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Research Analysis on Multi Representation in Physical Materials in The Year of 2014 to 2021

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ABSTRACT

This research has the goal of analyzing the research of multi representation capabilities in physical matter. This research is a literature study with bibliometric analysis. Secondary data collection of research using Publish or Perish (PoP) in the form of articles of the last six years (2014-2021) on Google Scholar and Scopus. The results of the analysis of 19 research articles were analyzed based on the number of studies each year, VOSViewer visualization, multi representation of measured abilities including problem-solving, understanding concepts, student activities. The highest number of publications in 2021 was 6 articles, in 2015, 2016 there was no VOSViewer Visualization obtained by three dominant clusters. There are seven articles linking multi representation capabilities to problem-solving abilities for a variety of physical materials. The application of multi representation to the understanding of concepts in some materials has been carried out in as many as seven studies. This research is expected to be the next research reference in analyzing the application of appropriate learning models to improve the multi representation ability of learners for various levels of education.

INTRODUCTION

Physics is a branch of science that studies the symptoms of nature associated with matter and energy. Natural symptoms are compounded by the interaction of various physical magnitudes. Informing natural symptoms one or more physical quantities are interconnected and interact with each other. To facilitate the process of analysis and explanation of natural phenomena, physicists usually use various forms of representation of multi representation abilities can enrich the student context so as to strengthen the understanding of concepts (Abdurrahman et al., 2019; Becker et al., 2020; Purba & Hwang, 2017; TMS & Sirait, 2016), correct diagramming helps students in solving challenging problems (Falkner et al., 2014; Surya et al., 2013; Van Garderen et al., 2013), multi representation is important in physics learning (Mehta & Schwab, 2014; Montavon et al., 2013; Sengupta et al., 2013).

Multi representation is able to help formulate student goals and memory loads during the problem-solving process, multi representation approach can improve students' cognitive abilities (Widianingtiyas, et al., 2015), multi representation is able to improve mental models, and correct visual representation correlates with the student's understanding of physics concepts (Jauhariyah & Wasis, 2018). There is a tendency: the higher the student's multi representation skills, the higher the conception of the student. Representation is a form that can describe something in another form. Multi-representation is to re-represent the same concept in other forms including images, graphics, and mathematics. The three main functions of multi-representation, namely (1) Complimentary; (2) Interpretation limiters; (3) Building understanding (Ainsworth, 1999).

The ability of multi representation can be interpreted as the ability to apply some type of representation to the concept of physics (Kusumawati et al., 2015). Multi representation is a way to describe a concept through various types of forms such as verbal, graph, and mathematical. Based on some of these understandings, it can be concluded that multi representation way of applying various types of representations in verbal, graphic, and mathematical forms into a concept. A concept should use various representations to equally benefit learners. If you only use one representation, then the one who benefits is also the only one. For example, if a concept is only presented in verbal representations, then learners whose mathematical abilities are more prominent will have difficulty understanding the concept. Previous research conducted by Huda et al., (2016) implemetationof multi-representation in physics learning tools significantly improves students' grades. In other research conducted by Theasy et al. (2018) multi-representation capabilities integrated by high, medium, and low category students each have significant differences in Physics learning.

Based on the description above shows that the multi representation ability of learners has a strong relationship with the understanding of physics and other abilities needed by students to understand and interpret physics concepts. There has been a lot of research related to multi representation that has been done. The research included a multi representation profile for certain physical materials of learners, describing the relationship of multi representation ability with problem-solving ability, the relationship of multi representation ability with understanding concepts, and others. To review previous studies that have been done and published, this research is carried out

RESEARCH METHOD

This research uses a type of library research (literature research) aimed at analyzing the application of guided inquiry learning models based on science literacy in physical learning using bibliometric analysis methods. Bibliometric analysis is used to evaluate the progress of knowledge in the literature using mathematical and statistical approaches (Ayudha & Setyarsih, 2021).

