Momentum: Physics Education Journal
7 (2), 2023, 188-200
Available at: ejournal.unikama.ac.id/index.php/momentum
ISSN 2548-9127(print) | 2548-9135 (online)

The multi-representational ability profile of physics students in the interactive multimedia assisted problem-based learning during the Covid-19 pandemic

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Received: 27 September 2022; Revised: 24 January 2023; Accepted: 14 February 2023

Abstract: This study aims to analyze the multi-representation ability profile of physics students in the interactive multimedia assisted problem-based learning during the Covid-19 pandemic. This research is a qualitative descriptive study. This research involved 9 female teachers and 1 male teacher. Data on the multi-representation abilities of Physics teachers were obtained by using the 5 item multi-representation problem instrument in the form of representing image to verbal, verbal to mathematical, verbal to image, table to graph, and mathematical to verbal. Meanwhile, researchers utilized interviews to gather information on the difficulties that prospective physics teachers had in working on multi-representational problems. The results of the analysis show that the multi-representation ability of prospective physics teachers is generally good. This can be seen from the average percentage obtained by 63%. However, there are two indicators that are still not good, namely verbal to mathematical representation and mathematical to verbal representation with an average percentage of 30% and 43% respectively. For this reason, it is necessary to make efforts to increase the multi-representational abilities of prospective physics teachers by using approaches, teaching materials, and learning media that are able to teach and present physics concepts in various forms of representation so that it is easier to understand the concepts presented.
Keywords: problem based learning; interactive multimedia assistant; learning in the COVID-19 pandemic

How to Cite: Masrifah, M., & Amiroh, D. (2023). The multi-representational ability profile of physics students in the interactive multimedia assisted problem-based learning during the Covid-19 pandemic. Momentum: Physics Education Journal, 7(2), 188-200. https://doi.org/10.21067/ mpej.v7i2.7501

Introduction

The COVID-19 pandemic has had an impact on the education sector causing the face-to-face learning method has changed to online learning (Abumalloh et al., 2021; Hu et al., 2022; Iglesias-Pradas, Hernández-García, Chaparro-Peláez, & Prieto, 2021). Online learning is a distance learning system with a variety of effective learning methods that can assist users in delivering learning (Cheng, 2012; Yao, Wang, Jiang, Li, & Li, 2022). The success of online learning depends on the infrastructure, the pedagogy and management of learning materials (Costa & Silva, 2010), the motivation, and the student character, because not all students are able to understand concepts well online. The learning process aims to instill concepts to students in order to improve soft skills and hard skills in the aspects of attitudes, knowledge, and skills (van Laar, van Deursen, van Dijk, & de Haan, 2017). Therefore, understanding the concept becomes an important factor for students in learning physics (Çepni, Ülger, & Ormanci, 2017; Hsieh & Tsai, 2017; Soeharto & Csapó, 2021). Understanding concepts is not enough to just memorize them because concepts in physics need to be explained into various kinds of representations. The

DOI: 10.21067/ mpej.v7i2.7501

display of various representations can help students understand the concepts they are learning. This relates to the abilities possessed by each student, some are more prominent in their verbal abilities than their spatial and quantitative abilities, but some are the opposite. If a concept is presented in only one representation, it will only benefit some students (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

Related to that, it is very important to provide multi-representation skills to students because it can affect concept understanding (Nussifera, Sinaga, & Setiawan, 2017), and problem-solving skills (Simbolon, Sinaga, & Utari, 2017). Multi-representation ability is the ability to apply various representations in explaining the concepts and problems in physics. Prospective physics teacher students must have representation skills to help them learn or overcome students' difficulties in understanding physics concepts. The teacher's ability to convey a material of subject will greatly affect the student's representation ability. When teachers can instruct in various ways or various kinds of representations, students will have knowledge of various representations in their minds (Nurrahmawati, Sa'dijah, Sudirman, & Muksa, 2019).

