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Physics Learning Media with Multirepresentation: A Systematic Literature Review

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Abstract

This research examines the development of physics learning media with a multi-representation approach through a systematic literature review. The research method follows the PRISMA stages with data sources from Google Scholar, including articles published between 2015-2023, which SINTA/Scopus index. Of the initial 769 titles, 30 articles were selected based on inclusion and exclusion criteria. The results show the dominance of development research focused on high school students and validated by experts. Modules are the most frequently used media. A spike in publications occurred in 2020, possibly due to the COVID-19 pandemic, which encouraged innovation in distance learning. Research finds that interactive media encourages active student involvement more effectively in increasing understanding of complex physics concepts. The multiple representation approach is proven to improve students' understanding, because it allows them to access information through multiple representations. Further research is needed on a variety of physics topics and involving more diverse samples and the use of new technologies. This article provides practical recommendations for developers and educators to discover trends, challenges, and opportunities in the further development of multi-representation-based physics learning media.

Keywords: learning media, physics, multirepresentation

INTRODUCTION

The rapid development of technology and learning methodologies in education has encouraged innovation in developing learning media (Sari & Siahaan, 2022; Beautemps et al., 2024). Conventional physics learning is often limited to delivering material verbally or textually, which is less able to reach the needs of students' various learning styles. This results in less in-depth understanding of physics concepts (Aisyah et al., 2021; Tristanti & Sudarti, 2021), especially for students who need more concrete visualization or exploration. In facing various educational challenges, especially physics learning, teachers can use technology/media with several approaches and other supporting activities (Becker et al., 2020). Therefore, an approach is needed that can provide variations in the presentation of physics concepts, one of which is multi-representation. One approach that has received special attention in the last few decades is using multiple representations in learning, especially in complex subjects such as physics. Physics learning media with multiple representations aims to facilitate understanding abstract physics concepts through various forms of representation such as visual, verbal, symbolic, graphic, and mathematical (Abdillah et al., 2021; Nikat, Loupatty & Zahroh, 2021). This is important considering physical material characteristics, which are often difficult to understand if only presented in one form of representation.

The multi-representation approach is supported by cognitive theories such as Dual Coding Theory (Paivio, 1986), which states that combining visual and verbal information can improve students' understanding by activating multiple cognitive pathways (Cai et al., 2020). Appropriate representations can reduce students' cognitive load, allowing them to focus more on understanding abstract physics concepts. This approach is crucial in physics because of its abstract and mathematically intensive nature (Widianingtiyas et al., 2015). With graphical representation and animation/learning media, students may be able to understand physical phenomena deeply (Astuti et al., 2017). Technology development in the digital era has opened up great opportunities to create more interactive learning media that support multi-representation (Gao et al., 2022). Technology-based media such as simulations, augmented reality, and interactive videos allow students to interact directly with physics concepts, increasing their active engagement and understanding (Rustan, 2021). By utilizing this technology, educators can meet the needs of students with various learning styles, whether visual, auditory, or kinesthetic (Cai et al., 2020).

The use of multiple representations in physics learning media offers several advantages. Among these is the ability to increase students' conceptual understanding (Mardatila, Novia & Sinaga, 2019; Ishmahaniyyah, Sinaga & Amsor, 2020; Abdillah et al., 2021; Wiyani, 2022; Dağli & Satici, 2023), provide variations in the way information is delivered (Damayanti, Mahardika & Indrawati, 2016; Febryanti & Taqwa, 2021), and support various student learning styles (Permadi, Anggreini & Wicaksono, 2020). For example, visual representations can help students who tend to learn visually to understand physical phenomena through pictures or animations (Khairunnisa, Ishafit & Fayanto, 2020; Mirzatullah, Halim & Hamid, 2020). The multi-representation approach (verbal, graphic, and mathematical) is believed to make it easier for students to learn concepts in various representations (Ansari et al., 2015). Multirepresentation has several advantages, namely helping to construct abstract representation forms and brain visualization. So it can be concluded that the multirepresentation approach has a positive effect on students' cognitive abilities (Widianingtiyas et al., 2015).

