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The Effect of Triangulation-Based Metacognitive Learning Strategy on Students' Chemistry Literacy and Learning Achievement

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Abstract

This study aimed to investigate the effect of triangulation-based metacognitive learning strategy on students' chemistry literacy and learning achievement. This study was conducted by using a pretest-posttest control group design. The participants of this research were two classes of 10^{th} grade natural science students of Senior High School in Pasuruan, Indonesia. One class was taught using triangulation-based metacognitive learning strategies consisting of four steps (Preparing, Doing, Checking, and Assessing & Following-Up) abbreviated to MLS-PDCA, and another was taught using expository learning strategy (ELS). Data was collected by pretest and posttest. Based on the data analysis, it was known that the N-gain averages of students' chemistry literacy were 54% in MLS-PDCA class as the middle category and 38% in the ELS class as middle category. N-gain averages of learning achievement were 56% in experiment class as middle category and 40% in ELS as middle category. Mann-Whitney U and independent sample t-test showed that the improvement of students' chemistry literacy and learning achievement in MLS-PDCA class was more significant than in the ELS class. It can be concluded that MLS-PDCA can enhance the students' chemistry literacy and learning achievement in senior high school.

Keywords: chemistry literacy, electrolyte and nonelectrolyte solutions, learning achievement, metacognitive learning strategy, triangulation

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1. Introduction

The 21^{st} century is marked by the development of technology and information that can provide solution and problems in various aspects of global life (Aslamiah et al., 2021). One example of the problems caused is environmental pollution. These problem can be overcome if the society has knowledge of science and technology, which known as a science-literate society (Chen & Osman, 2017). Scientific literacy is the ability to engage as citizens who think about scientific issue's and ideas (OECD, 2016).

The result of research from the Program International Student Assessment (PISA) in 2018 showed that the scientific literacy of Indonesian students was ranked the 69^{th} of 78 country participants. It could be categorized as very low (Schleicher, 2019). In line with the results Sukowati et al. (2017) reported that several senior high school apply the 2013 curriculum showed the average score of scientific literacy ability in each school is less than 50 categorized as low.

The results of interviews with chemistry's teachers at Senior High School in Pasuruan obtained information that students had difficulties when asked to explain scientifically natural phenomena which became an important part of scientific literacy. The school has implemented the 2013 curriculum since

2016, but has not yet fully implemented the scientific approach.

The causes of low literacy were learning that still uses lecture method, the delivery of concept that does not introduce science processes and application, and practicum activities are rarely carried out (Anggraeni & Wardani, 2020), the level of intelligence and student learning methods which are an important part of metacognition (Affandi et al., 2015). Moreover, this problem is also caused by the low abilities of teachers which include: difficulty in integrating science on learning activity, having a low knowledge of learning models that able to integrate of science, and a low motivation in learning integrated science consistently (Rubini et al., 2016). This causes the students required to be able to find the right way of learning in improving the quality of scientific literacy.

The implementation of the 2013 curriculum in Indonesia places chemistry literacy as part of scientific literacy which has several aspects of assessment, consisting of context, knowledge, competence, and attitude (OECD, 2016). Chemistry literacy is closely related to the ability to understand text scientifically as an important part that can help students in providing scientific explanation. According to Dori et al. (2018) context-based learning with high intensity combined with metacognitive clues which are an important part of metacognitive learning can improve scientific understanding of texts. MLS have the potential to improve the quality of chemical literacy. One of the MLS that can be applied is the MLS-PDCA developed by Parlan et al. (2018a) which consists of four phases, which are Preparing, Doing, Checking, and Assessing & Following-Up. This learning strategy realizes meaningful learning by linking new concept with prerequisite knowledge and student-centered (Parlan et al., 2018a).

MLS can be supported by the triangulation method developed by Thomas (2017), which is looking for relationships between chemical representations (macroscopic, sub-microscopic, and symbolic) that can improve the explanation of phenomena at the molecular level (Sunyono & Meristin, 2018; Widarti et al., 2019). Students' misunderstanding and difficulty about submicroscopic representations level can lead to misconceptions (Treagust et al., 2018). One of the concept that caused of misconception is electrolyte and nonelectrolyte solutions which include (1) types of particles that cause electric currents (Lu et al., 2019); (2) concepts of ions, molecules, and the dissociation process of electrolyte solutions (Adadan & Savasci, 2012); and (3) the perception of electric current generates ions (Rahayu & Kita, 2010). The study of the effects of Triangulation-Based Metacognitive Learning Strategies on Students' Chemistry Literacy and Learning Achievement in Electrolyte-Nonelectrolyte Solutions hasn't been conducted.

