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Implementation of Multi-representation Learning on Climate Change Integrated Dynamic Fluid to Improve Student's Problem-Solving Skills

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Abstract

This research aims to analyze the implementation of multi-representation learning on climate change topics integrated fluid dynamics to improve students' problem-solving skills and analyze student responses to multi-representation learning on climate change topics integrated fluid dynamics. The type of this research is quantitative research with a pre-experimental that uses a one-group pretest-posttest design. This research was conducted in XI MIPA-1 at Senior High School 4 Sidoarjo with 36 students. Data collection techniques in this research used tests with test instruments in the form of description questions and questionnaires (responses) on a Likert scale. The data analysis technique is N-gain for the description test instrument and descriptive for student response questionnaires. The results of this research obtained the score of N-gain is 0.565 with a category of the medium. The results of student responses carried out using a Likert scale questionnaire for ten statements had positive and very positive results with a percentage of more than 77%. Thus, it was concluded that learning multi-representation could improve students' problem-solving skills with the topic of climate change integrated with fluid dynamics and elicit positive and very positive responses from students.

Keywords: climate change; multi-representation; problem-solving skills

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INTRODUCTION

Indonesia is a country crossed by the equator, so it experiences significant climate change (Perdana et al., 2015). Global phenomena with natural conditions that experience a shift or anomaly to the initial state (on average) over a long period (tens or hundreds of years) are the definition of climate change (Puspitasari & Surendra, 2016). Climate change is a natural event that is dangerous for humans because anything related to climate change can damage social structures, especially ecosystems (Nabilah & Hariyono, 2021). Some indicators of climate change that occur in Indonesia are air humidity, rainfall, air temperature, increased intensity of extreme weather such as rain accompanied by strong winds and storms, and others (Manik et al., 2017; Solihin et al., 2021).

Indonesia has varying rainfall levels, ranging from high to low, due to the influence of the monsoon climate; namely, there is a significant difference

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between the wet and dry seasons (Gunadi et al., 2018; Susilokarti et al., 2015). In line with the statement, the indicator of climate change in the tropics is the element of rainfall (Pradana & Sesanti, 2018). Increased rain intensity (Extreme rain) causes a flood disaster (Laia & Setyawan, 2020). Otherwise, low rainfall intensity results in drought and reduced water availability (Solihin et al., 2021).

In learning, the topic of climate change plays a very important role (Hartati & Hariyono, 2021). One of them is the material of changes in rainfall that may be used to educate students' problem-solving skills. One of the high-level skills that need to be mastered to improve the quality of human resources in competing to overcome the challenges of the 21st century is problem-solving skills (Batlolona et al., 2018; Citra et al., 2020; Jatmiko et al., 2018). This is in line with the fact that 21st-century education implements four things in curriculum 13: creativity and innovation, critical thinking and problem solving, collaboration, and communication (Romadhon, 2019).

The quality of education has not improved, one of which is physics (Bahaudin et al., 2019). Physics learning is closely related to solving a problem, so physics learning is said to be successful if students master problem-solving skills (Alfika & Mayasari, 2018). However, in reality, physics learning tends to prioritize mastery of concepts and pay less attention to students' physics problem-solving skills, thus resulting in a low classification of students' problem-solving skills. (Aji et al., 2016; Hoellwarth et al., 2005; Hudha et al., 2017).

Problem-solving is an essential skill in science, especially in physics, because students use problem-solving in their cognitive processes to develop physics knowledge and facilitate students during the physics learning process (Bahaudin et al., 2019; Docktor et al., 2015; Hartua & sirait, 2016). However, the problem-solving skills of students are low. This can be seen from the 2015 PISA data, which shows that Indonesia's scientific ability score (identifying problems and applying knowledge) is 403 and is ranked 69th out of 76 participating countries; when viewed from the similarity of the country's economy from each participant, the achievement of Indonesia's science ability score is 445 and up 11 places from before (Alfika & Mayasari, 2018; Nugrahanto & Zuchdi, 2019).