However, despite the potential benefits, the development of physics learning media with multiple representations also faces various challenges. One of the main challenges is how to design effective media that can be used optimally by teachers and students (Nurrita, 2018). In addition, integrating various forms of representation into one learning medium requires deep thinking about how each representation can complement each other and strengthen students' understanding rather than confusing them.

Many experts in the fields of education and educational technology have carried out research regarding the development of physics learning media with multiple representations. These studies examine various aspects, from media design and implementation to evaluating its effectiveness in improving student learning outcomes. Using a systematic literature review approach, this article aims to compile and analyze various research carried out regarding the development of physics learning media with multiple representations.

The systematic literature review method allows us to identify, assess, and synthesize relevant research systematically and structure (Suhada, Efan & Sasmita, 2024). This process involves comprehensive literature collection, study selection based on predetermined criteria, and rigorous data analysis. Through this method, we can get a clearer picture of research trends, primary findings, and gaps in the literature related to this topic (Blaxter, Huges & Tight, 2008).

One of the interesting findings from previous research is the importance of active student involvement in the learning process (Affandi & Megawati, 2024). Learning interactive media that allows students to explore physics concepts independently or in small groups has proven more effective than media that only present information passively (Ansari & Khan, 2020). This shows that learning media design must pay attention to aspects of representation and how the media can encourage active student involvement.

Finally, this article aims to provide practical recommendations for learning media developers and educators. By understanding the various factors that influence the success of physics learning media with multiple representations, we can design and implement media that is innovative and effective in helping students understand complex physics concepts. Thus, it is hoped that this article can identify physics material, trends, types of research, learning media used, subjects, and suggestions for further research, as well as make a significant contribution to the development of physics learning media and improving the quality of physics education at various levels of education.

METHODS

This research is a systematic literature review. The research method in this article follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) stage (Haddaway et al., 2018), with the main data source coming from Google Scholar. The selection of Google Scholar as a data source was based on its broad coverage and accessibility, although it is acknowledged that the quality of articles may vary. Therefore, strict selection criteria were used to ensure that only relevant and quality articles were analyzed. The systematic literature review process begins with the identification stage, where a comprehensive literature search is carried out on Google Scholar using the keywords multi-representation, learning media, and physics. This search was limited to articles published in the last 9 years, namely from 2015-2023 and written in English or Indonesian. In the initial search, 769 article titles were obtained that were relevant to the keywords.

Next, the screening and selection stage is carried out to ensure the quality and relevance of the included studies. Next is the eligibility stage. Articles that did not meet the inclusion criteria or were duplicates were removed. The inclusion criteria used include: (1) articles focusing on physics learning media with a multi-representation approach with a variety of methods, media types, and research results to ensure that the articles analyzed are in accordance with the main objective of the study to determine trends in physics learning media with multi-representation; (2) journals indexed by Sinta/Scopus to ensure the reliability of the articles; (3) articles are in the 2015–2023 range to cover the latest developments in the research topic. Exclusion criteria are applied to eliminate duplicate articles, articles that are not relevant to the research focus, such as theoretical studies without any connection to physics learning media with a multi-representation approach, and articles that do not meet the journal index quality standards. Based on these criteria, 30 article titles were obtained that met the criteria to ensure in-depth analysis and sufficient data representation related to the development of physics learning media with multiple representations.

TABLE 1. Journal Indexing

Journal Indexing	Number of Articles
Scopus Q4	2
Sinta 2	3
Sinta 3	9
Sinta 4	5
Sinta 5	11

The final stage included. There were 30 articles analyzed. Data from selected articles is extracted and analyzed qualitatively to identify physics material, trends, types of research, learning media used, subjects, and suggestions for further research. Thus, we can identify future opportunities for developing multi-representation-based physics learning media. The PRISMA flowchart was used to visually depict the article selection process visually, thereby ensuring transparency and replicability of the research methods used. The final results of this review will provide a comprehensive overview of the development of physics learning media with multiple representations and recommendations for further research.