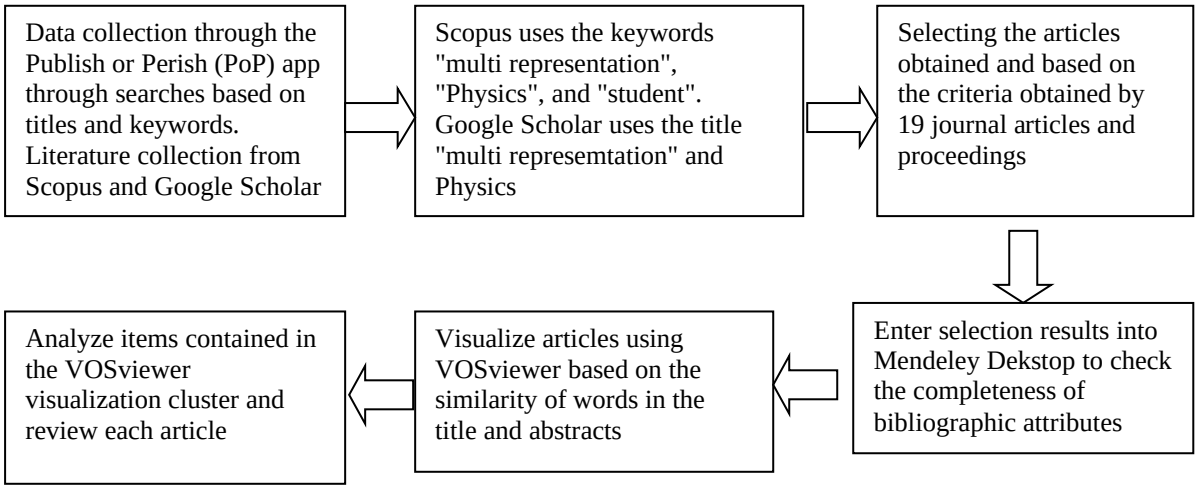

Figure 1. Research flowchart diagram.

The research data used in this study is secondary data obtained from articles and preceding over the last 5 years (2016-2020) and obtained as many as 19 journal articles and 2 preceding articles. This research data collection was conducted in November 2021.

Data acquisition is explained in the flowchart that can be viewed in Figure 1. Bibliometric mapping results using Co-Occurrence calculations on VOSViewer. Co-occurrence analysis is done to find out research in using the topic. Keywords that are increasingly related or paired indicate there is a relationship between keywords.

RESULTS AND DISCUSSION

Year of Article Publication

The results of mapping the publication of multi representation research in physics from 2014 to 2021 are shown in Figure 2. The number of documents over the past seven years has increased. It is estimated that in the following year it will experience a significant increase as multi representation research begins to gain attention.

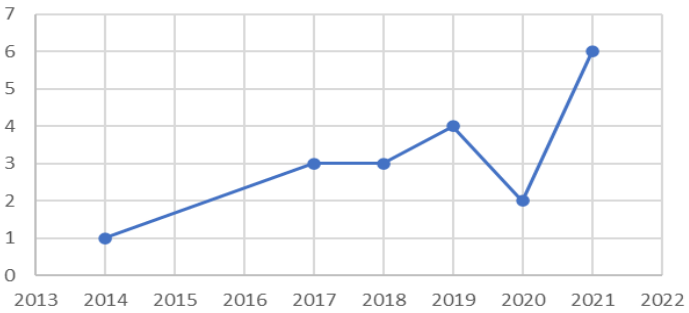

Figure 2. Article publications 2014 to 2021.

Figure 2 shows the most published article on multi representation research in physics learning in 2021 amounted to 6 articles. In 2014, the fewest articles were published. This research still needs to be done further research. Multi representation represents the same concept with different modes of representation, such as graphs, diagrams, verbal, and gestures.

VOSViewer Visualization of Multi Representation Research in Physics

The results of visualization of multi representation research topics in physics using VOSViewer software in 19 research articles found several research variables. Analysis of the relationships between variables that become a network with each other results in several clusters shown in Figure 3.

