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The role of multiple-representation-based ‘real’ learning model in the development of students’ metacognitive and problem-solving abilities

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Abstract. This study aims to determine the effect of learning REAL (Reconizing, Explaining, Applying, Looking back) based on multiple representations to build metacognition and problem solving skills in physics education students. The design of this research is the static group pretest-posttest. The total sample of the study was 114 people spread over 2 state universities in Lampung Province, Indonesia, each consisting of an experimental group (n=57) and a control group (n=57). The collected data were both descriptively and inferentially analyzed. A descriptive analysis was performed by grouping and interpreting data into three categories, while an independent samples t-test was used to perform an inferential analysis. The results revealed that there is a significant N-gain difference in metacognition and problem solving abilities between the experimental and control groups. The REAL learning model with multiple representations plays an important role in developing students’ metacognition and problem-solving abilities. The majority of them state that they are delighted and find it easier to understand basic concepts of electricity and magnetism learning materials. Similarly, metacognitive ability plays an important role in developing students’ physics problem solving skills, as evidenced by regression test results of $r = 0.71$.

Keywords. real learning model, multiple-representation, metacognition, problem solving

Introduction

In recent years, researchers have become increasingly interested in investigating physics learning. Physics is synonymous with problems to be solved. In order to reveal various events and natural phenomena, physics problem solving necessitates the use of mathematics as a language. Meanwhile, knowledge of mathematics and physics directly contributes to metacognitive awareness (Pantiwati & Husamah, 2017). Aside from difficulties in using mathematics in problem solving, students also encounter difficulties in problem solving involving figures and graphics (Sujarwanto et al., 2014). However, lecturers almost never pay attention to students’ metacognitive and problem-solving abilities in physics classes. Meanwhile, some research findings indicate a positive relationship between metacognitive ability and student learning success. Most of the time, lecturers do not use a model or strategy

that can help students develop their ability to think about thinking. They only teach using a presentation model and a brief explanation without involving their students in the learning process (conventional learning). This traditional learning causes students to struggle with problem solving, particularly in abstract and complex learning materials.

It is mainstream in the literature that physics learning necessitates that students master metacognitive knowledge in order to solve abstract and complex problems. Metacognition knowledge enables them to investigate declarative, procedural, and conditional knowledge; to plan and predict; and to monitor and evaluate each learning activity completed. According to Nool (2012), most students use a less precise strategy to improve their metacognitive ability. In problem solving, students are using fewer systematic approaches and efficient strategies such as reasoning and verbal representation. Students also fail to monitor and evaluate some of the problems on which they have worked. Therefore, efforts should ideally be made to improve their metacognitive ability in each learning, so that they can recognize their own abilities in terms of what they do and do not know (Costa, 1984). Given the importance of metacognitive ability in learning, the Indonesian government issued a Government Regulation No. 32 of 2013 concerning the National Standard of Education, which was implemented in Curriculum 2013, requiring all education providers, beginning at the high school level, to incorporate metacognition knowledge into each learning experience.

Metacognition is concerned with the awareness and control of one's own thought process as well as self-regulation in the areas of behavior, motivation, and cognition (Dinsmore et al., 2008). Metacognition is made up of two parts: knowledge and regulation. Gok (2010) suggests that the parts of metacognition that students need in problem solving include planning, monitoring, and evaluation, and that metacognitive skill plays a significant role in problem solving. Sengul & Katranci (2015; Yildirim & Ersozlu (2013) found that metacognitive awareness and problem solving ability influence each other. According to Sengul & Katranci (2015), a special strategy and a mental process are two crucial components in problem solving development. Moreover, Segedy et al. (2015) suggested that self-regulated learning (SRL) is a type of active learning in which a student sets a goal, creates a plan, and monitors his or her progress. The stages of orientation, implementation, and reflection are all SRL aspects in learning (Segedy et al., 2015).