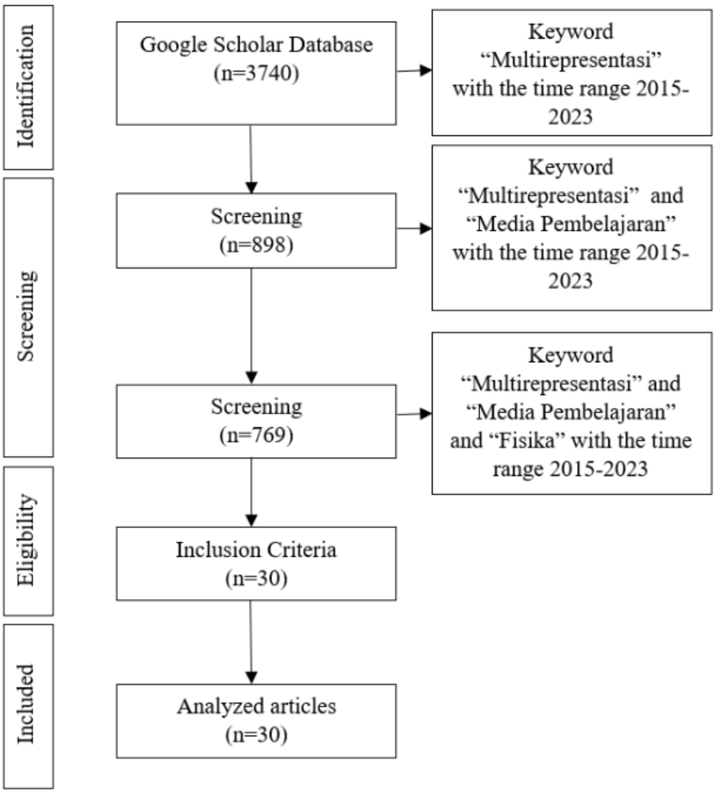

FIGURE 1. Flow diagram of the Prisma stages

RESULTS AND DISCUSSION

Multirepresentation is the conveying of a concept through various methods and forms, including verbal, graphic, pictorial, and mathematical (Sariningrum, Mahardika & Supriadi, 2017; Febryanti & Taqwa, 2021; Sari & Siahaan, 2022). Students often experience difficulties in complex physics materials, such as momentum, momentum changes, and impulses often expressed in vector representations (Karim, Saepuzaman & Sriyansyah, 2015). Students often need help describing and interpreting these concepts accurately, because they require a deep understanding of the relationship between physical quantities in vector space. Multiple representations help understand the material by displaying the same idea in different forms, such as graphics, videos, and images (Sari & Siahaan, 2022). It is designed to have a positive influence on students' cognitive abilities (Widianingtiyas et al., 2015), help students better understand the concepts being studied (Sari & Siahaan, 2022), and improve students' learning achievement (Sari, Feranie & Karim, 2015). Several studies have shown that multiple representations can help students overcome cognitive difficulties, especially in understanding abstract concepts in physics (Damayanti, Mahardika & Indrawati, 2016). However, it should be noted that the application of media with multiple representations also has challenges in terms of active student involvement and providing sufficient time for students to understand the various representations provided.

Learning media are tools used in learning to help carry out a creative, communicative, and innovative learning process and support improving student learning outcomes (Muslihah & Suryaningrat, 2021). By using multi-representation-based learning media, the information conveyed becomes clearer, facilitating the learning process and improving learning outcomes (Muslihah & Suryaningrat, 2021). Using media that combines various forms of representation, such as text, illustrations, animations, diagrams, graphics, videos, and simulations, can improve student understanding and enable two-way interaction between interactive teaching materials and their users (Rahmansyah, Muslim & Sinaga, 2022).

The findings from 30 articles answer the problem formulation that reviews articles about learning media with multiple representations. The first research findings are grouped based on the discussion topics shown in TABLE 2. Next, the research results are detailed in TABLE 2.