Various studies have shown that representational ability is related to understanding physics concepts (Demirbag & Gunel, 2014; Hand, Gunel, & Ulu, 2009; Park, Chang, Tang, Treagust, & Won, 2020). However, the current condition of students' representational abilities at various levels of education is still inadequate (Mäntylä & Hämäläinen, 2015; Nussifera et al., 2017; Sezen, Uzun, & Bulbul, 2012). Teachers and pre-service teacher also experience problems related to inadequate representation abilities (Aisyah, Okta. Sudarti, 2021; Bajracharya, Emigh, & Manogue, 2019; Coleman, McTigue, & Smolkin, 2011; Hill & Sharma, 2015; Masrifah, Setiawan, Sinaga, & Setiawan, 2020). In fact, understanding the various types of representations facilitates someone in gaining a deep understanding of physics concepts (Demirbag & Gunel, 2014).

One learning model that can facilitate students in representing concepts is the problem-based model (PBL) because it is focused on learning experiences that include investigation and problem solving, especially those related to everyday life (Sulaiman, 2010). The PBL model was chosen because it is one of the innovative learning models as demanded by the applicable curriculum. In this model, students are faced with a real or contextual problem related to physics concepts that must be solved in groups so that students are accustomed to and able to solve physics problems encountered in everyday life. When compared to other learning models, the PBL model can improve critical, creative, and collaborative thinking skills (Selçuk & Çalişkan, 2010; Yew & Goh, 2016), including learning achievement (Davidson & Major, 2014; Dolmans, Loyens, Marcq, & Gijbels, 2016; Fidan & Tuncel, 2019; Selçuk, 2010). In addition, this model can also assist students in building abstract concepts, especially through interactive multimedia so that online learning becomes more effective (Ak, 2011; Fidan & Tuncel, 2019). Learning technology and media must be designed and adapted to the needs of students so as to help them achieve their highest potential. Digital technology provides visual models or representations that students cannot obtain through their own efforts. Technology has the potential to make it easier for students to link their individual representations so as to achieve a solid understanding (Nousiainen, 2013).

This study aims to analyze the profile of the multi-representation ability of physics students in problem-based learning with interactive multimedia-assisted learning during the Covid-19 pandemic. This research is important to carry out to support the RIP of Khairun University, namely competency mapping, development and innovation of learning tools to improve the quality of education.

Method

This type of research is descriptive qualitative research. The research was carried out at Khairun University. The research subjects were students of the second semester in Physics Education study program for the 2021/2022 academic year who were taking Basic Physics II course. There were 10 respondents consisting of 9 female and 1 male students. The instruments applied in this study were the researcher himself as the main instrument and the supporting instrument in the form of five multi-representation questions on the concept of static electricity with various forms of representation and interview guidelines. Question instruments in the form of descriptions include a question of representation of image to verbal (I-V), verbal to mathematical (V-M), verbal to image (V-I), table to graph (T-G), and mathematical to verbal (M-V). Before being applied, the instrument was validated by 3 experts in the field of physics content. The answers were analyzed and scored to identify student' tendencies in using the presentation of physics concepts in multi-representation so that a pattern of learning difficulties would be obtained which refers to the ability of multi-representation to solve a problem on the concept of static electricity. The Physics Education Research (PER) rubric developed by Etkina is applied for the scoring process. The rubric uses scores ranging from 0 - 3, where 0 is for those who do not represent or do not work on problems (missing), 1 for inadequate representations, 2 for incomplete or inaccurate representations that require improvement (need some improvement), and 3 for adequate and correct representations. Meanwhile, the instrument in the form of an interview guide was applied to explore information of pre-service physics teacher's difficulties in working on multi-representation questions so that clearer and more complete information was obtained. These instruments were tested for validity before being applied for research. The data obtained from the research in the form of multi-representation abilities and student difficulties in solving representation problems were then analyzed, presented in the form of brief descriptions, tables and charts. The conclusions are then drawn through data triangulation. To determine pre-service physics teachers' multi-representation abilities, the test result data were analyzed using descriptive statistics in the form of percentages. The results of the analysis are then interpreted according to the following criteria Table 1.

Table 1. Multirepresentation Ability Criteria

Average Score (%)	Criteria
> 75-100	Very good
> 50-75	Good
> 25-50	Bad
0 – 25	Very bad

Results and Discussion

The pre-service physics teachers' multi-representation abilities were assessed based on their ability to solve physics problems on the concept of static electricity in the form of verbal, image, mathematics, and table representations. Questions were given after they took part in the static electricity learning process using interactive multimedia with a problem-based learning model. The following are the results of the analysis of the multi-representation abilities of pre-service physics teacher which are described in general, on each type of representation, and based on each question indicator. Data on the multi-representation ability of pre-service physics teacher in general on the concept of static electricity can be seen in Figure 1.

