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Bibliometric Analysis of Multi Representation Based on Problem-Solving Skills Using VOSviewer

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Abstract

The purpose of this study was to analyze the scope related to the subject of problem-solving skills based on multiple representation in 2016 – 2020 with 20 documents through bibliometric analysis. The research method used was a literature study through all the articles analyzed in this study. The articles were taken from the Scopus database with sampling in 2003 – 2020, resulting in 29 scientific work data exported in *.ris (RIS) and *CVS formats. Then, those data were processed using VOSviewer and Microsoft Excel. The results of publications in the last five years have increased. Indonesia is the dominant country in publicizing papers about this topic. Institutions from Germany managed to publish most of the documents about multi representation. Meanwhile, Poland is the origin country of the authors with most publications. The visualization of research trends on multi representation resulted in four main clusters: (1) multi representation related to students, representation, and learning processes (2) multi representation as a class (3) multi representation related to the problem (4) multi representation as a model and process. Meanwhile, Indonesian researchers are very active in contributing to this topic, in line with the number of publications by country, namely Indonesia.

Keywords: Bibliometric Analysis; Multi Representation; Scopus; Vosviewer

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INTRODUCTION

One of the essential skills in Physics is problem-solving skills. Problem-solving skills in physics learning are a vital part of the curriculum in Indonesia (Kemendikbud, 2016). In general, the development of problem-solving skills is one of the focuses on 21st century educational goals (Kivunja, 2015), especially in physics education (Shishigu, Hailu, and Anibo, 2018). Problem-solving is an important part of scientific reasoning because it affects emotional, cognitive, and psychomotor enhancement and changes (Alshamali & Daher, 2016).

Physics learning is said to be successful if students can master problem-solving skills from the material taught. This fact is in line with one of the learning outcomes according to the INQF (*Indonesian Qualification Framework*) (Jatmiko et al., 2016), and one of the 21st-century learning achievements are *problem-solving* (Bellanca and Brandt,

2010). However, the ability of Indonesian students to solve physics problems is still low (Eriza et al., 2017). To be able to solve these problems, learning strategies and appropriate approaches are needed. Applying appropriate learning approaches and models positively affects achieving goals and training students' problem-solving skills (Cvetković & Stanojević, 2017; Naz & Murad, 2017). Applying learning strategies to overcome problem-solving skills in physics learning is necessary, such as the multi representation approach (Simamora, Sinaga, and Jauhari, 2016).

The multi representation approach consists of two words, namely multi and representation. Multi means various, while representation means the method used in demonstrating the situation or series of activities (Doyan, Taufik, and Anjani, 2018). Retranslating similar concepts in different formats, including pictures, verbal, graphics and mathematics, is a multi-representation understanding (Waldrip, Prain, and Carolan, 2010).

In the process of learning physics, representation does not only use graphics, pictures, and verbal representation. However, mathematical representation also uses its function to visualize a set of variables with the system and describe the related variables (Angell et al., 2008; Opfermann, Schmeck, and Fischer, 2017). Researchers say that if students can understand various types of representations, it will encourage students to form a perfect understanding of scientific knowledge (Ainsworth, Prain, and Tytler, 2011; Rosengrant, Van Heuvelen, and Etkina 2006).

The role of multi representation in the process of improving problem-solving skills is crucial. Multi representation can be used as an alternative instruction for learning physics. It is beneficial for students to understanding a concept and visualizing problems before proceeding to the derivation or mathematical equations (Hartua, 2016). The results of several studies suggest that multi representation-based learning can be used to improve problem-solving skills, representation skills, physics learning outcomes and mastery of a concept (Abdurrahman et al., 2011; De Cock, 2012; Doyan et al., 2018; Sutopo, 2013).

The purpose of this study was to analyze the scope of multi representation-based problem-solving skills in terms of the distribution of bibliometric mapping with the following questions: (a) How is the distribution of publication results and types of documents in *Multi Representation* research during 2016 – 2020? (b) What is the distribution of publications on *Multi Representation* research by country and institution in the world? (c) Who are the top authors in *Multi Representation* research? (d) How are the results of visualization of *Multi Representation* research trend*?*(e) How is the contribution of researcher from Indonesia to *Multi Representation* research?