It is widely accepted that effective problem solving invites students to actively explain, classify, interpret, make definitions, and solve problems using logic, critical and creative thinking (Crebert et al., 2011), with students going through the following stages: 1) construct a model, 2) analyze the problem, 3) interpret or validate (Savage & Williams, 1990). However, control functions such as information management strategy, planning, and procedural knowledge; and monitoring functions such as declarative knowledge, evaluation, and comprehensive monitoring are required for comprehensive problem solving (Makos & Katoussi, 2013).

The ability to solve problems is mainly reliant on reasoning and verbal representation skills (Nool, 2012). Data that have been presented in the literature suggest that adopting multiple representations allows students to solve problems more effectively (Madden et al., 2011; Nguyen & Rebello, 2011). This is due to the fact that using multiple representations in physics learning allows students to explain, describe, manipulate, and predict the difficulty level of a problem they are confronted with (Kang & Noh, 2012). However, the question if multiple representations significantly help students with their physics learning remains open. In other words, this question is presently inconclusive. Therefore, in the current study, we adopted a multiple-representation-based REAL learning model, consisting of the following four phases:

recognizing, explaining, applying, and looking back (Distrik et al., 2018).

The first phase is for lecturers to introduce the target concept and its characteristics. Students recognize the target concept by comparing it to analogous concepts. An analog concept is one that is closely related to a target concept but is difficult for students to grasp. Analogies can help students not only understand concepts more deeply, but also overcome misconceptions and limitations in their knowledge of the target concepts (Al-Hinai & Al-Balushi, 2015). Using analogies in learning can help students improve their conceptual understanding and metacognitive awareness (Coll et al., 2005). In the second phase, students use observations and experiments to try to explain the concept they have already recognized verbally, visually, and symbolically. Explaining a concept using appropriate representations can help in overcoming cognitive limitations (Ainsworth, 2006) that it can improve cognition-related thinking skills some students may struggle to understand verbal explanations. Therefore, other representations such as visual, numerical, and symbolical representations are extremely important for them to understand concepts in various forms. The following phase is to apply the concept by following problem-solving examples. Students are given some problems to solve that are related to the concept they have learned. They are required to identify problems by writing down components that they already have and are unaware of (Savage & Williams, 1990), describing the position of an object and other components, writing corresponding formulas, selecting corresponding examples, and solving problems by following problem-solving examples. When it comes to problem solving of electricity and magnetism learning materials in basic physics courses, most students may struggle to apply concepts, principles, and formulas (Nguyen & Rebello, 2011). This is due to the fact that electricity and magnetism learning materials are abstract, complex, and involve complex mathematics. As a result, scaffolding in the form of problem solving examples with similar principles is required to assist students in problem solving (Muldner & Conati, 2010). The final phase is to look back or reflect on and self-assess the outcomes of all learning activities. Reflection is an important learning success factor for teachers (Yaacob et al., 2014). Reflection also indicates the ability to connect theory and practice, allowing students to improve their metacognitive abilities through activities such as questioning what they already know and what they do not know (Costa, 1984), to improve question responding and to evaluate their understanding of assignments (Segedy et al., 2015).

Method

Research Design

This study employed a static group pretest-posttest design (Figure 1) and was conducted in the even semester of the 2019-2020 academic year at two universities: the University of Lampung and Universitas Islam Negeri Radin Intan, Lampung Indonesia. A total of 114 first-year physics education students who had enrolled in Basic Physics course took part in the current study. They were split into two groups: experimental (n=57) and control (n=57). The experimental group was taught using a multiple-representation-based REAL learning model, while the control using a representation and brief explanation.