Learning strategies and appropriate approaches are needed to solve the problems of Indonesian students related to low problem-solving skills. Students must apply various methods, techniques, strategies, and approaches to solve physics problems appropriately, which is known as multi-representation (Dewati et al., 2019a; Simamora et al., 2016). Multi-representation is a strategy developed to improve conceptual understanding and problem-solving in physics (Dewati et al., 2019b; Prahani et al., 2016). Multi-representations (verbal, graphic, visual, and equation) are needed to visualize data in problem-solving and master scientific concepts (Docktor & Mestre, 2014; Nieminen et al., 2010). Some researchers suggest that using a multi representation strategy in physics can help students improve their problem-solving skills (Aha, 2020; Mardatila et al., 2019; Solihah et al., 2018; Trisayuni et al., 2019).

The implementation topic of climate change learning integrated with dynamic fluid materials is a new thing, so it is necessary to test parameters to measure the success of the application of the learning, such as students' problem-solving skills in solving problems related to climate change. The more students who know the problems of climate change and successfully solve these problems, the greater their awareness of

students in protecting the universe (Hartati & Hariyono, 2021). Thus, the research aims to analyze the implementation of multi-representation learning on climate change integrated dynamic fluid to improve students' problem-solving skills and analyze student responses to multi-representation learning on climate change integrated dynamic fluid.

METHOD

The type of this research is quantitative research with the Pre-Experimental method. The design used is one group pretest-posttest; the design is used so that the known results are more accurate because they can compare the conditions before and after being given treatment (Sugiyono, 2013). The design of one group pretest-posttest can be described in Table 1.

Table 1 Research design

Pretest	Treatment	Posttest
A_1	Y	A_2

(Sugiyono, 2013)

Description:

A_1 = pretest score before implementing multi-representation learning treatment

A_2 = posttest score before implementing multi-representation learning treatment

Y = multi-representation learning treatment

This research was conducted in December 2021 with the class of XI MIPA-1 at Senior High School 4 Sidoarjo with 36 students. Before the treatment of multi-representation learning, students were given a pretest. Then students were treated with multi-representation learning. After implementing multi-representation learning, students were given a final test (posttest). Researchers used the findings of the pretest and posttest to specify how students' problem-solving skills had improved. After being given the posttest, the researcher gave a questionnaire sheet to analyze students' responses to multi-representation learning on climate change integrated with dynamic fluid to improve their problem-solving skills. The indicator of problem-solving skills used refers to (1) making visualization of the problem; (2) a description of physics; (3) making a strategy for a solution; (4) carrying out the strategy; (5) examining and assessing (Heller et al., 1992).

The data collection technique in this research used a test with a test instrument of 5 questions to measure students' problem-solving skills and a questionnaire (response) to determine student responses after learning. The data analysis technique used to specify the improvement of students' problem-solving skills is normalized gain (N-gain), which has the following formula. The data analysis technique used is normalized gain (N-gain) with the following formula to discover the improvement of students' problem-solving skills.

$$Ngain = \frac{\bar{X}_{posttest} - \bar{X}_{pretest}}{\bar{X} - \bar{X}_{pretest}} \quad (1)$$

Description:

$\bar{X}_{posttest}$ = average posttest score

$\bar{X}_{pretest}$ = average pretest score

$\bar{X}$ = maximum score

The N-gain score is interpreted as follows in table 2.

Table 2 Interpretation normalized gain

Score <g>	Qualification
$(\langle g \rangle) \geq 0.7$	High
$0.7 > (\langle g \rangle) \geq 0.3$	Medium
$(\langle g \rangle) < 0.3$	Low

(Hake, 1999)

The questionnaire (response) used is based on a Likert scale using ten statements. This statement is used to determine student responses by responding to choices in each statement

item (Hasyim, 2019). The Likert scale category used is visible in Table 3.

Table 3 Likert scale category

Score	Description
5	Strongly agree
4	Agree
3	Slightly disagree
2	Disagree
1	Strongly disagree

The results of the Likert scale can be calculated by the formula (Efendi et al., 2021):

$$P = \frac{\sum x}{\sum i} x100\% \quad (2)$$

Description:

P = Percentage

$\sum x$ = The total number of answers in all item

$\sum i$ = The total number of ideal scores per item

To find out the results of student response analysis using student response criteria are visible in Table 4.

Table 4 Student response criteria.

Student Response Interval	Criteria
$80\% \leq P < 100\%$	Very positive
$60\% \leq P < 80\%$	Positive
$40\% \leq P < 60\%$	Fairly positive
$20\% \leq P < 40\%$	Less positive
$P < 20\%$	Very less positive

(Efendi et al., 2021)

RESULT AND DISCUSSION

This research aims to specify students' problem-solving abilities by implementing multi-representation learning on climate change topics. The research was conducted by providing five questions in the form of a description related to the topic of climate change integrated dynamic fluid material. The representations used in this research are visual, verbal, and mathematical representations. Furthermore, the researchers gave a questionnaire containing ten statements. The questionnaire is used to find out the student's responses to multi representation learning on the topic of climate change.