METHOD

The method used in this research was a literature study through all the articles analyzed in this research taken from the Scopus database. Scopus is one of the best complete *peer-review* journal databases globally, and it can provide information related to scientific and academic well (Klapka & Slaby, 2018). The research was conducted by searching for articles online in April 2021 with the keyword of "*Multi Representation-Based Problem-Solving Skills*". The period used in this sampling was 2003 – 2020. Based on the search results, the researchers obtained 29 scientific work data exported in *.ris (RIS) and *CVS format, then processed using VOSviewer and Microsoft Excel. The data analysis process used documents in the 2016 – 2020 meantime, as many as 20 documents.

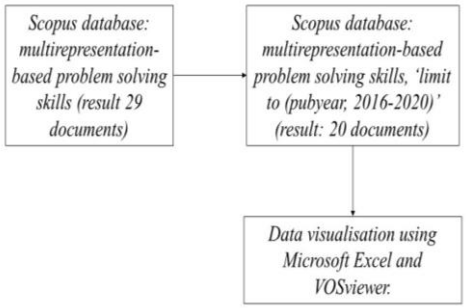

Figure 1 Research procedure

To visualize and analyze the parameters of the bibliometric map, we can use VOSviewer (Van Eck and Waltman, 2010). VOSviewer can create publication maps, country maps, or journal maps based on networks (Hudha et al., 2020).

RESULT AND DISCUSSION

Publication results and document types

The results of mapping the publication of multi representation-based problem-solving skills articles from 2016 to 2020 are shown in Figure 2. The total number of documents during the last five years has increased. It can be predicted that the following year will experience a significant increase because this document includes a document novelty. In 2019, there were six documents published, while in 2020, there were three documents published.

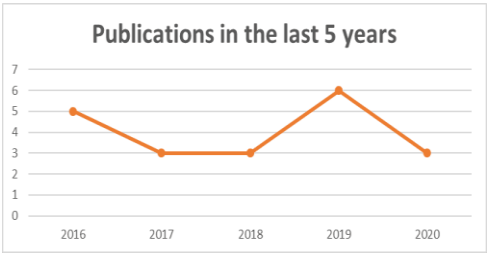

Figure 2 Number of document publications during 2016-2020

The types of documents published in 2016 – 2020 were various. *Conference Paper* was the type of document with the most publications, namely 13 documents *Conference Paper*. The fewest were *Books* and *Book Chapters*, which only had one record, as seen in figure 3.

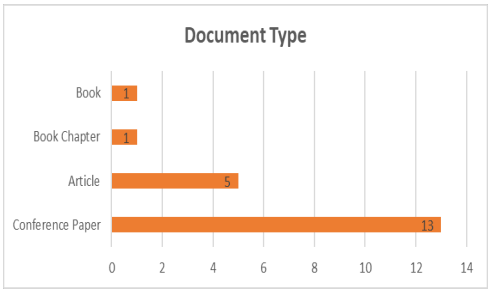

Figure 3 Number of Multi Representation articles by category of document type

Distribution of countries and institutional publications

Based on the number of document publications in various countries (Figure 4), Indonesia dominated with six documents from 2016 to 2020. The second place was Poland and France, with three papers published. Other countries such as China, Germany, and the UK contributed two documents on this topic.

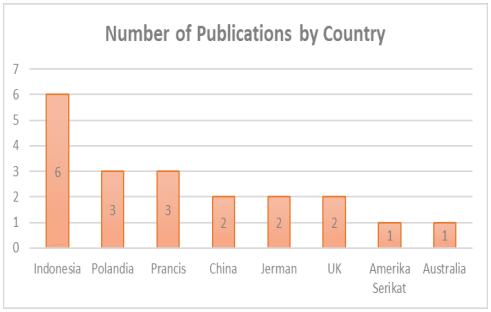

Figure 4 Number of publications of Multi Representation articles by country (2016-2020)

The number of multi representational article documents by the institution can be seen in Table 1. Germany ranked first with the Technische Universität Berlin (TU Berlin) which had five documents. The second rank was the United Kingdom, with the University of Oxford contributed four documents. Indonesia was not included in the top 5 institutions with the highest number of records.