0	X ₁	0 & R
0	X ₂	0

0 = Pretest-Posttest, X₁ = multiple-representation-based REAL learning model
X₂ = representation and brief explanation, R = Perception questionnaire

Figure 1. Research Design

Data Collection

The metacognitive ability test was based on Desoete et al.'s (2001) version, which was modified to include electricity and magnetism learning materials. There were seven indicators in the metacognitive ability test: declarative, procedural, conditional, prediction, planning, monitoring, and evaluation indicators. The test consisted of 21 items divided into seven items for each subject: electrostatics, electrodynamics, and magnets. The ability tests for metacognition were in the form of brief explanations, multiple choice questions, and essays. The problem-solving test comprised of 15 problems covering all aspects of electricity and magnetism. Before being employed in research, metacognitive and problem-solving ability tests were evaluated for validity and reliability, and the results were found to be valid and reliable. Both the experimental and control groups were given tests before and after treatments. The experimental group was given a questionnaire at the end of the lecture to express their opinions on the difficulty and ease of grasping ideas and solving physics problems of electricity and magnetism in Basic Physics course.

Data Analysis

The data of the metacognitive and problem-solving ability tests were both descriptively and inferentially examined. The descriptive analysis was performed by grouping and interpreting data into three categories: high, medium, and low. A statistical test was used to perform an inferential analysis. The increase in metacognitive and problem-solving abilities was measured using the N-gain ($\langle g \rangle$) score, which was determined using the formula below.

$$\langle g \rangle = \frac{\% \text{ of posttest score} - \% \text{ of pretest score}}{100 - \% \text{ of pretest score}} \times 100 \quad (\text{Hake, 2002})$$

If $\langle g \rangle$ was more than ($>$) 70, the average N-gain score was categorized high; moderate if $\langle g \rangle$ was less than or equal to (\leq) 70; and low if $\langle g \rangle$ was less than or equal to (\leq) 30. Finally, a linier regression test was used to examine the correlations between variables.

Results

A pretest was used to measure the initial ability and differences in metacognitive and problem solving abilities between the experimental and control groups before learning began in both groups. The independent samples t-test resulted in a $p < 0.05$ (Table 2), indicating that there is no significant difference between the two groups' metacognitive and problem-solving abilities.

Table 2. The results of the Independent samples t-test of metacognitive and problem-solving abilities on the pre-test

Pretest type		Group	Descriptive Statistics			Independent samples t-test		
nx	s	t	df	p				
Metacognitive ability		Exp.	57	41.67	4.67	-1.121	55	0.265
		Control	57	42.61	4.19			
Problem solving ability		Exp.	57	26.04	2.99	-0.543	55	0.588
		Control	57	26.32	2.51			

* $p > 0.05$

Metacognitive ability

The results of pre-test, post-test, and N-gain of metacognitive abilities between the experimental and control groups are presented in Figure 2 below.

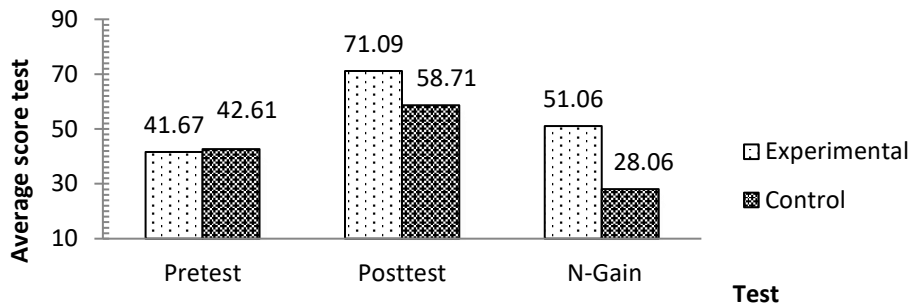


Figure 2. Averages of pretest, posttest, and n-gain of metacognitive abilities

There is a difference n-gain of metacognitive ability between the experimental group and the control (Table 3).

Table 3. Independent samples t-test results of metacognitive ability between the experimental and control groups

Group	Descriptive Statistics			Independent samples t-test		
	N	N-gain	s	T	df	P
Experimental	57	51.06	7.46	11.027	112	0.000*
Control	57	28.06	5.11			

*p < 0.05

Problem Solving Ability

The pre-test, post-test, and N-gain results of problem solving abilities of experimental and control groups are presented in Figure 3 below.