2. Method

This research used quasi-experimental design with pretest–posttest control group design model (Creswell, 2012). The quasi-research design aims to investigate the differences in students' chemical literacy and achievement between the experimental class (learning with triangulation-based MLS-PDCA) and control class (learning with ELS). The participants of the research were one class (34 students) as an experimental class and another one class (34 students) as a control class. The research design is presented in Table 1.

Table 1. Scheme of Research Design

Group	Pretest	Treatment	Posttest
Experiment	O	X	O
Control	O	C	O

Description:
O : Pretest and posttest
X : Learning using triangulation-based MLS-PDCA
C : Learning using ELS

Learning with ELS is done in four stages, which are Preparation, Presentation, Correlation, and Generalization. In ELS, students are passive receivers of a teacher's explanation (teachers centered). The description of each phase (syntax) in the MLS-PDCA is shown in Table 2. The research instruments used include treatment instruments and measurement instruments. The treatment instruments used included the syllabus, lesson plans for the experimental class and the control class, student worksheets for the experimental class and the independent learning activity unit for the control class. The measurement instrument used in the study consisted of multiple-choice type test questions of chemistry literacy and learning achievement as well as learning implementation observation sheets.

Hypothesis test used here was processed by SPSS 17 with independent sample t-test for parametric analysis and Mann-Whitney U for non-parametric analysis. The improvement of chemistry literacy and learning achievement obtained from pretest to posttest were measured using average normalized-gain score. The formula used is as follow (Hake, 1998).

$$< g > = \frac{\%S_f - \%S_i}{100 - \%(S_f)}$$

The interpretation of the value <g> was given by (Hake, 1998) as follow: low category if <g> < 0.3; medium category if 0.3 ≤ <g> < 0.7; and high category if <g> ≥ 0.7.

Table 2. Student and Teacher's Activity in Triangulation-Based MLS-PDCA

Phase	Teacher's Activity	Student's Activity	Aim
Phase 1: Preparing	Facilitating the students to learn the teaching material and determine the goal of learning, identify the key concepts that will be learned, relevant prior knowledge and concepts that have been understood, make a summary and question list that will be proposed in the face to face	• Reviewing the teaching material • Determining the learning goal • Determining the learning strategy • Arranging the learning schedule • Identifying the significant concepts that wll be learned	Preparing the students to study
Phase 2: Doing	Facilitating the students to actively learn in the class (presentation, discussion, question and answer, and making a note/summary of the lesson)	The students are involved in the learning activity in the class (presentation, discussion, question and answer, proposing questions)	Facilitating the students to construct their understanding through active learning
Phase 3: Checking	• Facilitating the students to check or monitor their learning progress • Facilitating the students to reflect themselves regarding the topic that has been learned • Helping the students to find out the difficulties faced during the learning and the alternative of the problem solving	The students check/monitor whether the planning has been done, assess the learning, check whether the learning method has been used effectively, whether they understand the topic to teach the other friends? What are the obstacles and difficulties that they found in the learning, what should they do to avoid such difficulties in the next learning?	Monitoring the planning, checking the learning method employed, reflecting on the learning process used
Phase 4: Assessing & Following-Up	Facilitating the students to assess their learning progress and evaluate whether their planned learning goal is achieved (if it is not, what should be done then). Orienting the students to plan the next learning activity	The students with their teacher test the understanding of the topic that has been learned. Has the goal of the learning that has been formulated and agreed together been achieved? Should the additional tasks be given to reinforce the understanding? What will be done in the next meeting?	Knowing the achievement of the learning goal, giving the feedback, and following up with the learning outcome

3. Result and Discussion

Triangulation-based metacognitive learning strategy is a metacognitive learning that is developed by connecting triple representation of chemistry (macroscopic, submicroscopic, and symbolic) about context of science that can stimulate student's metacognitive reflection. This research assesses the achievement of scientific literacy in the aspect of context, knowledge, and competence. Meanwhile, the learning achievements of students measured by cognitive question at the C4 (evaluation)-C6 (create) level. The pretest given to students about chemistry literacy and learning knowledge. Then, after learning the students also got posttest about chemistry literacy and learning achievement. Before testing statistics inferentially, a prerequisite test had been carried out, which where testing for normality and homogeneity then proceeded with t-test. The result or normality, homogeneity, and t-test (Mann-Whitney U and independent sample t-test) of chemistry literacy and learning achievement data is presented in Table 3.