Table 1 Number of Multi Representational article documents by the institution (2016-2020)

No	Institution	Number of Documents
1	Technische Universität Berlin, Germany	5
2	University of Oxford, United Kingdom	4
3	AGH University, Poland	3
4	Sorbonne Université, France	3
5	UNSW Sydney, Australia	3

Top Authors in Research on Multi Representation-Based Problem-Solving Skills

In terms of the most prolific authors, figure 5 shows the top seven authors researching *Multi Representation-Based Problem-Solving Skills.* Skowron, P. and Faliszewski P., were the most prolific authors on this topic.

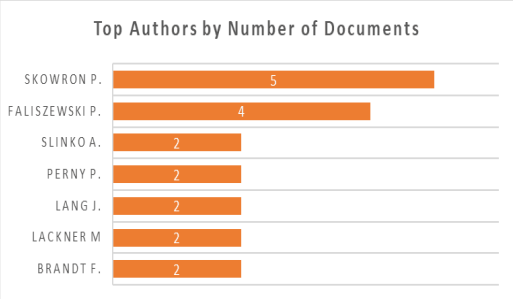

Figure 5 Top authors in Multi Representation research in 2016 – 2020

One way to see the author's performance is by citing articles over the years, which can be seen in Table 2. One of them is that Brandt had 284 citations until April 2021.

Table 2 Most citations to Multi Representation articles in 2016-2021

Authors	Journal	Number of Citation
Brandt F., Conitzer V., Endriss U., Lang J., Procaccia A.D. (2016)	Handbook of Computational Social Choice	284
Skowron P., Faliszewski P., Lang J. (2016)	Artificial Intelligence	71
Bredereck R., Faliszewski P., Igarashi A., Lackner M., Skowron P. (2018)	32nd AAAI Conference on Artificial Intelligence, AAAI 2018	20
Lian J.W., Mattei N., Noble R., Walsh T. (2018)	32nd AAAI Conference on Artificial Intelligence, AAAI 2018	12
Skowron P., Faliszewski P., Slinko A. (2019)	Journal of Economic Theory	8

Visualization of Research Topics on Multi Representation Based on Problem-Solving Skills Using VOSviewer Software

The minimum number of relationships between terms in using VOSviewer is set in seven terms. After being analyzed using VOSviewer, four clusters (red, green, blue, and yellow) were found, showing the relationship between one topic and another. VOSviewer can display bibliometric mappings in three different visualizations; *network*

visualization, overlay visualization and density visualization. Keywords were labelled with coloured circles. The size of the circle was positively correlated with the occurrence of keywords in the title and abstract. Therefore, the size of letters and circles was determined by the frequency that occurred. The more often the keyword appears, the larger the font and circle size will be.

The overall research topic relevant to multi representation-based problem-solving skills produced 98 records using the relationship between two terms. After the analysis, four clusters can be seen in figure 6: the red cluster with the dominant topics were students, representation, and the learning process. The yellow cluster has a prevalent topic, namely class. According to Ligorio et al. (2017), students can show their learning process individually by using representations to be interpreted as multidimensional. The development of representation can be observed through class and gender. The blue cluster has a dominant topic, namely problems and multiple representations. In line with research conducted by Dewati et al. (2019), the use of multiple representations can make it easier for students to solve problems. The green cluster has a dominant topic of models and processes. In line with Siswanto, Susantini, and Jatmiko (2018) research, the learning model with an *Investigation-Based Multi Representation* is more practical if used in physics learning activities.