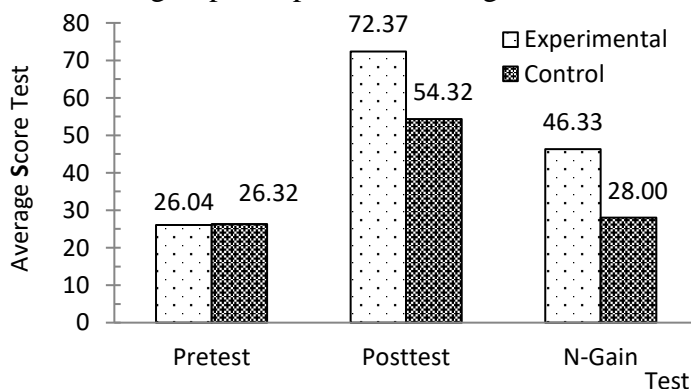


Figure 3. The averages score of pre-test, post-test, and N-gain of problem solving abilities

The results of the analysis revealed that there is a significant difference in n-gain of problem solving abilities between the experimental and control groups, as determined by the independent samples t-test (Table 4).

Table 4. N-gain results of independent samples t-test of problem solving abilities between experimental and control groups

Group	Descriptive Statistics			Independent samples t-test		
	n	n-gain	S	T	Df	P
Experimental	57	46.33	8.18	12.986	112	0.000*
Control	57	28.00	6.83			

* $p < 0.05$

We also used a correlational test to see if there was a correlation between metacognitive and problem-solving abilities in this study. The result showed a positive correlation between metacognitive and problem-solving abilities, with a p value < 0.05 . The regression test resulted in $r = 0.71$ and $r^2 = 0.504$.

Perception towards the Usefulness of Model

Table 5 below shows student responses to the multiple-representation-based REAL learning model.

Table 5. Student response toward multiple-representation-based REAL learning model

Response	% students
Happy	87.43
Easier	84.65
Unhappy	6.02

In Table 5 above, it is apparent that more than 80 percent of students favor the multiple-representation-based REAL learning model. Most of them enjoy learning physics concepts and find it easier to grasp.

Discussion

According to the statistical test results (Table 2), both groups have the same initial ability in metacognition and problem solving. This means that both the experimental and control groups began with the same metacognitive knowledge and problem-solving abilities. Following a 12-week period in which both groups received electricity and magnetism learning materials, post-tests were administered to assess their metacognitive and problem-solving abilities. The average metacognitive ability score for the experimental group is 71.09, with N-gain of 51.6 percent, while the control group is 58.71, with N-gain of 28.06 percent (Figure 2). Both learning models, the multiple-representation-based REAL learning model and the presentation one, have positive effects on cognitive ability, but the improvement in metacognitive ability in the experimental group is significantly different from that in the control group (Table 3)

When compared to the presentation and brief explanation models utilized by lecturers so far, learning with the multiple-representation-based REAL learning model plays an essential role in developing metacognitive abilities. The findings of this study support Sunyono et al.'s (2015) findings that a multiple-representation-based 'SiMaYang' learning model can help students develop a mentality model. This agrees with Distrik et al. (2021), who claim that a REAL learning model based on multiple representations is useful in improving students' concept understanding. The first phase, recognizing the target concept using previously acquired knowledge, is a metacognitive strategy (Segedy et al., 2015).

In multiple representations, the REAL (Recognizing, Explaining, Applying, and Looking Back) phases can motivate students (Table 5), allowing them to grasp and recognize the target concept by applying knowledge they already have. A metacognitive learning model is a learning paradigm that may motivate, provide opportunities, and recognize information (Ngozi, 2009). The metacognitive ability improvement in multiple-representation based learning through the use of REAL phases allows for the recognition of target concepts through analogies. According to Coll et al. (2005), using analogy in learning can help students improve their metacognitive awareness and abilities. In order to solve problems, students must plan, monitor, and evaluate their progress (Makos & Katoussi, 2013). Reflection and self-assessment are also used to improve metacognitive abilities (Phase 4). The technique of self-questioning can stimulate thinking and contribute to the development of metacognitive abilities. This is in line with Özsoy & Ataman's (2009) finding that self-questioning technique can be used to develop metacognitive abilities.