Table 3. Normality, Homogeneity, and t-Test of Chemistry Literacy and Learning Achievement

Variable	Class	Normality (Sig)	Homogeneity (Sig)	t-Test (Asymp. Sig)	Description
Students' Chemistry Literacy	Experiment	0.129	0.821	0.001	Mann-Whitney U
	Control	0.030			
Students' Learning Achievement	Pretest	0.062	0.132	0.001	Independent Sample t-Test
	Posttest	0.081			

The result of the normality test of students' chemistry literacy was not normally distributed with value of sig < 0.05 in control class, while the students' learning achievement was normally distributed with value of sig > 0.05. Based on the results of the normality test, the statistical test of students' chemistry literacy data used the non-parametric statistical method of the Mann-Whitney U test, while the student achievement data used the parametric statistical method of the independent sample t-test. According to the Mann-Whitney U and independent sample t-test showed that sig = 0.001, it can be interpretated there was a significant discrepancy of students' chemistry literacy and learning students' learning achievement between experimental and control class.

The improvement of student's chemistry literacy in electrolyte and nonelectrolyte solution topic was calculated by normalized gain (N-gain) formula based on pretest and posttest data. Comparison of student's chemistry literacy from experiment and control class is represented on Figure 1.

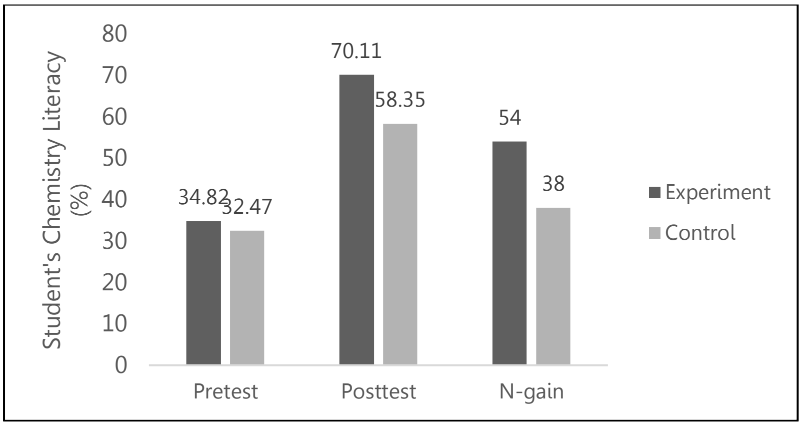

Figure 1. The Comparison of Mean Score Percentage of the Pretest, Posttest, and N-gain in Students' Chemistry Literacy of Experimental Class and Control Class

Figure 1 shows that there is a difference of students' chemistry literacy score average between experimental and control class. Pretest score average at experiment class was higher than control class, it is respectively 34.82% and 32.47%. Posttest score average at experiment class was higher than control class, it is respectively 70.11% and 58.35%. The improvement of pretest and posttest average in each class was represented by N-gain where 54% in experimental class (medium category) and 38% in control class (medium category). It can be interpretated that the improvement student's chemistry literacy of experiment class was better than control class. This result was supported by student's activity during the learning process because in MLS-PDCA based triangulation learning strategy facilitated students to be active in learning activity.

The results of research by Parlan et al. (2018b) inform that MLS can improve scientific explanation abilities, especially on concepts that require in-depth understanding of concepts. The ability to provide scientific explanations is one aspect of competence in chemical literacy which has an important role in helping students to explain scientific phenomena (Shwartz et al., 2006). MLS involve active students in learning so that enable meaningful learning to occur. Metacognitive skills which include planning, monitoring, and evaluating learning are able to help students control understanding, develop critical thinking skills, and find appropriate learning strategies for problem solving (Lavi et al., 2019). MLS are able to train students in improving critical thinking skills so that when given a chemistry literacy test with a high cognitive level students are able to solve these problems well and maximally. The results of this study are supported by Amin et al. (2019) which shows that the higher the students' metacognitive abilities, the higher their critical thinking abilities.

Chemistry literacy on electrolyte and nonelectrolyte topics that were examined in this research consist of context, knowledge, and competency. Context aspect on electrolyte and nonelectrolyte solution is divided into 7 topics of accumulator, water coconut, oralyte, fish electrocution, electrical conductivity's solution, electrical conductivity's experiment, and salt form's experiment. Figure 2 show the improvement of student's achievement context aspect during the learning process. Generally, MLS-PDCA can improve chemistry literacy especially in content aspect. The highest improvement was in "oralyte context" of both group that used MLS-PDCA based triangulation and ELS. Furthermore, knowledge aspect of chemistry literacy consists of content knowledge, epistemic knowledge, and procedural knowledge. The comparison of knowledge aspect in this research can be seen in Figure 3.