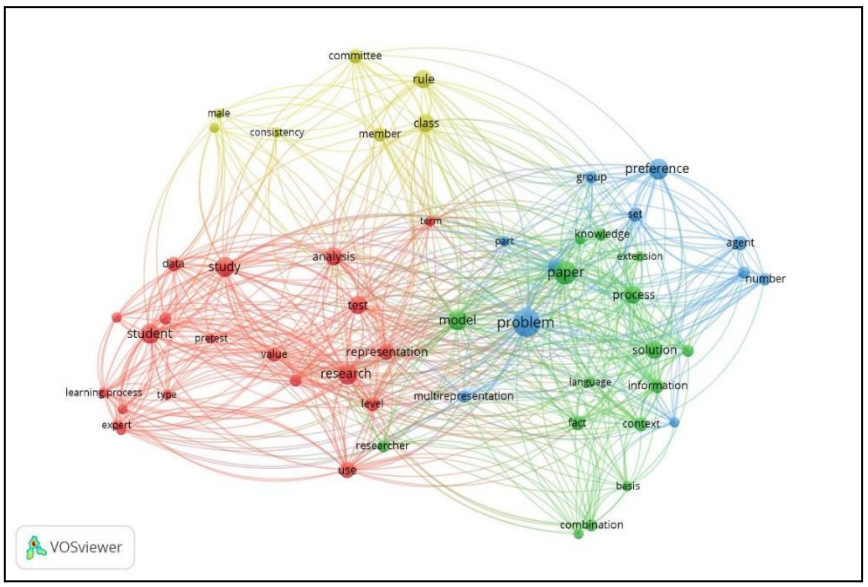

Figure 6 Visualization of Research Topics Using VOSviewer Software with *Network Visualization*

The map distribution of the visualization is disparted into a bound relationship according to the keyword of Multi Representation, and then several findings are obtained as follows:

The dominant keyword is “problem”, and it can be emphasized that the visible relationship is the one between multiple representations and problems that can be seen in figure 7. It is based on the fact that solving a problem can be done with multiple representations (Dewati et al., 2019). By involving multiple representations to solve a problem, doing research should collect facts to find solutions or solve problems. In the

learning process, it is necessary to use a suitable learning model to complement multi representations. Problem-based learning models can help students improve their problem-solving skills. Problem-Based Learning based on Multi Representation is considered an appropriate method to solve a problem because Multi Representation-assisted students can understand materials with various existing representations. Also, in the implementation of Problem-Based Learning, students must be actively involved in conducting useful investigations to find solutions to existing problems or to solve problems (Nova, 2021). Other than Problem-Based Learning, another learning model can also help students improve problem-solving skills, one of which is the Investigation Based Multiple Representation (IBMR) learning model (Setyarini et al., 2021). In the distribution below, there is also a relationship between students and Multi Representations.

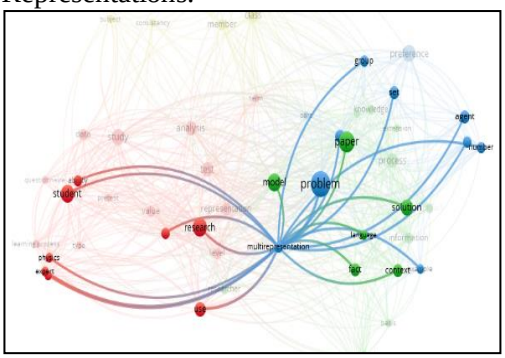

Figure 7 The relationship between Multi Representation and problem

The relationship between students and multiple representations is shown in detail in Figure 8. Figure 8 shows that students can do Multi Representation. However, the completion process is carried out in stages, such as recognizing problems, learning processes, applying appropriate models, conducting research, conducting *pre-tests* and *tests*, and analyzing.

An analysis is needed because there are verbal, graphic, and mathematics in Multi Representations. The graph can be used to answer the questions asked so that in the completion process, analytical skills are needed. Proving that the student can do multiple representations was done by giving a *pre-test* and a *test*. The pre-test contained various kinds of questions based on Multi Representation, such as the questions of mastery of concepts and pictures or graphs that supported the explanation of the questions. The answers to these questions used mathematics (for the exact sciences).

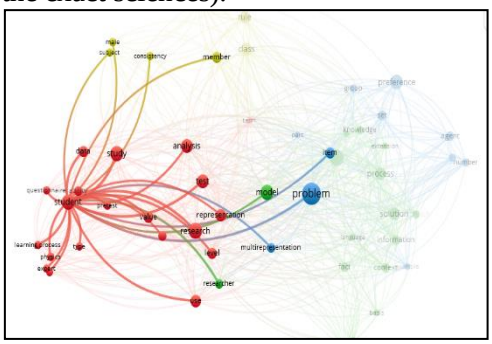

Figure 8 The relationship between students and Multi Representation

The relationship between physics and Multi Representation is that Multi Representation can be used to solve a physics problem, as shown in figure 9. One of the learning process strategies carried out by physics teachers is Multi Representation (Dewati et al. 2019b; Prahani et al. 2016). By applying this Multi Representation, students are expected to solve problems related to physics (Theasy, Wiyanto, and Sujarwata, 2017).