Student's Problem-Solving Skills

To find out if there is an increase in student problem solving, it is visible from the score of N-gain. The following data comes from the N-gain calculation score, visible in tables 5a and 5b.

Table 5a The average pretest and posttest

Class	Pretest	Post-test
Experiment	21.81	33.78

Table 5b N-gain score

Class	N-gain	Category
Experiment	0.565	Medium

From Table 5, the average posttest score increased compared to the average score of the pretest, and the score of N-gain obtained was 0.565 with a category of the medium. Based upon the score of N-gain, it can be deduced that students' skills in solving problems related to climate change that are integrated with dynamic fluids have increased; this cannot be separated from the implementation of multi-representation learning strategies. Multi-representation affects improving students' problem-solving skills. Amiroh et al. (2021) discovered that multi representation learning could improve problem-solving skills from low to medium levels.

The multi-representation approach positively influences the learning process and may be used to improve students' problem-solving skills. Teachers can apply representations to help students comprehend the concepts when explaining a concept. (Simamora et al., 2016). Solving problems related to climate change and using multi-representation learning begins by providing important information from the representations in the learning process as well as in the pretest and posttest. Multi-representation has various types, including verbal, visual, symbolic,

graphic, diagrammatic, and mathematical forms (Yinka et al., 2021). In the learning process with the topic of climate change integrated dynamic fluid. In the pretest and posttest, the representations used are visual, mathematical, and verbal to support students in improving problem-solving skills.

The results of improving students' problem-solving skills that were not maximal were caused by unsystematic pretest and posttest. In Figure 1, it can be seen that the categories of visual, verbal, and mathematical representations have varying scores.

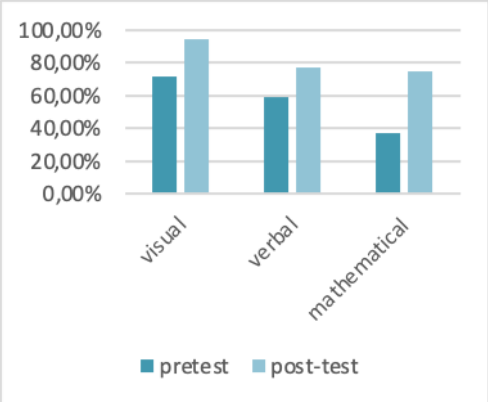


Figure 1 Students' problem-solving skills using multi-representation

Based on Figure 1, the grouping of representations is based on the pretest and posttest. The percentage of each representation for the posttest has increased compared to the pretest. In the pretest results, the larger representation is a visual representation, then verbal, and the lower one is mathematical. In the posttest results, the larger representation is the visual representation; the verbal and mathematical representation scores show a slight difference. Visual representations have a higher percentage score than verbal representations or mathematical representations. Mathematical representations experience a lower percentage than visual representations or verbal representations. However, after the post-test was conducted, it increased the mathematical representation, and the percentage score was almost equivalent to the verbal representation. The representation category aims to discover students' skills in solving problems using multi-representations.

The pretest and posttest visual representation shows higher scores than the verbal and mathematical representations. Students' understanding of representations with visual formats has increased. The percentage of posttest on visual representation has increased compared to the percentage of the pretest. In Figure 2, it is visible that student answers on visual representation.

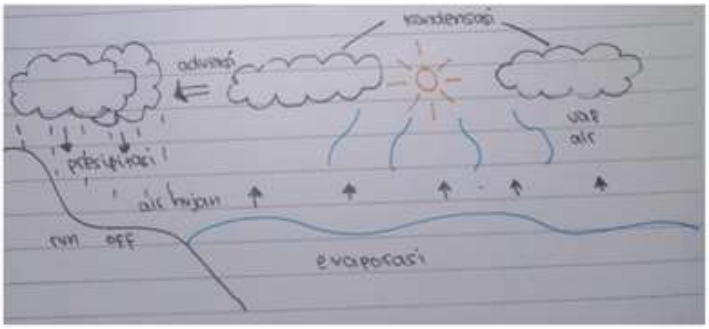
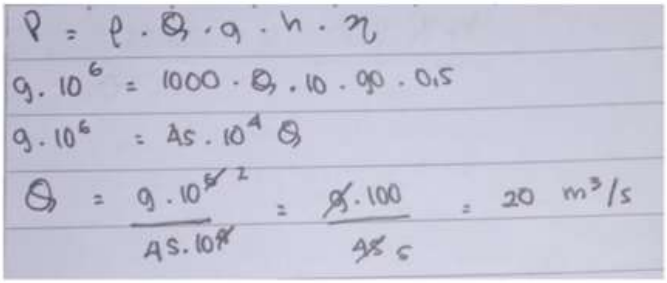