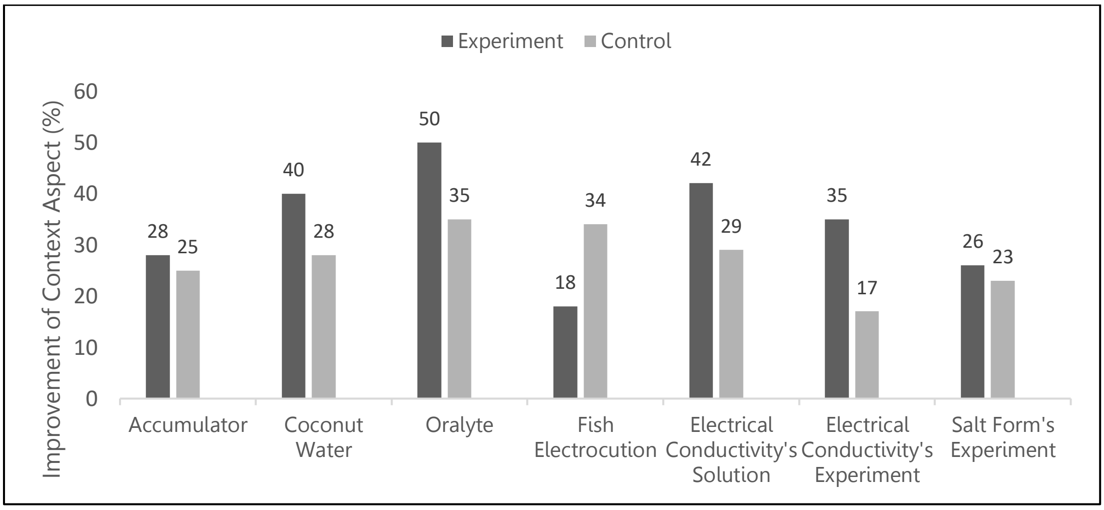

Figure 2. Improvement of Content Aspect after Using Triangulation-Based MLS-PDCA (Experiment) and ELS (Control)

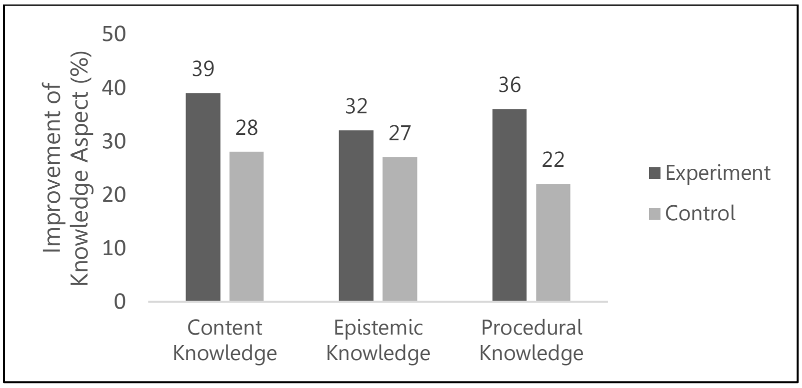

Figure 3. Improvement of Knowledge Aspect between Triangulation-Based MLS-PDCA and ELS

Metacognition has an important role in chemistry learning which requires awareness in interpreting the interrelationships of various levels of chemical phenomena. The process of understanding chemical literacy is closely related to chemical representation. Gkitzia et al. (2019) showed that most students had difficulty in finding the relationship of the chemical triplet representation (macroscopic, submicroscopic, and symbolic) of a chemical phenomenon. The interconnection of chemical representations helps students to construct understanding maximally.

This research also observes competency aspect of chemistry literacy after obtaining learning using triangulation based MLS-PDCA. Competency aspect facilitated students to solve the problem using their knowledge. Competency aspect's indicator according to PISA 2015 divided into three parts; explaining phenomena scientifically, interpretating data and evidence scientifically, designing and evaluating scientific investigation. The improvement of student's competency aspect after using triangulation-based MLS-PDCA and ELS can be seen in Figure 4.