In applying Multi Representation in physics subjects, measurement indicators are needed, such as *pre-test* and *post-test.* Generally, in completing the pre-test and post-test in physics learning, Multi Representation has been applied, such as verbal, graphic or picture, and mathematical. Meanwhile, the pre-test and post-test questions only used verbal Multi Representation indicators and graphs/pictures. One way to apply pre-

test and post-test is to use student worksheets, but teachers used student worksheets for activities in the post-test. In this case, there was a Multi Representation worksheet based on problem-solving in physics learning with an outstanding response from students. Students liked it because the language, subject matter, writing, pictures, and layout were easy to understand. Students' problem-solving skills were included in good criteria when measured using the worksheet (Maharani et al., 2015).

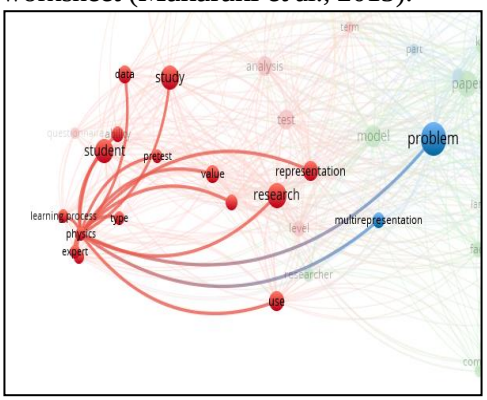

Figure 9 Relationship between physics and Multi Representation

The distribution of researchers depends on the country and the involvement of research documents with each other. Skowron, P. occupied the highest position as a researcher, seen from the size of the circle, which is larger than the others, as seen in figure 10. Faliszewki, P. And Lackner occupied the next position, M. Author Skowron, P. has tied to several authors, namely Aziz, H., Lackner, M., Bredereck, R., Brandt, F., Stahl, K., and Conitzer, V. Authors in this relationship did not publish articles at the same time, they published them at various times, as it is seen from the colour parameter indicator in each author's name.

In Figure 10, a year parameter shows the year the author's article was published in the journal. The purple indicator of author parameters is more than others so that many authors published articles in that year. However, these authors are not related to each other. It is characterized by the absence of a network or line that connects the authors.

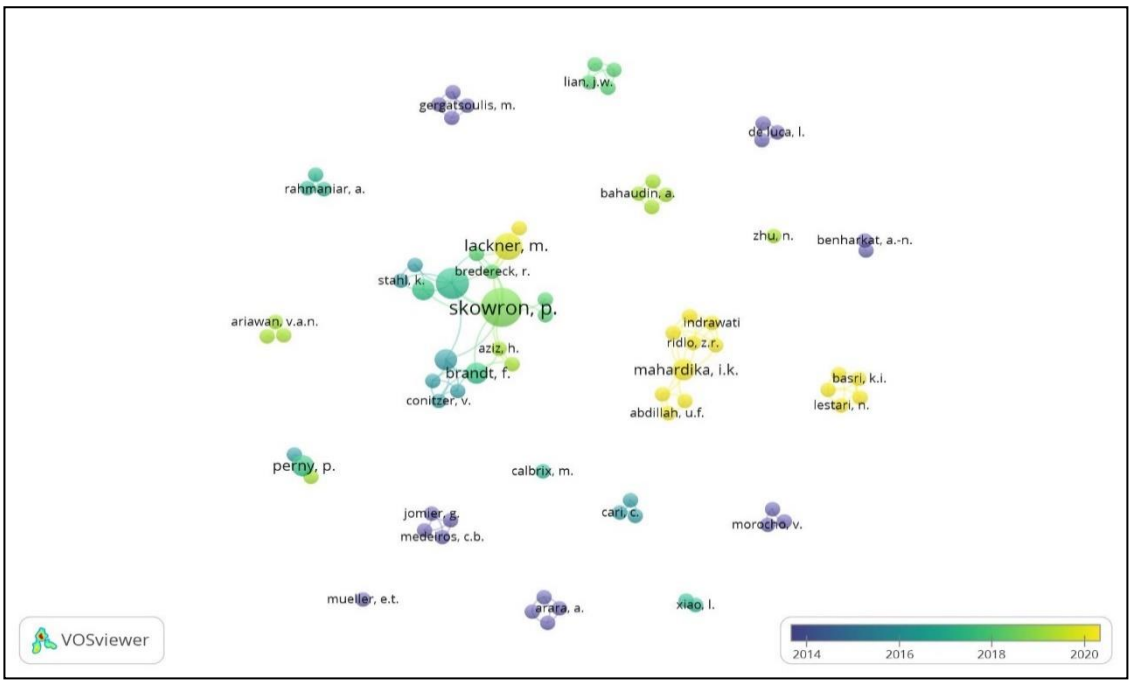

Figure 10 Researcher Visualization Using VOSviewer Software with *Network Visualization*