Figure 2 Student answers on visual representation

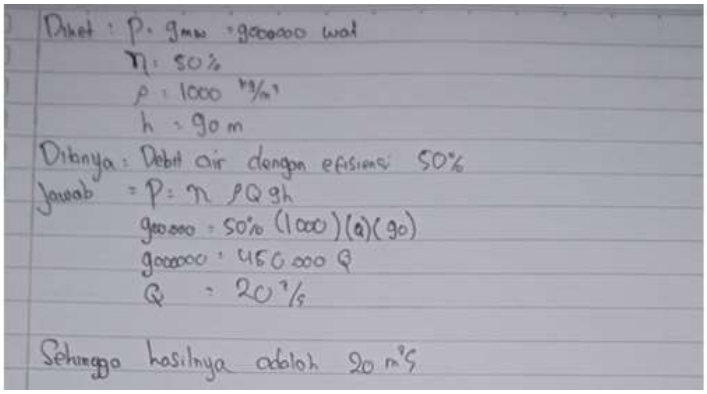
In Figure 2, the question of *the rain process not only immediately drops water to the earth but also the process of rain is related to the hydrological cycle. The most important stages in the hydrological cycle are four, namely evaporation and transpiration, condensation, participation, and runoff.*

Describe the stages or processes of the hydrological cycle. Students were asked to depict the stages of the hydrological cycle. The question's objective is to assess the students' visual representation abilities. Students answer this question correctly. This shows that students can solve problems in visual forms, such as by providing information on the images that have been made, classifying visuals appropriately, translating the meaning of the questions, and providing information by the questions command. In the research of Niko et al., (2018), it is stated that the ability of visual representation has a higher value than verbal and symbol representation, so students' multi-representation abilities are categorized as moderate.

The mathematical representation on the pretest and posttest shows a lower value than the verbal and visual representations. From the results of the scores pretest, students' skills in problem-solving in the form of mathematical representations have very low scores. Students' answers to mathematical representation are visible in Figure 3.



a



b

Figure 3 Student answers on mathematical representation

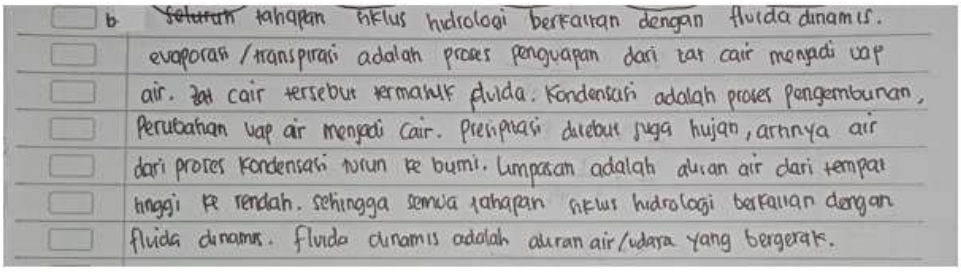
In Figure 3, the question of *Sumbersono Village, Pacet-Mojokerto is still untouched by electricity. However, the village has resources in the form of a river which has a heavy flow from a waterfall with a height of 90 m. So assume that there are 10,000 households in the village, with a power consumption of 900 VA per house. So it requires 9 MW of electricity. How much can water discharge be generated from the river flow? (with 50% generating efficiency)*. Students were required to compute the water discharge based on the effectiveness of the electrical bending. The question's objective is to specify a student's mathematical representation ability. The answers are diverse. Figure 3a indicates the student's pretest answer,

while Figure 3b indicates the student's posttest answer.