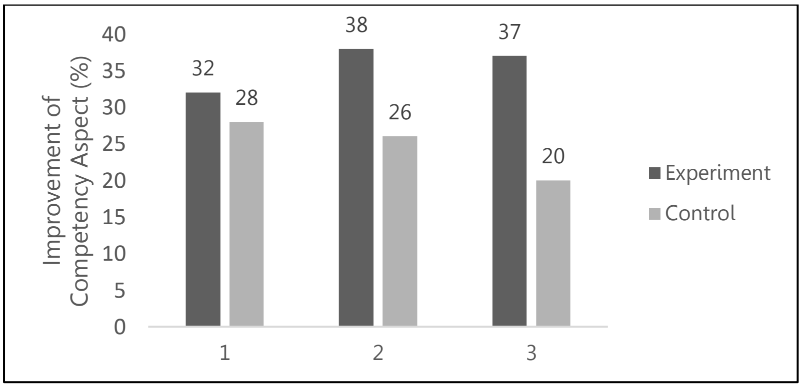

Figure 4. Improvement of Competency Aspect between Triangulation-Based MLS-PDCA and ELS 1). Explaining Phenomena Scientifically; 2). Interpretating Data and Evidence Scientifically; 3). Designing and Evaluating Scientific Investigation)

Figure 4 shows that student's competency aspect overall showed encouraging results. This result informed that the indicator "explaining phenomena scientifically" improved 32% for triangulation-based MLS-PDCA and 28% for ELS. Then the indicator of "interpretating data and evidence scientifically" improved 38% for triangulation-based MLS-PDCA and 26% for ELS. Beside of that, the indicator "designing and evaluating scientific investigation" improved 37% for triangulation-based MLS-PDCA and 20% for ELS. The improvement in competency aspect is caused by MLS that used in the learning process. The triangulation method used in the study is very effective in understanding the interconnection of chemical representations, making it easier for students to provide accurate scientific explanations related to scientific phenomena (Thomas, 2017). This is in line with Treagust et al. (2003) research which informed that understanding submicroscopic and symbolic representations can help scientific explanation abilities. The practicum carried out in learning contributes to helping improve students' chemical literacy through scientific investigation activities which include experimental design and verification of hypotheses and variables as an important part of the aspect of chemical literacy competence. This statement is supported by Genc (2015) findings which inform that learning through scientific inquiry encourages students to develop skills through discussion and exchange of information so that it has an impact on increasing literacy and attitudes towards science.

The triangulation-based MLS-PDCA directs students to be active in learning activities and organize learning strategies effectively in constructing conceptual, procedural, and metacognitive understandings that are strengthened by the interconnection of triplet representations that can stimulate metacognitive reflection. The triangulation-based MLS-PDCA is supported using a context approach by connecting learning materials with science-related phenomena in life which are important characters that must be mastered in an effort to improve the quality of chemical literacy. This is supported by research by Cigdemoglu and Geban (2015) which shows that context-based learning can effectively improve students' chemical literacy. The learning process in the triangulation-based SM-PDCA class is also supported by worksheet which is compiled based on MLS and contains discourses on science problems in life which is equipped with triplet representations so that it is easier and arouses student motivation in learning. This is in accordance with the results of research by Upahi and Ramnarain (2019) which informed that in an effort to improve students' understanding of chemical concepts, it is necessary to integrate various chemical representations through the learning process and the learning resources used. In addition, teaching materials that are oriented towards a balanced scientific literacy context can also help in improving chemical literacy (Sastri et al., 2020). In the ELS class, UKBM (self-study activity unit) is facilitated to support the learning process. The UKBM used emphasizes a scientific approach that can build chemical literacy skills in the aspects of knowledge and competence. But the learning does not involve students in learning activities so that it is considered less effective in improving chemical literacy. Therefore, the chemistry literacy obtained by ELS class is lower than the triangulation-based MLS-PDCA. This research not only investigate how triangulation-base MLS-PDCA influences the students' chemistry literacy but also investigate how it affect the learning achievement. The comparison of the mean score percentage of pretest, posttest, and N-gain of student's learning achievement between experiment and control group is shown in the Figure 5.