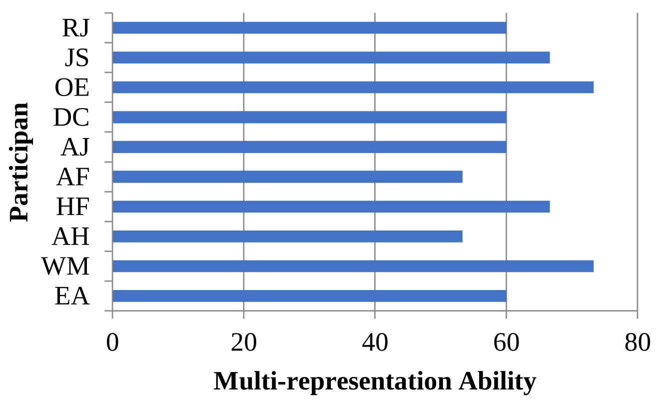


Figure 1. The ability of multiple representations of preservice physics teacher in general

Based on Figure 1, it can be seen that the highest multi-representation ability achieved by preservice physics teacher is 73%, and the lowest is 53%. However, the multi-representation ability of the 10 students who were participants in this study was in the good category. In general, the average percentage of the ability of multiple representations of preservice physics teacher on static electricity concept is 63% in the good category. So it can be said that all participants in this study already have good multi-representation abilities. One of the factors that influence this is that students have gone through a problem-based learning process (PBL) using interactive multimedia in which physics concepts are presented in various forms of representation such as verbal, image, mathematical, animation, and simulation, thus the students are easier to understand the concept. One of the learning models that can facilitate students in representing concepts is a problem-based model (PBL) because it is focused on learning experiences that include investigation and problem solving, especially those related to everyday life. The PBL model can help students build abstract concepts, especially through interactive multimedia so that online learning becomes more effective. Learning technologies and media must be designed and adapted to students' needs so as to help them reach their highest potential. Digital technology provides visual models or representations that students cannot obtain through their own efforts. Technology has the potential to make it easier for students to connect their individual representations so as to achieve a strong understanding (Nousiainen, 2013).

Although in general, the multi-representation ability of pre-service physics teacher is stated to be good, when viewed from the 5 indicators of the type of representation studied (the ability to represent image to verbal, mathematical to verbal, verbal to image, verbal to mathematical, and table to graph) it is still found to be low in multi-representation abilities. The results of the analysis of pre-service physics teacher multi-representation abilities for each type of representation are shown in Figure 2.

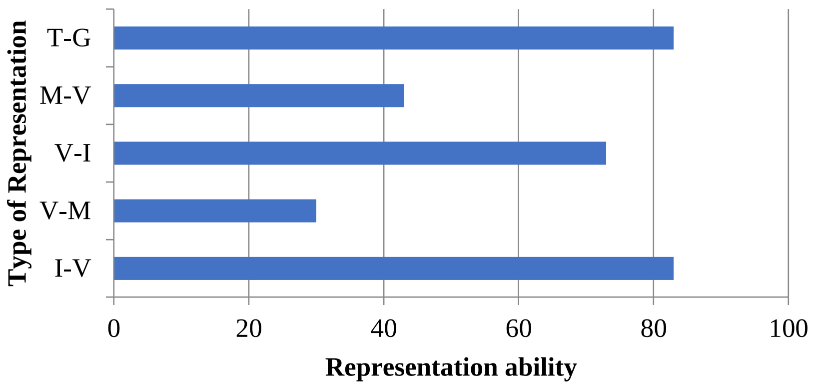


Figure 2. Multi-representation ability of preservice physics teacher in each type of representation

Figure 2 shows that the multi-representation ability of pre-service physics teachers on the verbal to mathematical representation indicator is 30% and included in the bad category. Likewise, the mathematical to verbal representation indicator is in the bad category with a percentage of 43%. Meanwhile, the highest multi-representation ability achieved was in the image to verbal representation indicators, and table to graph representation with a large percentage of 83%, which included in the very good category. Furthermore, the verbal to image representation indicator has a percentage of 73% and is declared good.