In Figure 3a, the result of a student's pretest. The final result of the student's answer was correct, but the student did not get the maximum score for the question. This is because students directly enter the formula without giving initial steps, even though in the question instructions there is a systematic, such as what is known in the problem, what to look for, how to solve it, and what the final result will be. According to Selamet. et al., (2018) found that generally, students tend to memorize formulas without identifying the questions first; students also have difficulty determining the right strategy to solve the problem, so the percentage on the mathematical representation indicator is low and categorized as less.

In Figure 3b, the results of a student's posttest. Students carried out the representation problems systematically, and students understood the identification of the problem. The results of the student's work looked more systematic because the student explains in advance what is known from the problem, writes down what is being asked, solves it using the appropriate formula, and then states the final result.

Verbal representation in post-tests increases compared to pretest. Students' ability to answer verbal representation is good. Because verbal representations are used in questions that explain concepts, certain situations, and problem solutions. Students' answers on verbal representation are visible in Figure 4.


b. Seluruh tahapan siklus hidrologi berkaitan dengan fluida dinamis.
evaporasi / transpirasi adalah proses penguapan dari zat cair menjadi uap air. Zat cair tersebut termasuk fluida. Kondensasi adalah proses pengembunan, perubahan uap air menjadi cair. Presipitasi disebut juga hujan, artinya air dari proses kondensasi turun ke bumi. Limpasan adalah aliran air dari tempat tinggi ke rendah. sehingga semua tahapan siklus hidrologi berkaitan dengan fluida dinamis. fluida dinamis adalah aliran air/udara yang bergerak.

All stages of the hydrological cycle are involved in dynamic fluids. The transformation of liquids to water vapour is known as evaporation and transpiration. Fluids are among these liquids. The process of turning water vapour into liquid is known as condensation. Precipitation, commonly known as rain, is water that falls to the ground due to condensation processes. The flow of water from a high point to a low point is known as runoff. As a result, all stages of the hydrological cycle are involved in dynamic fluids. The flow of water/moving air is a dynamic fluid.

Figure 4 Student answers on verbal representation

In Figure 4, students must explain the relationship between the hydrologic cycle stages and dynamic fluid. The question's objective is to determine a student's verbal representation ability. The student's answer to the question is not yet appropriate because the student has not emphasized the interrelationship between the hydrological cycle and dynamic fluid. Students' answers tend to explain the concepts of hydrological cycles and dynamic fluids. Students' explanations of these concepts are suitable, indicating that they have a good capacity to explain concepts in written (verbal) is good. In physics learning, teachers use verbal explanations to explain concepts accompanied by visuals as support to strengthen the concepts that have been explained by the teacher

(Hasbullah et al., 2019). Students can solve problems with the type of verbal representation caused by the teacher who explains the material verbally. The teacher gives a student book containing all the material to be taught. According to research by mahardika et al., (2019), students' ability in verbal representation increased after learning inquiry.

The results obtained have increased if the representation is reviewed by looking at the pretest and posttest categories. Thus, students' skills to solve the problems of climate change integrated dynamic fluid using multiple representations has increased.

Student Responses to Multi-Representation Learning

Data on student response to multi-representation learning obtained from working on statements in the form of Likert scales are visible in Figure 5.

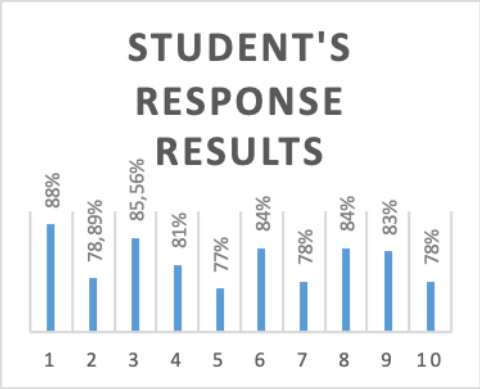


Figure 5 Results of students' response to multi representation learning topics of climate change integrated dynamic fluid

Description for each number in Figure 5.

1 Multi-representation learning on climate change integrated dynamic fluid is something new for me.
2 Multi-representation learning on the topic of climate change integrated fluid dynamics intrigued me when the first time I heard it.
3 With multi-representation learning on climate change integrated fluid dynamics, I am skilled in solving a problem.
4 With multi-representation learning on climate change integrated fluid dynamics, I am skilled at thinking analytically.
5 With multi-representation, learning about climate change and integrated fluid dynamics motivates me to find new ideas.
6 The multi-representation learning on the topic of climate change integrated fluid dynamics made me better understand the material.
7 Multi-representation learning on fluid dynamic integrated climate change topics is more interesting to study.
8 Multi-representation learning on fluid dynamics integrated climate change topics can add insight.
9 Material dynamic fluid, especially the principle of continuity, is suitable for implementing climate change, namely flooding.
10 Several climate change phenomena, namely rain, river flow, and flooding, are related to dynamic fluids.

