Student Attitudes toward Chemistry Lessons to Enhance Teaching in the Secondary School. *Educ. quím,* 22(2), 117-122. https://doi.org/10.1016/S0187-893X(18)30123-X

Dalgety, J., Coll, K.R., & Jones, A. (2003). Development of Chemistry Attitudes and Experiences Questionnaire (Caeq). *Journal of Research in Science Teaching, 40 (7),* 649–668. https://doi.org/10.1002/tea.10103.

Duran, M., & Dokme, I. (2016). The Effect of The Inquiry-Based Learning Approach of Student's Critical-Thinking Skills. *Eurasia Journal of Mathematic Science & Technology Education, 12(2*), 2887-2908. https://doi.org/10.12973/eurasia.2016.02311a

Ferrel, B., & Barbera, J. (2015). Analysis of Students' Self-Eficacy, Interest, and Effort Beliefs in General Chemistry. *Chem. Educ. Res. Pract, 16*, 318-337. https://doi.org/10.1039/C4RP00152D.

Grangeat, M. (2016). Dimensions and Modalities of Inquiry-Based Teaching: Undestanding the Variety of Practices. *Education Inquiry*, 7(4), 421-442. https://doi.org/10.3402/edui.v7.29863.

Ismiani, S., Syukri., & Wahyudiati, D. (2017). Pengaruh Penerapan Metode Problem Based Learning Terhadap Sikap Ilmiah dan Hasil Belajar Biologi Siswa Kelas VII MTs NW 01 Kembang Kerang. *Biota*, *10*(1), 68-75. https://biota.ac.id/index.php/jb/article/view/27

Jarjoura, C., Tayeh, P.A., & Zgheib, N.K. (2015). Using Team-Based Learning to Teach Grade 7 Biology: Student Satisfaction and Improved Performance. *Journal of Biological Education, 49(4)*, 401-419. https://doi.org/10.1080/00219266.2014.967227.

Johnstone, A.H. (2006). Chemical Education Research in Glasgow in Perspective. *Chemistry Education Research and Practice*, 7(2), 49-63. https://doi.org/10.1039/B5RP90021B.

Koksal, E. A., & Berberoglu, G. (2014). The Effect of Guided-Inquiry Instruction on 6th Grade Turkish Students Achievment, Science Process Skills, and Attitudes Toward Science. *International Journal of Science Education*, 36(1), 66-78. https://doi.org/10.1080/09500693.2012.721942.

Luvat, T., Dally, K., Clement, N., & Toomey, R. (2011). Values Pedagogy and Teacher Education: Reconceiving the Foundations. *Australian Journal of Teacher Education*, *36(7)*, 136-144. https://doi.org/10.14221/ajte.2011v36n7.3.

O'dwyer, A. (2012). *Identificationof The DifficultiesiIn Teaching Andlearning of Introductoru Organic Chemistry in IrelandaAnd The Developmnet of A Secobd-Level Instruction Programe to Address These*. Ollscrie Luimnegh. University of Luimnegh.

Orhan, A. (2008). Assessment of the Inquiry-Based Project Implementation Process in Science Education Upon Students' Points of Views. *International Journal of Instruction*, *1(1)*, 1–12. https://www.ijsr.net/search_index_results.php.

Overton, T., & Bradely, S. J. (2010). Internalitations of The Chemistry Curriculum: Two PBL Activities for Undergraduate Chemists. *Chemistry Education Research and Practice*, *(11)*, 124-128. https://doi.org/10.1039/c005356m

Penfield, R. D., & Giacobbi, P. R. Jr. (2004). Applying A Score Confidence Interval to Aiken's Item Content-Relevance Index. *Measurement in Physical Education and Exercise Science*, *8*(4), 213-225. https://doi.org/10.1207/s15327841mpee0804_3.

Philip, L. (2006). Encourging Reflective Practice Amongst Students. *A direct assesment approach. Planet*, *17(1)*, 37-39. https://doi.org/10.11120/plan.2006.0017003.

Ramson, A. (2010). Model Pembelajaran Konstruktivis untuk Meningkatkan Pemahaman Konsep dan Keterampilan Berpikir Kritis Siswa SMP pada Topik Cahaya. *Tesis*, tidak diterbitkan, UPI, Bandung.