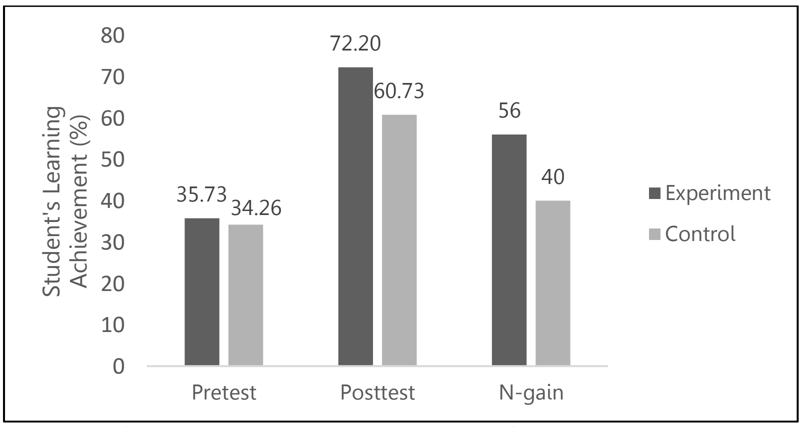

Figure 5. The Comparison of The Mean Score Percentage of the Pretest, Posttest, and N-gain Between Experiment and Control Group

According to the pretest and posttest data on Figure 5, it is shown that the students' learning achievement from experiment group is rising 36.47% and the control group is rising 26.47%. It shows that the alteration on student's learning achievement is happened after applying triangulation-based MLS-PDCA. Furthermore, N-gain mean score on both group experiment and control group respectively 56% and 40 % are categorized into medium category, but the experiment group is higher than the control group. This result is caused by the students' activity in the classroom during the learning.In experiment class students directed to be active in the learning activity. The research of Jayapraba (2013) inform that metacognitive instruction in learning can improve student's achievement. MLS is a student centered learning strategy, so it can make students more active to construct the understanding in meaningful learning (Cook et al., 2013). Triangulation-based MLS-PDCA is able to direct students in exploring the formulation of learning objectives, prerequisite concepts, concepts that are not yet understood, and concept that have been understood which are carried out at the "Prepare" phase, so the students can be responsible independently in the learning context related to the material being studied (Parlan et al., 2018a).

Cognitive knowledge constructed by students can be predicted through lesson planning and identification of prerequisite knowledge (Kallio et al., 2018). Important information found in the study shows that the prerequisite knowledge mastered by students can be a benchmark for the success of understanding the concept of material at a further level. Because of that, support and motivation must be given by teacher to students as an effort to increase metacognitive awareness. Students who have quality of prerequisite knowledge are easier to understand new concepts because chemistry is interconnected. Cognitive understanding and knowledge built by students are also supported through group discussion, question and answer activities, and practicum conducted at "Doing" phase (Parlan et al., 2018a).

Triangulation-based MLS-PDCA strongly support teachers and students in verifying concepts, monitoring, and evaluating the level of understanding mastered (Hammond et al., 2014). Concept verification and evaluation of the level of understanding carried out at the "Checking" phase can be parameters for the development of understanding constructed by students. Self-assessment of learning can improve student's metacognitive abilities. Self-assessment is able to generate student's metacognition to evaluate the efficiency of the applied learning method and the expected achievement targets (Young & Fry, 2008). Students who have high metacognitive abilities will have a better way of learning when compared to students who have low metacognitive abilities.

"Assessing & Following-Up" phase at triangulation-based MLS-PDCA facilitates students to conduct self-evaluation related to the level of understanding and mastery of concepts. The existence of self-assessment at this stage can motivate students to improve progress in future learning to be more leverage. Triangulation-based MLS-PDCA can train students to increase declarative, procedural, and conditional knowledge as the part of metacognitive knowledge in problem solving, so it has a positive impact on improving learning achievement. This information is supported by Bahri and Corebima (2017) who shows metacognitive knowledge has a greater role when compared to learning motivation. In addition, the students with a low level of chemistry skills in solving a problem did not use metacognitive skill of monitoring and evaluating (Ijirana & Supriadi, 2018). This fact can cause students to fail in solving problems of chemistry.

The MLS used in learning is supported by the triangulation method, so it can make students accustomed to study chemistry concept using chemical representations which are considered effective in understanding abstract chemistry. The use of chemical representation in learning also plays a role in assisting students in constructing deep conceptual understanding and increasing motivation in learning. This is directly proportional to the results of the research shows that involving chemical representations can increase the relevance of the concept to scientific phenomena in life, foster curiosity and learning motivation, and increase deep conceptual understanding (Baptista et al., 2019). Therefore, MLS-PDCA based triangulation has better performance than ELS.

4. Conclusion

Based on the results and discussion, it can be concluded that the implementation of triangulation-based MLS-PDCA increases the student's chemistry literacy and learning achievement. Triangulation-based MLS-PDCA facilitates students to learn meaningfully through activity to prepare for learning, planning learning strategies, being active in learning, and evaluating learning process that supported by connecting three types of chemical representation (macroscopic, submicroscopic, and symbolic) to understand chemical phenomena in daily life.