Based on Figure 5, the scores generated for each statement are above 70%, meaning that each statement in the questionnaire has a positive and very positive category. In this research, the highest percentage of students responded to the statement "multi-representation learning on the topic of climate change integrated dynamic fluid is something new for me" with a percentage gain of 88%. It can be concluded that this learning is a new thing for students because generally, physics learning is focused on material that is already in the book; only a few relate it to natural

phenomena or everyday life events (Afrizon, 2018).

Based on the outcomes of the response questionnaire, learning multi-representation can help students solve problems related to climate change. This is in line with the statement, "With multi-representation learning on the topic of climate change integrated fluid dynamics makes me skilled in solving a problem", by obtaining a score of 85.56% in the very positive category. Using multi-representation in the physics learning process can improve students' problem-solving and cognitive abilities (Mardatila et al., 2019).

Students can understand abstract problems through various forms of information presented by educators with a multi-representation approach (Hasbullah et al., 2019). Based on the results of the response questionnaire with a score of 84%, students are easier to understand the material with multi-representational learning on the topic of climate change integrated with dynamic fluid. Students' insight also increases with this multi-representation learning, according to statement number 8 with a percentage of 84%. The lowest percentage of student responses is in statement number 5, with a percentage gain of 77% related to the ability of students to find the latest ideas.

CONCLUSION

The results of this research obtained the score of N-gain is 0.565 with a category of the medium. The results of student responses carried out using a Likert scale questionnaire for ten statements had positive and very positive results with a percentage of more than 77%. Thus, it was concluded that learning multi-representation could improve students' problem-solving skills with the topic of climate change integrated with fluid dynamics and elicit positive and very positive responses from students.

The limitation in this study is to relate the dynamic fluid material, namely the continuity principle, with climate change. The results of this research can help other researchers interested in using multi-representation learning to improve students' problem-solving skills on climate change and students' responses to the use of such learning. The suggestions for further research are to develop other materials for climate change and use other learning approaches to improve problem-solving skills on the topic of climate change.

REFERENCE

Afrizon, R. (2018). Analisis persepsi mahasiswa pendidikan fisika terkait pentingnya pembelajaran fisika bermakna yang menerapkan unsur kearifan lokal sumatera barat. *ProsidingSemirata 2017 Bidang MIPA* . https://doi.org/10.31227/osf.io/rzjqg

Aha, L. H., Muhardjito, M., & Sunaryono, S. (2020). Pengaruh strategi pembelajaran multirepresentasi dengan pendekatan conceptual problem solving terhadap kemampuan pemecahan masalah dan kemampuan representasi. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *5*(1), 44-51.

Aji, S. D., Hudha, M. N., Permatasari, A., Problem, A., & Learning, B. (2016). Authentic problem based learning (aPBL) untuk meningkatkan kemampuan pemecahan masalah fisika siswa. *Seminar Nasional Pendidikan Sains*, 299–302.

Alfika, Z. A., & Mayasari, T. (2018). Profil kemampuan memecahkan masalah pelajaran fisika siswa mts. *Prosiding Seminar Nasional Quantum*, *25*, 583–589. http://seminar.uad.ac.id/index.php/quantum/article/download/318/267

Amiroh, D., Sibua, S., & Salim, A. (2021). Pendekatan multi representasi untuk meningkatkan

penguasaan konsep dan pemecahan masalah mahasiswa pada materi gelombang. *Briliant: Jurnal Riset Dan Konseptual*, *6*(2), 290. https://doi.org/10.28926/briliant.v6i2.615

Bahaudin, A., Festiyed, F., Djamas, D., & Putri, N. H. (2019). Validity of physics learning module based on multirepresentation to improve the problem solving ability. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012063

Batlolona, J. R., Baskar, C., Kurnaz, M. A., & Leasa, M. (2018). The improvement of problem-solving skills and physics concept mastery on temperature and heat topic. *Jurnal Pendidikan IPA Indonesia*, *7*(3), 273–279. https://doi.org/10.15294/jpii.v7i3.12432