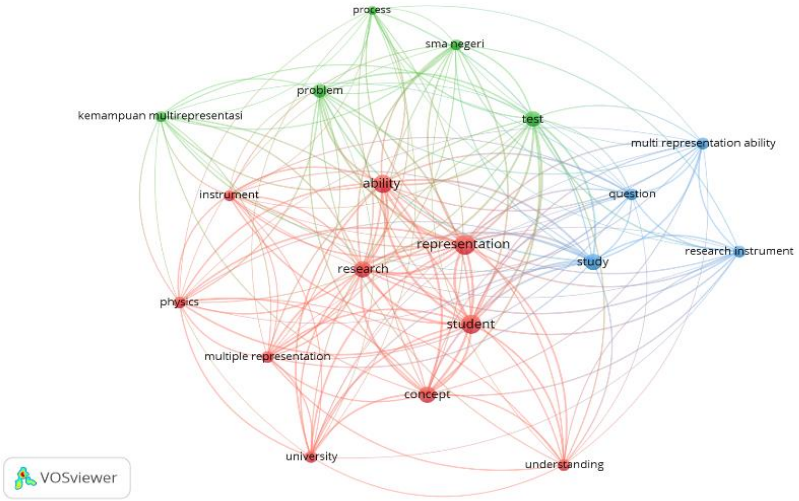

Figure 3. Network visualization VOSViewer.

Figure 3 shows a mapping based on the keyword of the article obtained by three clusters with each colour related to multi representation research in physics can be seen in Table 1. The findings in this study, the keywords "representation", "ability" and "student" indicated the dominant nodes in the red cluster, suggesting representation has a role in improving the quality of students' understanding.

Table 1. Topics of discussion in clusters.

Colours	Topics of Discussion
Red	Representation, student, ability, research, concept, instrument, physics, multiple representations, university, understanding
Green	Problem, test, state high school, process, multi representation ability
Blue	The study, question, multi representation ability, research instrument

Green clusters have the dominant keywords "test" and "problem". Students' abilities can be measured by completing various tests. The exam given by the teacher can measure students' multi representation ability (Harra H., et al., 2020). The blue cluster has the dominant keyword "study". The larger the nodes on the keyword, meaning that the keyword is related to other keyword.

Multi Representation Study of Measured Student Abilities

Physics learning through multi representation is effectively applied to help students understand the concepts of physics. Some of the topics discussed in the cluster have relationships between variables, namely the abilities measured in student multi representation research, including problem-solving, understanding concepts, multi representation skills, and learning activities that can be seen in Figure 4.

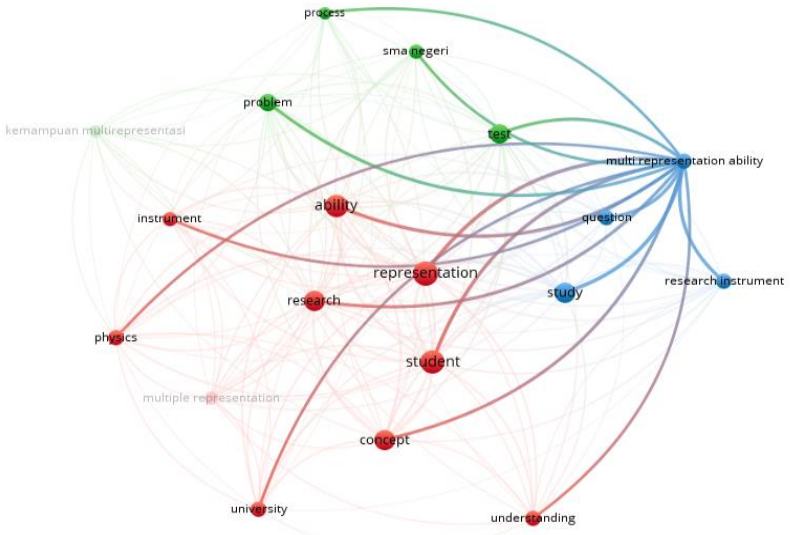

Figure 4. Multi representation and measured student ability.