This study also examines both groups' problem-solving abilities. The average post-test score for the experimental group is 72.37, while that of the control is 54.32. (Figure 3). The experimental group's N-gain score is 46.33 percent, while that of the control is 28.00 percent. Both learning models are capable of significantly improving problem solving abilities in electricity and magnetism learning materials, but the experimental group improvement is more effective compared to the control group (Table 4). Airey & Linder (2009; Güler & Ciltas (2011; Hwang et al. (2007) also found that multiple-representations play an important role in problem solving abilities. This is also consistent with Distrik et al.'s (2021) finding that multiple representations play an important role in improving problem solving abilities. The improvement in student physics problem solving ability is due to their metacognitive ability, which falls into the moderate N-gain category. Patonah (2014) found that metacognitive ability causes students to think about planning up to problem solving, and that students with good problem solving abilities improve their metacognitive abilities (Herlanti et al., 2017).

Multiple-representation-based REAL learning model allows students to explain target concepts using verbal, pictorial, and formula representations (Phase 2). Students are guided to apply concepts to solve problems in Phase 3. Scaffoldings for problem solving are provided to students in the form of problem solving examples that are similar to the problems to be solved. According to Gentner et al. (2003), problem solving examples with similar structures can help develop problem solving skills. The third learning phase employs a problem solving strategy developed by Savage & Williams (1990), which begins by presenting models verbally and graphically; analyzing problems, in which students elaborate or describe basic problems that they already have and have not known; and determining formulas to use in problem solving. In the final phase, students verify or validate the obtained results in order to correlate them with the real world. The Savage and Williams's problem solving model is excellent for physics problems with complex mathematical elements. In the fourth phase, students do reflection and self-assessment toward self-ability. Students evaluate themselves in this phase, recognizing their own limitations in explaining concepts and problem solving.

Another finding is a positive correlation between metacognitive and problem solving abilities ($p < 0.05$; $r^2 = 0.504$), meaning that 50.40% of problem solving ability can be explained by metacognitive ability. Students with strong metacognitive abilities are more likely to solve problems successfully. This supports Gok's (2010); Makos & Katoussi's (2013); Sengul & Katranci's (2015) findings, suggesting that metacognitive ability is crucial in problem solving. The positive correlation between metacognitive and problem solving abilities is consistent with what was found by Yildirim & Ersozlu (2013), claiming that metacognitive abilities influence

problem solving abilities.

Students respond positively to the REAL learning model based on multiple representations (Table 5). The majority of them (87.43 percent) say that learning with REAL phases is more enjoyable, and 84.65 percent say that abstract concepts are easier to grasp. Students are more comfortable learning with the REAL model since they may express their thoughts individually, discuss in groups, and access knowledge from the Internet sources. This supports Hwang et al.'s (2007) finding that students enjoy using multiple representations (analogies) and find it simple to apply in problem solving, which is also in line with Hasni & Kadir's (2014) finding that using analogies helps most students understand scientific concepts.

Conclusion

The model with the phases of recognizing, explaining, applying, and looking back plays an important role in developing students' metacognitive and problem solving skills in electricity and magnetism in basic physics courses. The experimental group's average n-gain of metacognitive ability is 0.51, falling into the medium n-gain category, while the control group's is 0.28, falling into the low n-gain category. The experimental group's average n-gain for problem-solving ability is 0.46, which is in the medium range, whereas the control group's is 0.28, which is in the low range. Between the experimental and control groups, there is a significant difference in the n-gain between metacognitive and problem-solving abilities ($P < 0.05$). The $r^2 = 0.504$ indicates a correlation between metacognitive and problem solving abilities suggesting that metacognitive ability accounts for 50.40 percent of problem solving ability, whereas other factors account for 59.60 percent. In addition, students respond positively to the multiple-representation-based REAL learning model.