Citra, C., Distrik, I. W., & Herlina, K. (2020). The practicality and effectiveness of multiple representations based teaching material to improve student's self-efficacy and ability of physics problem solving. *Journal of Physics: Conference Series*, *1467*(1). https://doi.org/10.1088/1742-6596/1467/1/012029

Dewati, M., Suparmi, A., Sunarno, W., Sukarmin, & Cari, C. (2019a). Pre service teacher's concept understanding profile about DC circuit based on multiple representation. *AIP Conference Proceedings*, *2202*(December). https://doi.org/10.1063/1.5141674

Dewati, M., Suparmi, A., Sunarno, W., Sukarmin, S., & Cari, C. (2019b). Implementasi multiple representation pada rangkaian listrik DC sebagai upaya meningkatkan problem solving skills. *Prosiding SNFA (Seminar Nasional Fisika Dan Aplikasinya)*, *4*, 140. https://doi.org/10.20961/prosidingsnfa.v4i0.35927

Docktor, J. L., & Mestre, J. P. (2014). Synthesis of discipline-based education research in physics. *Physical Review Special Topics - Physics Education Research*, *10*(2), 1–58. https://doi.org/10.1103/PhysRevSTPER.10.020119

Docktor, J. L., Strand, N. E., Mestre, J. P., & Ross, B. H. (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics-Physics Education Research*, *11*(2), 1–13. https://doi.org/10.1103/PhysRevSTPER.11.020106

Efendi, D. N., Supriadi, B., & Nuraini, L. (2021). Analisis respon siswa terhadap media animasi powerpoint pokok bahasan kalor. *Jurnal Pembelajaran Fisika*, *10*(2), 49. https://doi.org/10.19184/jpf.v10i2.23763

Gunadi, I. G. A., Aprilyana, A., & Dewi, K. (2018). Klasifikasi curah hujan di provinsi bali berdasarkan metode naïve bayesian. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, *12*(1), 14–25.

Hake, R. R. (1999). Analyzing change/gain scores.

Hartati, M., & Hariyono, M. E. (2021). *The Voices of Students About Climate Change : A Preliminary Research*. *209*(IJCSE), 580–583.

Hasbullah, H., Halim, A., & Yusrizal, Y. (2019). Penerapan pendekatan multi representasi terhadap pemahaman konsep gerak lurus. *Jurnal IPA & Pembelajaran IPA*, *2*(2), 69–74. https://doi.org/10.24815/jipi.v2i2.11621

Hasyim, F. (2019). Analisis respon siswa terhadap penggunaan kit kalorimeter dalam pembelajaran ipa pokok bahasan kalor. *Berkala Ilmiah Pendidikan Fisika*, *7*(1), 11. https://doi.org/10.20527/bipf.v7i1.58

75

Hoellwarth, C., Moelter, M. J., & Knight, R. D. (2005). A direct comparison of conceptual learning and problem solving ability in traditional and studio style classrooms. *American Journal of Physics*, *73*(5), 459–462. https://doi.org/10.1119/1.1862633

Hudha, M. N., Aji, S. D., & Permatasari, A. (2017). Authenthic problem based learninG (aPBL). *Jurnal Pendidikan Matematika Dan IPA*, *8*(1), 64–70.

Jatmiko, A., Kartina, Y., Irwandani, I., Fakhri, J., Pricilia, A., & Rahayu, T. (2018). Reading concept map-think pair share (remap-tps) learning model on cognitive ability and scientific attitude. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *3*(2), 183. https://doi.org/10.24042/tadris.v3i2.3184

Laia, M. L., & Setyawan, Y. (2020). Perbandingan hasil klasifikasi curah hujan menggunakan metode SVM dan NBC. *Jurnal Statistika Industri dan Komputasi*, *5*(02), 51-61

Mahardika, I. K., Rofiqoh, A., & Supeno. (2019). Model inkuiri untuk meningatkan kemampuan representasi verbal dan matematis pada pembelajaran fisika di sma. *Jurnal Pembelajaran Fisika*, *7*(2), 77–85.

Manik, T. K., Rosadi, B., Sanjaya, P., & Perdana, O. K. (2017). *Resiko Bencana : Kajian kerentanan, kapasitas dan pemetaan risiko bencana akibat perubahan iklim*. 1–128.