Figure 4 shows the use of various representations assisting students in knowledge, mastering concepts, and solving problems in physics learning. Students' multi representation abilities can be investigated using an instrument assessment in an effort to improve the achievement of better quality physics learning. Students' success in problem-solving and understanding physics concepts needs to be balanced with successfully understanding and using multi representation.

Problem Solving

The multi representation approach is problem-solving with various modes of representation such as image, verbal, graphic, and mathematical. Multi representation is used as an effective way of solving problems. Thus, the ability of students in solving a physical problem is supported by mastery of these representation concepts. Research on the ability of multi representation related to solving physical problems has been carried out by several researchers including Table 2.

Table 2. Results of multi representation studies on problem-solving.

Authors	Materials	Findings
Dharma & Sudarti (2021)	Electromagnetic radiation	Students' ability to use multi representation is inconsistent in solving the characteristics of electromagnetic waves. On the student's ability verbal representations and images of good Christianity.
Harra et al. (2020)	Newton's Law	A multi representation approach can solve physics problems. This is evidenced by the results of students' multi representation ability on Newton's law of gravity's material of high category. Students tend to solve mathematical representation problems by 100%, compared to verbal by 40% and drawing by 10%.
Yoan et al. (2018)	Work and Energy	Learning business material physics and energy using multi representation can improve students problem-solving. The accuracy of the use of multi representation in high, medium, and low category students in each aspect of representation each has a maximum score of 100%.
Anugraheni & Handhika (2018)	Fluids	The ability of student representation based on his daily life. Students tend to obtain the highest scores on verbal representation and graphic representations obtain the lowest grades.
Bollen et al. (2017)	Vector	Multi representation provides benefits in the physics of vector field matter in the form of a better understanding of the graphical and symbolic representations of vector fields.
Theasy (2017)	Work and Energy	The use of multi representation in the problem solving of business matter and energy shows the highest tendency toward mathematical representations. This is evidenced by the ability of students in solving problems influenced by their ability in mathematical calculations and verbal understanding of the language of the problem.

Based on the results of studies on several references, representations can be done for solving a problem related to physics. Multi representation-based learning models are suitable for solving problems, as students are helped easily to understand the material with various representations. The liveliness of students is also one of the factors in solving existing problems. When viewed in terms of students who are less active about the forms

of concepts in physics that actually make it easier for students to solve problems not only through memorization of equations or formulas (Anugraheni, N. S., & Handhika, 2018).

Concept Understanding

Understanding concepts is a major focus in physics research, due to the understanding of concepts based on more complex abilities and high-level thinking abilities. One of the concepts of good understanding is to solve a problem precisely and quickly that students apply according to the material. Material can be verbal, visual, mathematical, and graphically called multi representation. Multi representation has three main functions, among others, as a complement, limiting interpretation, and understanding of concepts that are coherent or more in-depth. The application of multi representation to the understanding of concepts in some materials has been carried out by several researchers as in Table 3.

Table 3. Results of multi representation study on understanding concepts.

Authors	Materials	Findings
Tristanti & Sudarti (2021)	Electromagnetic radiation	Multi representation ability can increase mastery of concepts. This is evidenced by the understanding of the concept of electromagnetic waves more towards understanding the concept of verbal representation than tables. The verbal ability presents questions related to a concept.
Aisyah & Sudarti (2021)	The Sun's Core Reaction	Educators use multi representation skills so that students can understand the delivery of materials. Through a verbal approach, students tend to better understand the concept of the sun's core reaction. Student answers are still not right when using an imaging approach because it is not familiar.
Campos et al. (2020)	Electric Field	The use of multi representation helps develop an understanding of concepts. This research uses semiotic representation, which is a relationship between the understandings of three representations used in the understanding of the concept of electric fields. There are student difficulties with the representation of electric field lines and diagrams.
Furqon & Muslim (2019)	Newton's Law	In addition to demonstrating an understanding of concepts, the ability of multiple representations also builds a coherent conceptual understanding. Students are more in the master of vector representations on Newton's legal material about resultant forces.
Kassiavera et al. (2019)	Work and Energy	The skill of double representation on verbal and mathematical aspects is easier for students to understand in the concept of the law of conservation of energy. Meanwhile, aspects of images and graphics have low representation. It is that students do not understand the concept correctly.