In question number 1 relating to charged objects, preservice physics teacher are asked to solve problems in the form of images converted into verbal representations. While in number 2 concerning the implementation of Coulomb’s law where the questions are in the form of verbal representations, they are asked to work on them in the form of mathematical equations. Furthermore, for question number 3 in the form of a verbal representation of the interaction between charges, preservice physics teacher are asked to describe the interaction between two similar charges and two dissimilar charges. In problem number 4, the mathematical equation of the electric field strength is presented. Furthermore, preservice physics teacher are asked to define the mathematical representation in the form of verbal representations or text descriptions. Meanwhile, in question number 5, the data on force and field strength are presented in tabular form, which preservice physics teacher are then asked to work on in the form of a graphical representation of the relationship between electric force and electric field strength.

Based on the findings of the research, it can be said that most preservice physics teacher have difficulty in changing the types of verbal representations to mathematical, and mathematical to verbal representations. Based on the results of the analysis of the answers and interviews, it can be concluded that they still have problems with mathematical representations.

The following are the results of the analysis of preservice physics teachers' multi-representation abilities when viewed from the indicator questions which include electrically charged objects, Coulomb forces, interactions between electric charges, electric field strengths, and the relationship between electric fields and electric forces. Students' multi-representational abilities in question number 1 which is in the form of verbal representations of electrically charged objects are presented in Figure 3.

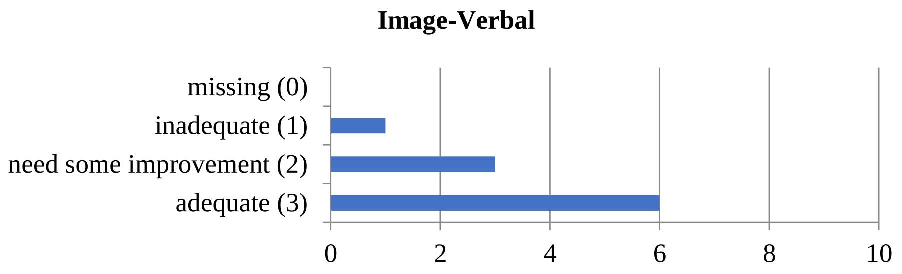


Figure 3. Preservice physics teachers' multi-representation ability in image to verbal representation

According to Figure 3, in question number 1, in the form of image to verbal representation there are 6 out of 10 students who answered completely and correctly, 3 people answered incompletely, and 1 person answered incorrectly. In the question number 1 (see Figure 4) which is in the form of a verbal representation of an electrically charged object, students are asked to change the image representation into a verbal or sentence representation.

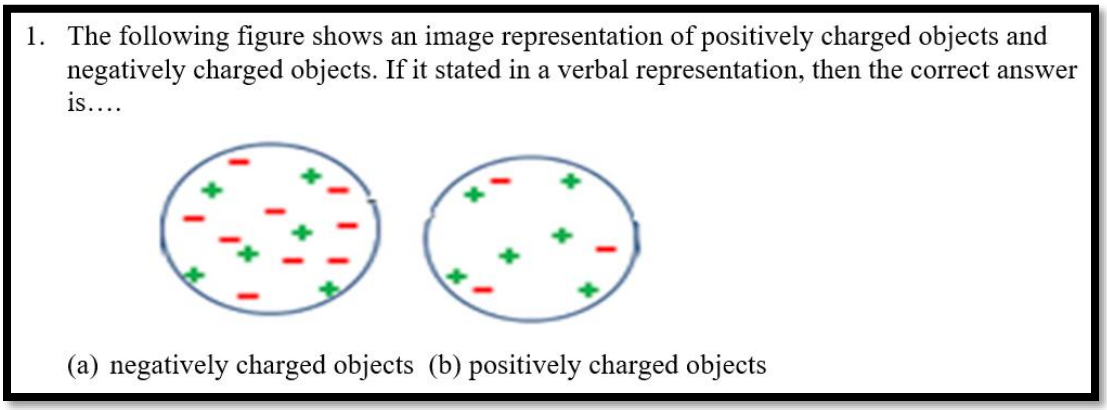


Figure 4. Problem representing images to verbal about electrically charged objects

An example of student completion results for question number 1 can be seen in Figure 5. The difficulties faced by students who are still incorrect in solving the problem, namely not being able to analyze the image representation which shows the number of positive and negative charges contained in two objects so that they are wrong in distinguishing between positively charged objects and negatively charged objects.