Singh, I. S. (2016). Effect of Ethnochemsitry Practice on Secondary Schools Structure Attitude Toward Chemistry. *Journal of Education and Practice 7*(17), 44-56. https://journals.org/journals/index.php/JEP

Sirhan, G. (2007). Learning Difficults in Chemistry: An Overview. *Journal of Turkish Science education, 4(2)*, 2-20. https://doi.org/10.4236/ns.2010.212171

Slavin, R. (1994). *Educational Psychology, Theory and Practice (4th ed)*. Masschusets: Allyn & Bacon Publisher.

Steven, J. (2002). Applied Multivariate Statistics for The Social Sciences. *Journal of Educational Statistics*, *47(2)*. https://doi.org/10.2307/1164712

Sumardi, L., Rohman, A., & Wahyudiati, D. (2020). Does the Teaching and Learning Process in Primary Schools Correspond to the Characteristics of the 21st Century Learning? *International Journal of Instruction*, 13(3), 357-370. https://doi.org/10.29333/iji.2020.13325a

Sumardi, L., & Wahyudiati, D. (2021). Using Local Wisdom to Foster Community Resilience During the Covid-19 Pandemic: A Study in the Sasak Community, Indonesia. *Proceedings of the 2nd Annual Conference on Education and Social Science (ACCESS 2020)*, *556*(Access 2020), 122–127. https://doi.org/10.2991/assehr.k.210 525.059

Suparno, P., Rohandi, R., Sukadi, G., & Kartono, S. (2002*). Educational Reform Is a Recommendation*. Yogyakarta: Kanisius.

Taber, K. S. (2011). Building the Structural Concepts of Chemistry: Some Considerations from Educational Research. *Chemistry Education Research and Practice in Europe*, *2(2)*, 123-158. https://doi.org/10.1039/B1RP90014E

Tosun, C., & Taskesenligil, Y. (2013). The Effectof Problem Based Learning on Undergraduate Student's Learning About Solutions and Their Physical Properties and Scientific Processing Skills. *Chemistry Education: Research and Practice*, (14), 36-50. https://doi.org/10.1039/c2rp20060k.

Vaske, J.J., Beaman, J., & Sponarski, C.C. (2016). Rethinking Internal Consistency in Cronbach's Alpha. *Leisure Sciences*, *39(2)*, 163-173. https://doi.org/10.1080/01490400.2015.1127189

Villafane, S.M., & Lewis, J.E. (2016). Exploring A Measure of Science Attitude for Diferent Groups of Students Enrolled in Introductory College Chemistry. *Chemistry Education Research and Practice*, *4(17)*, 731-742. https://doi.org/10.1039/c5rp00185d.

Wahyudiati, D., Sutrisno, H., & Louise, I.S.Y. (2019a). Self-Eficacay and Attitufes Towards Chemistry Teachers: Gender and Grades Level Perspective. *International Journal of Scientific & Technology Research, 8(9)*, 1041-1044. http://www.ijstr.org.

Wahyudiati, D., Sutrisno, H., & Louise, I.S.Y. (2019b). Investigation of Attitudes Towards Chemistry and Learning Experiences of Pre-Srvice Chemistry Teachers. *MIER Journal of Educational Studies Trends & Practices, 9(2),* 191-211. http://www.mierjs.in/ojs/index.php/mjestp

Wahyudiati, D. (2017). Analisis Efektivitas Kegiatan Praktikum Sebagai Upaya Peningkatan Hasil Belajar Mahasiswa. *Jurnal Tatsqif. 14*(2). 143–168. https://doi.org/10.20414/jtq.v14i2.27

Wahyudiati, D., Rohaeti, E., Irwanto, Wiyarsi, A., & Sumardi, L. (2020). Attitudes toward Chemistry, Self-Efficacy, and Learning Experiences of Pre-Service Chemistry Teachers: Grade Level and Gender Differences. *International Journal of Instruction*, 13(1), 235-254. https://doi.org/10.29333/iji.2020.13116a

Wahyudiati, D. (2021). Investigating Problem Solving Skills and Chemistry Learning Experiences of Higher Education Base on Gender and Grade Level Differences. Journal of Science and Science Education. 2(2). 62-67. https://doi.org/10.29303/jossed.

Yadav, M. K., & Argawal, G. G. (2013). On Estimation of Standard Error of Intra Class Correlation Coefficient in Unbalanced Nested Designs. *Communications in Statistic Theory and Methods, 42*(1), *88-97.* https://doi.org/10.1080/03610926.2011.575513.