Authors	Materials	Findings
Kusumawati et al. (2019)	Time Dilation	Java island students have an understanding of concepts through a multi representation approach with the highest percentage compared to Kalimantan island and Papua island. Multi representation learning provides students with opportunities in connecting words and images.

Based on the findings of several relevant studies, the ability to multi representation through verbal representation is easier for students to understand concepts. Students better understand verbal questions with sentences that are familiar in physics, compared to other representations. The ability of verbal representation is the ability to understand a theory by using verbal sentence instruments. If students have good multi representation skills, they will have a good understanding of concepts as well.

Multi Representation Capabilities

Multi representation ability is the main strategy in the study of physics regarding the ability to apply various types of representations in physical concepts, such as a verbal, graph, diagram, and mathematical forms. References to research on multi representation capabilities have been conducted by several researchers which can be seen in Table 4.

Table 4. Results of multi representation study on multi representation capabilities.

Authors	Materials	Findings
Suharsono et al., (2021)	Elasticity and Hooke's Law	The ability of student representation in each form of representation is different. The highest student representation ability is mathematical. This is proven by students being very smooth in numeracy and applying equations to the material. The ability of mathematical representation in students is high because students are accustomed to doing numeracy questions in everyday learning.
Murniati, et al., 2021)	Work	Most of the student's multi representation abilities in the type of representation of images to symbols (G-S) are better than other representations. Representation of images in the form of images of business events and the magnitude associated with the event.
Intania & Sudarti, (2021)	Electromagnetic Wave Spectrum	Students' multi representation ability to do electromagnetic wave spectrum problems using verbal and mathematical representations. The highest representation ability is verbal. Students' ability to physical concepts can be observed through multi representation-based instruments.
Ekawati, et al., (2019)	Mechanics	Students focus on solving mathematical problems related to physical concepts because they solve them without verbally defining them. Thus, the ability to represent prospective physics teachers is good at mathematical representation.

Based on the findings of several references, multi representation is used as an alternative approach to physical matter. Various representations are applied in physics

concepts based on each student's abilities, such as verbal representations, graphs, drawings, and mathematics. In a concept, it is better to use various representations to optimize students and have a positive impact. If using only one representation, multi representation ability does not increase students' understanding of physics concepts. For example, students get concepts that present only mathematical representations, then the ability to represent images, verbal, unbalanced graphics and there are difficulties in understanding concepts.

Learning Activities

Student learning activities are something that students do in the classroom during learning, in the form of activities that lead to learning goals and obstacles in learning. If students do learning activities, then students will easily master the materials provided by the teacher. Multi representation is widely used by educators in learning to obtain these learning goals. According to research Sutartoa et al. (2018) State that multi representation in impact material can be indicated if students have the ability to represent in the form of images, verbal, mathematical, and graphs. Most students master collision material by the representation of images and graphs, rather than verbal and mathematical representations. This is because the learning of impact materials is still less supported through demonstrations and experiments.

CONCLUSION

The results of the review literature that has been presented above show that: 1) Based on the keyword of the article obtained three clusters with each colour related to multi representation research; 2) The use of various representations help students in knowledge, mastering concepts, and solving problems in physics learning; 3) State that students' multi representation abilities can be investigated using multi representation ability instruments in an effort to improve the achievement of better quality physics learning; 4) Students' success in problem-solving and understanding physics concepts needs to be balanced with successfully understanding and using multi representation. The limitation of this research not specify to the Physics material. This research only describes in general terms about material physics, so that future research can use physics materials specifically.

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