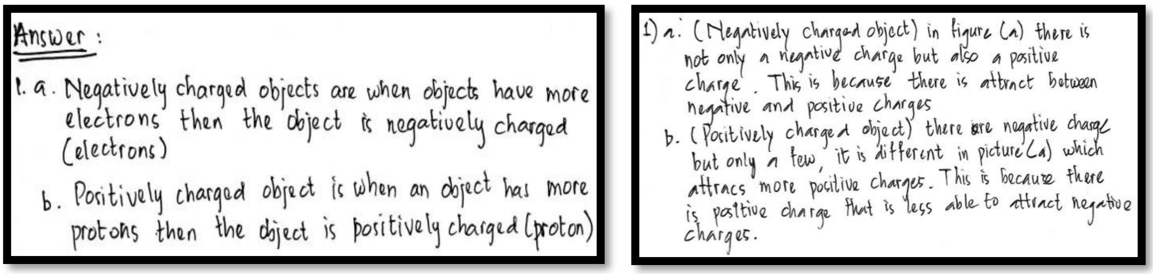


Figure 5. Student completion results; a) complete, b) incorrect

Students' multi-representational abilities in question number 2 which are in the form of verbal to mathematical representations of Coulomb force are presented in Figure 6.

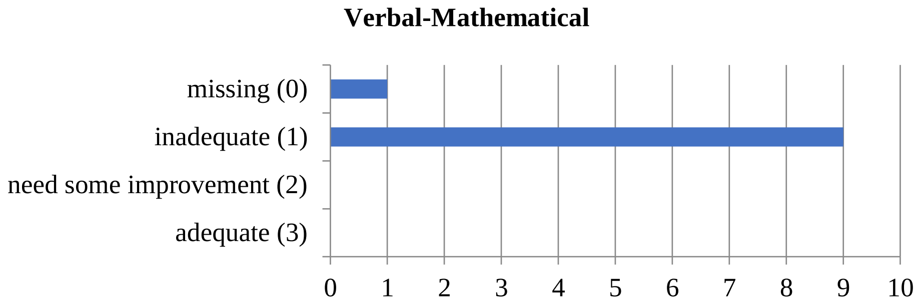


Figure 6. Preservice physics teachers' multi-representation ability on verbal to mathematical representation

In Figure 6 it can be seen that in question number 2 in the form of verbal to mathematical representation there are 9 out of 10 students who answered incorrectly, and 1 person did not give an answer. Based on the results of the analysis, it shows that all of them have not been able to solve problems in verbal form by applying mathematical equations. The problem of number 2 can be seen in Figure 7. In the problem number 2 which is in the form of verbal representation of an Coulomb force, students are asked to change the verbal representation into mathematical representation.

2. The magnitude of the attractive or repulsive force between two electrically charged objects is directly proportional to the charge of each object and inversely proportional to the square of the distance between the two objects. Express the sentence in the form of a mathematical equation!

Figure 7. Problems representing images to verbal about Coulomb force

An example of student completion results for question number 2 can be seen in Figure 8. The difficulties faced by them are due to their not being able to translate the physical quantities that appear in the problem so that it is difficult to determine the required mathematical equations.

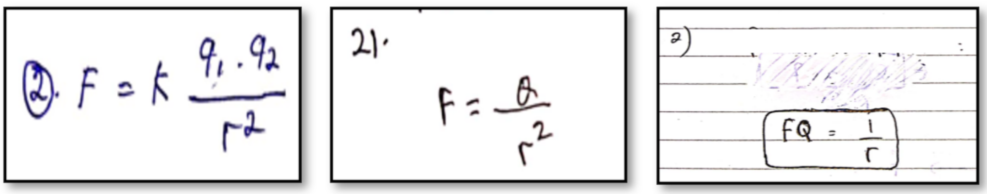


Figure 8. Student completion results; a) complete, b) incomplete, c) incorrect

Students' multi-representational abilities in question of number 3 which is in the form of verbal to image representations of the interaction between electric charges are presented in Figure 9.