References

Adadan, E., & Savasci, F. (2012). An analysis of 16-17-year-old students' understanding of solution chemistry concepts using a two-tier diagnostic instrument. *International Journal of Science Education*, *34*(4), 513–544. https://doi.org/10.1080/09500693.2011.636084

Affandi, Y., Abdurrahman, A., & Suana, W. (2015). Pengaruh self regulated learning siswa terhadap literasi sains melalui pembelajaran inkuiri terbimbing. *Jurnal Pembelajaran Fisika Universitas Lampung*, *3*(2), 120535. Retrieved from http://jurnal.fkip.unila.ac.id/index.php/JPF/article/view/8469

Amin, A., Corebima, A. D., Zubaidah, S., & Mahanall, S. (2019). The correlation between metacognitive skills and critical thinking skills at the implementation of four different learning strategies in Animal Physiology lectures. *European Journal of Educational Research, 9*(1), 143–163. https://doi.org/10.12973/eu-jer.9.1.143

Anggraeni, A. Y., & Wardani, S. (2020). Profil peningkatan kemampuan literasi kimia siswa melalui pembelajaran inkuiri terbimbing berbasis kontekstual. *Jurnal Inovasi Pendidikan Kimia*, *14*(1), 2512–2523. Retrieved from https://journal.unnes.ac.id/nju/index.php/JIPK/article/view/18979

Aslamiah, A., Abbas, E. W., & Mutiani, M. (2021). 21st-century skills and social studies education. *The Innovation of Social Studies Journal*, *2*(2), 82. https://doi.org/10.20527/iis.v2i2.3066

Bahri, A., & Corebima, A. D. (2015). The contribution of learning motivation and metacognitive skill on cognitive learning outcome of students within different learning strategies. *Journal of Baltic Science Education*, *14*(4), 487-500. Retrieved from http://eprints.unm.ac.id/11457/

Baptista, M., Martins, I., Conceição, T., & Reis, P. (2019). Multiple representations in the development of students' cognitive structures about the saponification reaction. *Chemistry Education Research and Practice*, *20*(4), 760-771. https://doi.org/10.1039/C9RP00018F

Chen, C. W., & Osman, C. (2017). Cultivating marginalized children's scientific literacy in facing the challenges of the 21st century. *K-12 STEM Education*, *3*(1), 157–167. Retrieved from https://www.learntechlib.org/p/209550/

Cigdemoglu, C., & Geban, O. (2015). Improving students' chemical literacy levels on thermochemical and thermodynamics concepts through a context-based approach. *Chemistry Education Research and Practice*, *16*(2), 302-317. https://doi.org/10.1039/C5RP00007F

Cook, E., Kennedy, E., & McGuire, S. Y. (2013). Effect of teaching metacognitive learning strategies on performance in general chemistry courses. *Journal of Chemical Education*, *90*(8), 961–967. https://doi.org/10.1021/ed300686h

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Boston: Pearson.

Dori, Y. J., Avargil, S., Kohen, Z., & Saar, L. (2018). Context-based learning and metacognitive prompts for enhancing scientific text comprehension. *International Journal of Science Education*, *40*(10), 1198–1220. https://doi.org/10.1080/09500693.2018.1470351

Genc, M. (2015). The effect of scientific studies on students' scientific literacy and attitude. *Ondokuz Mayis University Journal of Education Faculty*, *34*(1), 141-152. Retrieved from https://dergipark.org.tr/en/pub/omuefd/issue/20280/215035

Gkitzia, V., Salta, K., & Tzougraki, C. (2020). Students' competence in translating between different types of chemical representations. *Chemistry Education Research and Practice*, *21*(1), 307-330. https://doi.org/10.1039/C8RP00301G

Hake, R. R. (1998). Interactive-engagement versus traditional methods. *American Journal of Physics*, *66*, 64–74. https://doi.org/10.1119/1.18809

Hammond, L. D., Austin, K., Cheung, M., & Martin, D. (2014). *Session 9: Thinking about thinking: Metacognition*. Stanford University School of Education.