Recommendations

However, this study is not without its limitations. This study was only conducted at the university level in the basics of electricity and magnetism learning materials. Therefore, we suggest additional research with other physics abstract learning materials at lower educational levels.

References

- [1] Pantiwati, Y., & Husamah. (2017). Self and peer assessments in active learning model to increase metacognitive awareness and cognitive abilities. *International Journal of Instruction*, 10(4), 185–202.
- [2] Sujarwanto, E., Hidayat, A., & W. (2014). Kemampuan pemecahan masalah Fisika pada modeling instruction pada siswa SMA kelas xi (Physics problem solving ability in modeling instruction in class xi of high school students). *Jurnal Pendidikan IPA Indonesia*, 3(1), 65–78.
- [3] Nool, N. R. (2012). Exploring the metacognitive processes of prospective Mathematics teachers during problem solving. *2012 International Conference on Education and Management Innovation*, 30, 302–306.
- [4] Costa, A. L. (1984). Mediating the metacognitive. *Educational Leadership*, 42, 57–62.
- [5] Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2008). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review*, 20(4), 391–409. <https://doi.org/10.1007/s10648-008-9083-6>
- [6] Gok, T. (2010). The general assessment of problem solving processes and metacognition in physics education. *Eurasian Journal of Physics and Chemistry Education*, 2(2), 110–122.

- [7] Sengul, S., & Katranci, Y. (2015). Meta-cognitive aspects of solving indefinite integral problems. *Procedia - Social and Behavioral Sciences*, 197(February), 622–629. <https://doi.org/10.1016/j.sbspro.2015.07.205>
- [8] Yildirim, S., & Ersozlu, Z. N. (2013). The relationship between students' metacognitive awareness and their solutions to similar types of Mathematic problems. *Eurasia Journal of Mathematics, Science & Technology Education*, 9(4), 411–415. <https://doi.org/10.12973/eurasia.2013.946a>
- [9] Segedy, J. R., Kinnebrew, J. S., Goldberg, B. S., Sottolare, R. A., & Biswas, G. (2015). Designing representation and support for metacognition in the generalized intelligent framework for tutoring. In D. . Schmorow & C. . Fidopiastis (Eds.), *Lecture Notes in Computer Science* (pp. 663–674). Springer International Publishing Switzerland. https://doi.org/https://doi.org/10.1007/978-3-319-20816-9_63
- [10] Crebert, G., Patrick, C.-J., Cragnolini, V., Smith, C., Worsfold, K., & Webb, F. (2011). *Griffith graduate attributes problem solving skills toolkit*. Problem Solving Skills Toolkit. <http://www.griffith.edu.au/gihe/resources-support/graduate-attributes>
- [11] Savage, M., & Williams, J. (1990). *Mechanics in action: Modelling and practical investigation*. Cambridge University Press.
- [12] Makos, E., & Katoussi, S. (2013). Elementary students' spontaneous metacognitive functions in different types on Mathematical problem. *Journal of Research in Mathematics Education*, 2(2), 242–267.
- [13] Madden, S. P., Jones, L. L., & Rahm, J. (2011). The role of multiple representations in the understanding of ideal gas problems. *Chemistry Education Research and Practice*, 12(3), 283. <https://doi.org/10.1039/c1rp90035h>
- [14] Nguyen, D., & Rebello, N. (2011). Students' difficulties with multiple representations in introductory mechanics. *US-China Education Review*, 8(5), 559–569. <http://web.phys.ksu.edu/reese/papers/2010/nguyen-intro-mechanics.pdf>
- [15] Kang, O., & Noh, J. (2012). Teaching mathematical modeling in school mathematics. *12th International Congress on Mathematical Education (ICME12)*. http://www.icme12.org/upload/submission/1930_f.pdf
- [16] Distrik, I. W., Ertikanto, C., Suyatna, A., & Suana, W. (2018). The effect of REAL model in enhancing metacognition of abstract physics topic. *International Journal of Research - Granthaalayah*, 6(6), 389–395. <https://doi.org/10.5281/zenodo.1310000>
- [17] Al-Hinai, M., & Al-Balushi, S. (2015). Rectifying analogy-based instruction to enhance immediate and postponed science achievement. *Journal of Turkish Science Education*, 12(1), 3–17. <https://doi.org/10.12973/tused.10129a>
- [18] Coll, R. K., France, B., & Taylor, I. (2005). The role of models/and analogies in science education: Implications from research. *International Journal of Science Education*, 27(2), 183–198. <https://doi.org/10.1080/0950069042000276712>
- [19] Ainsworth, S. (2006). DeFT: A conceptual framework for learning with multiple representations. *Learning and Instruction*, 16(3), 183–198. <https://doi.org/10.1016/j.learninstruc.2006.03.001>
- [20] Muldner, K., & Conati, C. (2010). Scaffolding meta-cognitive skills for effective analogical problem solving via tailored example. *International Journal of Artificial Intelligence in Education*, 20, 99–136. <https://doi.org/10.3233/JAI-2010-0004>
- [21] Desoete, A., Roeyers, H., & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities*, 34(5), 435–449. <https://doi.org/10.1177/002221940103400505>