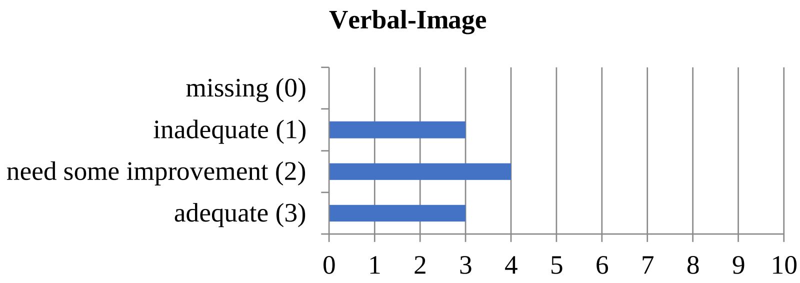


Figure 9. Pre-service physics teachers' multi-representation ability in verbal representation to image

Figure 9 reveals that, in problem number 3, which is in the form of verbal representations to image, there are 3 out of 10 students who answered completely and correctly, 4 students answered incompletely, and 3 students answered incorrectly. The problem of number 3 can be seen in Figure 10 below. In the problem number 3, which is in the form of verbal representation of interaction between electric charges, students are asked to change the verbal representation into image representation.

3. According to the coulomb law, like charges repel and opposite charges attract. Describe the charge interaction as the question!

Figure 10. Problem number 3 in the form of a verbal representation to a picture about the interaction between electric charges

An example of student completion results for problem of number 3 can be seen in Figure 11 below. The difficulty faced by them is that they do not understand the direction of charge flow from a positive charge to a negative charge so that they cannot describe the interactions between similar and dissimilar charges correctly.

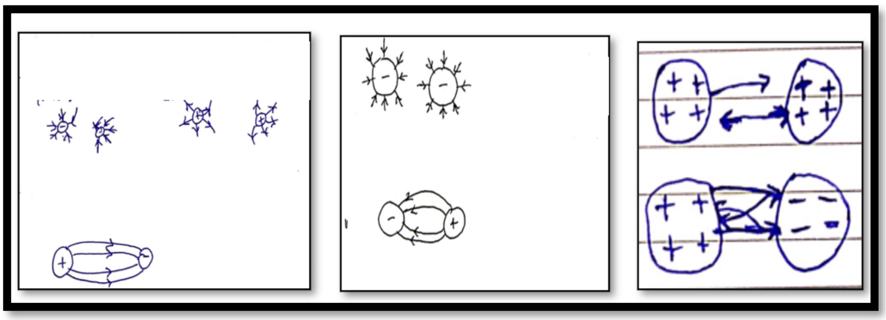


Figure 11. Student completion results; a) complete, b) incomplete, c) incorrect

Students' multi-representational abilities in problem of number 4 which is in the form of mathematical to verbal representations of electric field strength are presented in Figure 12.

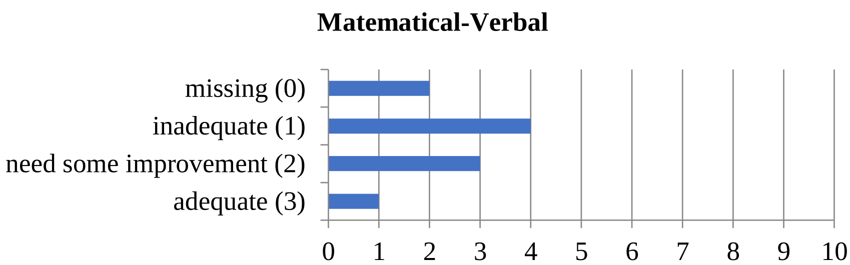


Figure 12. Preservice physics teachers' multi-representation ability on mathematical to verbal representation

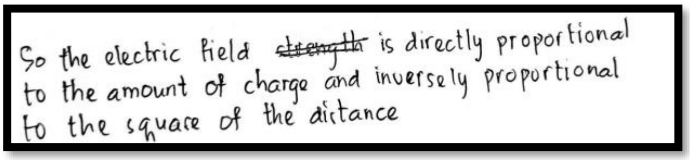
In problem number 4, there are 1 out of 10 students who answered completely and correctly, 3 students answered incompletely, and 4 students whose answers were incorrect and 2 others did not answer (see Figure 12). In the problem number 4 which is in the form of a mathematical to verbal representation of the electric field strength (see Figure 13), students are asked to change the mathematical representation into verbal or sentence representation.