Many researchers from Indonesia are not related, but many researchers from Indonesia have published documents or articles in the last five years, namely in 2016-2020. In line with the number of publications by a country, Indonesia ranked first with the most publications than other countries. There is one author with three or more interconnected small circles. The small circle indicates that the author has written more than 1 article, or it can be said that the number of small circles is the number of articles written by the author. In figure 11, we can see that many Indonesian researchers contributed to this research.

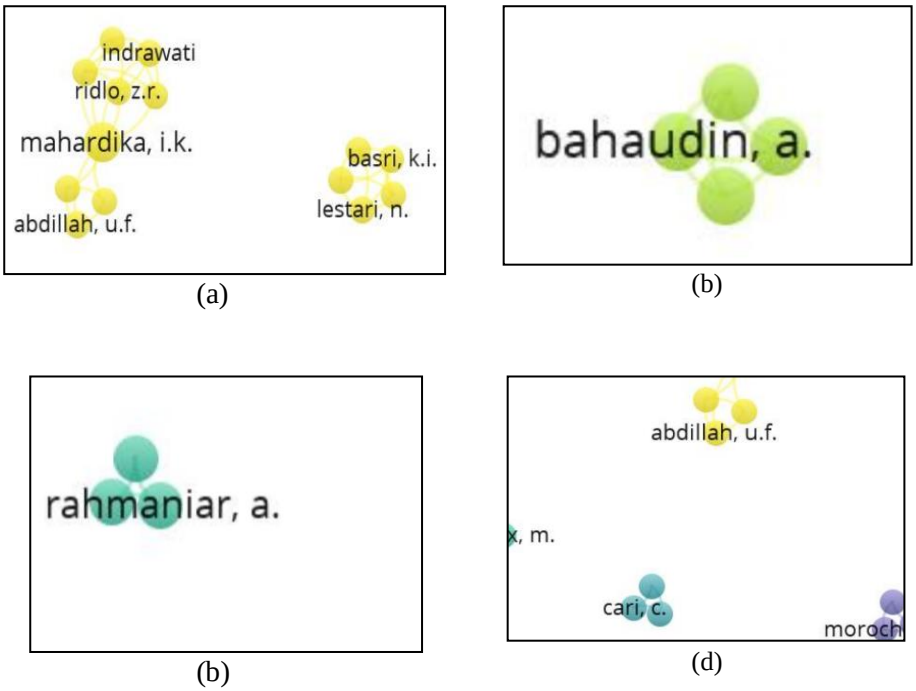

Figure 11 Visualization of Indonesian Researchers

CONCLUSION

Multi representation in the learning process can help students understand concepts, improve their problem-solving skills in physics learning, and visualize problems before using their mathematical equations.

Several important points can be obtained from the research trend *Multi Representation* during 2016-2020. The results of publications in the last five years have increased. The type of document *conference paper* ranked first with more numbers of articles. Indonesia was the dominant country in the publication of this topic. Institutions from Germany managed to publish the documents about *Multi Representation* the most. Meanwhile, Poland was the origin country of authors with the most publications.

The visualization of research trends about multi representation resulted in four main clusters: (1) Multi Representation related to students, representation, and learning processes, (2) Multi Representation as a class, (3) Multi Representation related to the problem, and (4) Multi Representation as a model and process. Meanwhile, Indonesian researchers were very active in contributing to this topic, in line with the number of publications by country: Indonesia.

The limitation of this paper was the focus of analysis on Multi Representation based on problem-solving skills in the 2016 – 2020 period. The results in this

paper can help researchers find trends in Multi Representation research in the world which can be used as a direction for further research on Multi Representation to improve problem-solving skills.

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