- [22] Hake, R. (2002). Relationship of individual student normalized learning gains in mechanics with gender, high-school physics, and pretest scores on mathematics and spatial visualization. *Physics Education Research Conference*, 8(August), 1–14.
- [23] Ngozi, H. (2009). Metacognitive strategies on classroom participation and student achievement in senior secondary school science classrooms. *Review of Educational Research*, 20(1), 25–31.
- [24] Özsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on mathematical problem solving achievement. *International Electronic Journal of Elementary Education*, 1, 67–82.
- [25] Airey, J., & Linder, C. (2009). A disciplinary discourse perspective on university science learning: Achieving fluency in a critical constellation of modes. *Journal of Research in Science Teaching*, 46(1), 27–49. <https://doi.org/10.1002/tea.20265>
- [26] Güler, G., & Ciltas. (2011). The visual representation usage levels of mathematics teachers and students in solving verbal problems. *International Journal of Humanities and Social Science*, 1(11), 145–154.
- [27] Hwang, W. Y., Chen, N. S., Dung, J. J., & Yang, Y. L. (2007). *Multiple representation skills and creativity effects on Mathematical problem solving using a multimedia whiteboard system Jian-Jie Dung Yi-Lun Yang* (Vol. 10, pp. 191–212).
- [28] Distrik, I. W., Imam Supardi, Z. A., Jatmiko, B., & Yuberti. (2021). The effects of multiple representations-based learning in improving concept understanding and problem-solving ability. *IOP Conference Series: Earth and Environmental Science*, 1796(1). <https://doi.org/10.1088/1742-6596/1796/1/012044>
- [29] Patonah, S. (2014). Elemen bernalar tujuan pada pembelajaran IPA melalui pendekatan metakognitif siswa SMP (Elements of objective reasoning in science learning through a metacognitive approach for junior high school students). *Jurnal Pendidikan IPA Indonesia*, 3(2), 128–133.
- [30] Herlanti, Y., Mardiaty, Y., Wahyuningtyas, R., Mahardini, E., Iqbal, M., & Sofyan, A. (2017). Metacognitive knowledge on Biology learning in secondary school. *Jurnal Pendidikan IPA Indonesia*, 6(1), 179–186. <https://doi.org/10.15294/jpii.v6i1.9605>
- [31] Gentner, D., Loewenstein, J., & Thomson, L. (2003). Learning Transfer: A general role for analogical encoding. *Journal of Educational Psychology*, 95(2), 393–408. <https://doi.org/10.1037/0022-0663.95.2.393>
- [32] Hasni, K., & Kadir, A. (2014). Merging analogy and ICT as a teaching strategy to enhance students' thinking skill & understanding of science concept. *Journal of Applied Sciences Research*, 10(15), 27–31.