4. If it is known that the mathematical equation of the electric field is as follows, state it in the form of a description of the sentence

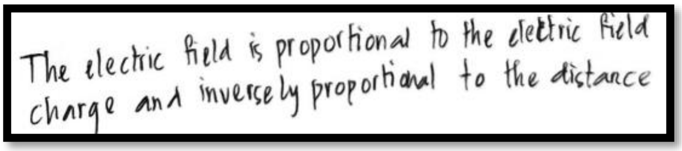
$$E = k\,\frac{q}{r^2}$$

Figure 13. Problem number 4 in the form of a mathematical to verbal representation of the electric field strength

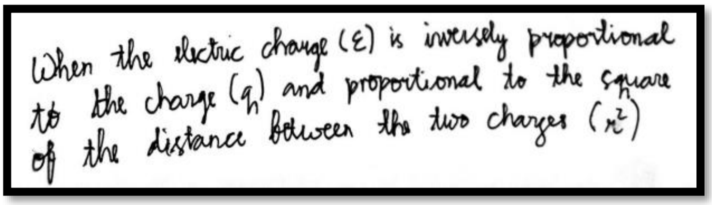
An example of student completion results for problem number 4 can be seen in Figure 14 below. The difficulty experienced by students is not understanding the symbols of the physical quantities that appear in the problem, but because they do not understand the symbols of the physical quantities that appear in the problem.



(a)



(b)



(c)

Figure 14. Student completion results; a) complete, b) incomplete, c) incorrect

Students' multi-representation ability in the problem of number 5 in the form of a table representation to a graph can be seen in Figure 15.

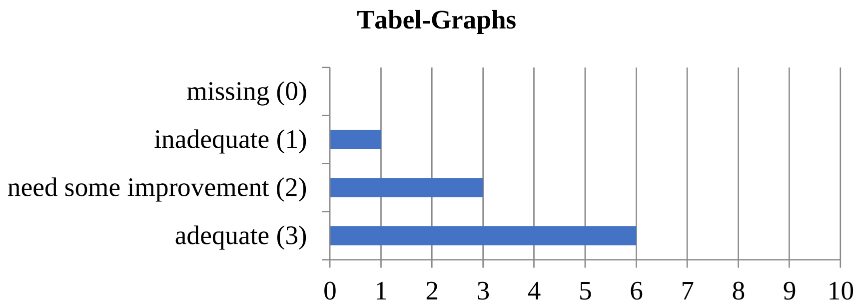


Figure 15. Multi-representation ability of preservice physics teachers in table to graph representation

Figure 15 reveals that in the problem of number 5, 6 out of 10 students answered completely and correctly, 3 students answered incompletely, and only 1 student answered incorrectly. The problem of number 5 is in the form of a tabular to graphical representation of the relationship between electric field strength and Coulomb forces, where students are asked to change the table representation into a graphic representation (see Figure 16).

5. Electric field (E) is directly proportional to the magnitude of the coulomb force (F). Based on the data in the following table, draw a graph of the relationship between both of them!

No.	Coulomb force (F) Newton	Electric field (E) N/C
1	5	10
2	6	12
3	7	14
4	8	16
5	10	20

Figure 16. Problem number 5 in the form of a table-to-graphic representation of the relationship between the electric field strength and the Coulomb force

The example of student completion results for problem number 5 can be seen in Figure 17 below. The difficulty experienced by them is that they do not understand how to draw a line connecting the variables on the x-axis and y-axis. Their answers are considered incomplete because they do not write information on the coordinate axis and describe the direction of the arrow on the coordinate axis.