Ijirana, & Supriadi. (2018). Metacognitive skill profiles of chemistry education students in solving problem at low ability level. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 239–245. https://doi.org/10.15294/jpii.v7i2.14266

Jayapraba, A. P. D. G. (2013). Metacognitive instruction and cooperative learning-strategies for promoting insighful learning in science. *International Journal on New Trends in Education and Their Implications*, *4*(1), 165-172. Retrieved from http://www.ijonte.org/FileUpload/ks63207/File/15.jayapraba.pdf

Kallio, H., Virta, K., & Kallio, M. (2018). Modelling the components of metacognitive awareness. *International Journal of Educational Psychology*, *7*(2), 94-122. https://doi.org/10.17583/ijep.2018.2789

Lavi, R., Shwartz, G., & Judy, Y. (2019). *Metacognition in chemistry education: A literature review*. 583–597. https://doi.org/10.1002/ijch.201800087

Lu, S., Bi, H., & Liu, X. (2019). A phenomenographic study of 10th grade students' understanding of electrolytes. *Chemistry Education Research and Practice*, *20*(1), 204–212. https://doi.org/10.1039/C8RP00125A

OECD. (2016). *PISA 2015 results (Volume I): Excellence and equity in education*. Paris: OECD Publishing.

Parlan, Ibnu, S., Rahayu, S., & Suharti. (2018a). The improvement of metacognition of chemistry education students using metacognitive learning strategy. *Social Science, Education and Humanities Research*, *218*, 269–278. https://doi.org/10.2991/icomse-17.2018.46

Parlan, P., Ibnu, S., Rahayu, S., & Suharti, S. (2018b). Effects of the metacognitive learning strategy on the quality of prospective chemistry teacher's scientific explanations. *International Journal of Instruction*, *11*(4), 673–688. Retrieved from https://eric.ed.gov/?id=EJ1191723

Rahayu, S., & Kita, M. (2010). An Analysis of Indonesian and Japanese students' understandings of macroscopic and submicroscopic levels of representing matter and its changes. *International Journal of Science and Mathematics Education*, *8*(4), 667–688. https://doi.org/10.1007/s10763-009-9180-0

Rubini, B., Ardianto, D., Pursitasari, I. D., & Permana, I. (2016). Identify scientific literacy from the science teachers' perspective. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 299–303. Retrieved from https://journal.unnes.ac.id/nju/index.php/jpii/article/view/7689

Sastri, Y., Suryawati, E., & Hatta, M. (2020). The Use of Flip Chart as a tool to strengthen scientific literacy at junior high school student. *In Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning, 17*(1), 91-97, Surakarta: Universitas Sebelas Maret. Retrieved fromhttps://jurnal.uns.ac.id/prosbi/article/view/54045

Schleicher, A. (2019). *PISA 2018: Insights and interpretations*. Paris: OECD Publishing.

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). Chemical literacy: What does this mean to scientists and school teachers? *Journal of Chemical Education*, *83*(10), 1557–1561. https://doi.org/10.1021/ed083p1557

Sukowati, D., Rusilowati, A., & Sugianto. (2017). Analisis kemampuan literasi sains dan metakogntif peserta didik. *Physics Communication*, *1*(1), 16–22. Retrieved from https://journal.unnes.ac.id/nju/index.php/pc/article/view/8961/0

Sunyono, S., & Meristin, A. (2018). The effect of multiple representation-based learning (MRL) to increase students' understanding of chemical bonding concepts. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 399–406. https://doi.org/10.15294/jpii.v7i4.16219

Thomas, G. P. (2017). "Triangulation:" an expression for stimulating metacognitive reflection regarding the use of "triplet" representations for chemistry learning. *Chemistry Education Research and Practice*, *18*(4), 533–548. https://doi.org/10.1039/C6RP00227G

Treagust, D., Chittleborough, G., & Mamiala, T. (2003). The role of submicroscopic and symbolic representations in chemical explanations. *International journal of science education, 25*(11), 1353-1368. https://doi.org/10.1080/0950069032000070306

Treagust, D., Nieswandt, M., & Duit, R. (2018). Sources of students difficulties in learning chemistry. *Educación Química*, *11*(2), 228. http://doi.org/10.22201/fq.18708404e.2000.2.66458

Upahi, J. E., & Ramnarain, U. (2019). Representations of chemical phenomena in secondary school chemistry textbooks. *Chemistry Education Research and Practice*, *20*(1), 146-159. https://doi.org/10.1039/C8RP00191J

Widarti, H. R., Marfu'ah, S., & Parlan. (2019). The effects of using multiple representations on prospective teachers' conceptual understanding of intermolecular forces. *Journal of Physics: Conference Series*, *1227*(1). https://doi.org/10.1088/1742-6596/1227/1/012006

Young, A., & Fry, J. D. (2008). Metacognitive awareness and academic achievement in college students. *Journal of the Scholarship of Teaching and Learning*, *8*(2), 1-10. Retrieved from https://eric.ed.gov/?id=EJ854832