Mardatila, A., Novia, H., & Sinaga, P. (2019). Penerapan Pembelajaran fisika menggunakan multi representasi untuk meningkatkan kemampuan kognitif dan pemecahan masalah siswa sma pada pokok bahasan gerak parabola. *Omega: Jurnal Fisika Dan Pendidikan Fisika*, *5*(2), 33. https://doi.org/10.31758/omegajphysphyseduc.v5i2.33

Nabilah, H., & Hariyono, E. (2021). Analysis on climate literacy capacity of level xi high school students in surabaya. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *9*(1), 28. https://doi.org/10.33394/j-ps.v9i1.3816

Nieminen, P., Savinainen, A., & Viiri, J. (2010). Force concept inventory-based multiple-choice test for investigating students' representational consistency. *Physical Review Special Topics - Physics Education Research*, *6*(2), 1–12. https://doi.org/10.1103/PhysRevSTPER.6.020109

Nugrahanto, S., & Zuchdi, D. (2019). *Indonesia PISA Result and Impact on The Reading Learning Program in Indonesia*. *297*(Icille 2018), 373–377. https://doi.org/10.2991/icille-18.2019.77

Perdana, D. A., Zakaria, A., & Sumiharn. (2015). Studi Pemodelan sintetik curah hujan harian pada beberapa stasiun hujan di kabupaten pringsewu. *Jrsdd*, *3*(1), 45–56.

Pradana, O. C. P., & sesanti, r. n. (2018). analisis dampak perubahan iklim terhadap curah hujan berdasarkan perubahan zona agroklimatologi pada skala lokal politeknik negeri lampung. *Jurnal Wacana Pertanian*, *14*(1), 24. https://doi.org/10.37694/jwp.v14i1.23

Prahani, B. K., Limatahu, I., W.W, S., Yuanita, L., & Nur, M. (2016). Effectiveness of physics learning material through guided inquiry model to improve student's problem solving skills based on multiple representation. *International Journal of Education and Research*, *4*(12), 231–242.

Puspitasari, N., & Surendra, O. (2016). Analisis tren perubahan suhu udara

minimum dan maksimum serta curah hujan sebagai akibat perubahan iklim di provinsi. *Balai Besar Meteorologi Klimatologi da Geofisika Wilayah V Jayapura*

Romadhon, D. N. A. (2019). Implementasi keterampilan berpikir kritis pada pembelajaran ips eksistensi meningkatkan keterampilan abad 21. *Jurnal Istoria*, *3*(2), 94–99.

Simamora, R., Sinaga, P., & Jauhari, A. (2016). Pembelajaran fisika menggunakan multirepresentasi untuk meningkatkan kemampuan kognitif dan kemampuan pemecahan masalah siswa smp pokok bahasan getaran dan gelombang. *Prosiding SNIPS*, 501–505.

Solihah, A., Sinaga, P., & Amsor, A. (2018). Multi representasi momentum dan impuls untuk meningkatkan kognitif dan kemampuan pemecahan masalah siswa SMA. *Seminar Nasional Quantum*, *25*(21), 338–344. seminar.uad.ac.id/index.php/quantum

Solihin, R. R., Ramadan, A., & Asniar, N. (2021). Studi analisis perubahan iklim terhadap distribusi curah hujan pada daerah tangkapan air pataruman. *Jurnal Ilmiah Teknik Sipil*, *1*(2), 10–19. http://www.e-journal.unper.ac.id/index.php/JITSi/article/view/538

Sugiyono, D. (2013). Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D.

Susilokarti, D., Arif, S. S., Susanto, S., & Sutiarso, L. (2015). Identifikasi perubahan iklim berdasarkan data curah hujan di wilayah selatan jatiluhur kabupaten subang, jawa barat. *Jurnal Agritech*, *35*(01), 98. https://journal.ugm.ac.id/agritech/article/view/13038/15155

Trisayuni, D. N. R. W., Supeno, S., & Sudarti, S. (2019). Identifikasi kemampuan pemecahan masalah pada materi hukum newton ditinjau dari kemampuan multirepresentasi. *FKIP E-PROCEEDING*, *3*(2), 241–245.

Yinka, O., Tunde, O., & Hakeem, A. (2021). Exploring the nexus among multiple representations, problem-solving and multiple representational abilities of physics students. *IJER-International Journal of Educational Research*, *4*(03), 31-43.