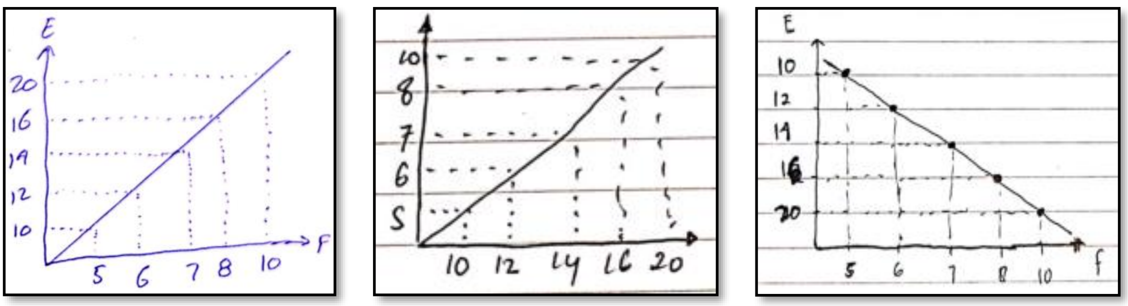


Figure 17. Student completion results; a) complete, b) incomplete, c) incorrect

The results of the analysis of their answers show that they have not been able to translate the physics quantities that appear in the problem so that it is difficult to determine the required mathematical equation. In addition, they also do not understand the translation of the mathematical equations used, thus, it is difficult to apply them in solving problems. This was reinforced by the results of interviews conducted with them who stated that they had difficulty understanding and distinguishing physics quantities that were known and asked in the question because during the online learning process in the covid-19 pandemic, the lecturer's explanation about the elaboration of the physical formula and the quantities contained in the formula is less in-depth. Theoretical concepts are more of a focus in the online learning process. Students are assigned to study the material provided by the lecturer independently and then proceed with discussion and question and answer. Students have difficulty in understanding mathematical concepts of physics through virtual face-to-face learning.

Even though during the research the lecturer used interactive multimedia which presented the concept of static electricity in various forms of representation, but there were still limitations in presenting mathematical equations which only presented formulas and explanations without any in-depth formula explanations. This shows that the use of multimedia affects students' ability to represent physics concepts. Therefore, the use of multimedia plays a very important role in the learning process, especially during the COVID-19 pandemic, considering that there are still restrictions on face-to-face learning activities and social distancing. During the Covid-19 pandemic, its use became very significant because interactive multimedia has advantages that can be used even in distance learning conditions.

Multimedia has a good impact on educators because they have the opportunity to develop learning techniques so that they can improve learning outcomes for the better. Multimedia is also expected to make it easier for students to absorb subject matter quickly and efficiently and can apply independent learning. The use of interactive multimedia-based learning media in the learning process will change boring learning into fun learning. The use of interactive multimedia makes the teacher no longer the only source of student learning because multimedia is expected to make students active in learning. Student interest in interactive multimedia-based learning media will also increase student learning motivation because this learning provides opportunities for students to study independently at any time (Nasution, Harahap, Harahap, & Wahdi, 2022).

The findings in this study indicate that the ability of pre-service physics teachers in representing a concept greatly influences the understanding of the concept. Understanding concepts is not enough just to memorize them because concepts in physics need to be explained in various representations. The appearance of various representations can help students understand the concepts they are learning. This is related to the abilities possessed by each student, where there are students whose verbal abilities are more prominent than their spatial and quantitative abilities, and vice versa. If a concept is presented in only one representation, it will only benefit some students (Dunlosky et al., 2013). Various studies have shown that the ability of representation is related to the understanding of physics concepts (Demirbag & Gunel, 2014; Franco et al., 2012; Nussifera et al., 2017); and problem-solving skills (Simbolon et al., 2017). Pre-service physics teacher must have representation skills in order to help the learning process or overcome students' difficulties in understanding physics concepts (Kohl, Rosengrant, & Finkelstein, 2007; Nurrahmawati et al., 2019; Zhuang et al., 2021).

Conclusion

Based on the results of the analysis and discussion, it can be concluded that the pre-service physics teachers’ multi-representation abilities are generally good. This can be seen from the average percentage obtained by 63%. However, when viewed from the type of representation, students’ multi-representation ability on verbal to mathematical representation indicators is still bad with an average percentage of 30%. Likewise, the indicators of mathematical to verbal representation are in the bad category with an average percentage of 43%. For this reason, it is still necessary to make efforts to increase the multi-representation ability of preservice physics teachers’ by using approaches, teaching materials, and learning media that are able to teach and present physics concepts in various forms of representation so that they are easier to understand the concepts presented.

Acknowledgment

The authors would like to thank to the leadership of the university and the faculty of teaching and education at Khairun University who have provided financial support through the 2022 PKUPT grant.

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