TABLE 2. Grouping of Articles Based on Topic

No	Topic/Material	Article
1	Physics	(Laili, Mahardika dan Ghani, 2015) (Maharani, Prihandono dan Lesmono, 2015) (Damayanti, Mahardika dan Indrawati, 2016) (Sariningrum, Mahardika dan Supriadi, 2017) (Susiana, Mahardika dan Bachtiar, 2017) (Zulaiha, Sinaga dan Rusli, 2019) (Khairunnisa, Ishafit dan Fayanto, 2020) (Permadi, Anggreini dan Wicaksono, 2020) (Ramadayanty, Sutarno dan Risdianto, 2021) (Rahmawati, Nisrina dan Abdani, 2022) (Sari dan Siahaan, 2022) (Monika, Fatmaryanti dan Maftukhin, 2022) (Mulhayatiah, Sinaga dan Hidayatulloh, 2022) (Prahastiwi dan Zain, 2023)
2	Thermodynamics	(Ni’mah, 2016) (Permadi, 2018) (Hartini dan Martin, 2022)
3	Elasticity and Hooke's Law	(Nurdiyana, 2016) (Mizayanti et al., 2020)
4	Newton's Laws	(Soleha, Maharta dan Rosidin, 2017) (Mushlihah, Yetri dan Yuberti, 2018) (Shavira, Ertikanto dan Suyatna, 2019)
5	Temperature and Heat	(Jatmiko et al., 2020)
6	Black Bodies	(Mirzatullah, Halim dan Hamid, 2020)
7	Straight Motion	(Saputra, Pathoni dan Kurniawan, 2020)
8	Kinematics	(Febryanti dan Taqwa, 2021)
9	Waves	(Annisa, Miriam dan Suyidno, 2022) (Rahmansyah, Muslim dan Sinaga, 2022)
10	Impulse and Momentum	(Malika, Sarwanto dan Budiharti, 2022)
11	Projectile Motion	(Mulhayatiah, Sinaga dan Hidayatulloh, 2023)

The results of this research review articles about learning media with multiple representations grouped based on the topics shown in TABLE 2. Each topic shows various representations to help students understand, such as visualization, interactive simulations, and mathematical models. This grouping illustrates how multi-representational learning media is widely used to increase the effectiveness and attractiveness of physics learning. Further analysis of these data shows that the use of multi-representational media in certain physics topics, such as general physics, is more frequently applied due to the need to explain more complex and abstract concepts that are difficult to understand with only one type of representation.

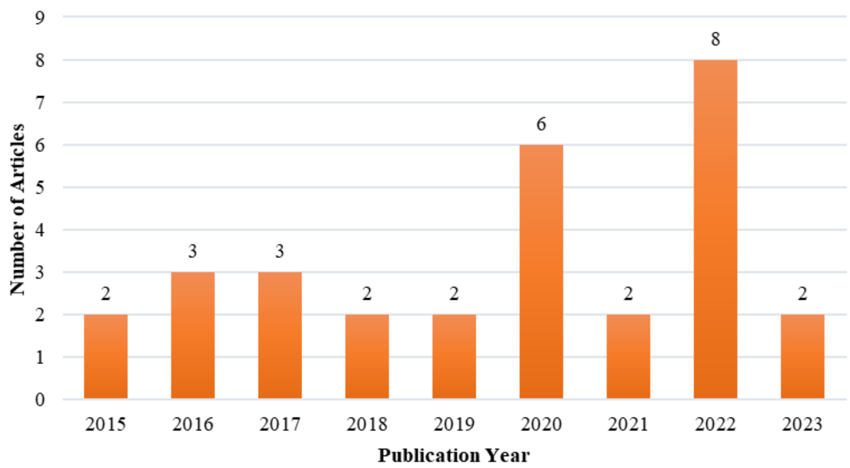

FIGURE 2. Bar diagram of distribution of the number of physics learning media articles with multiple representations for 2015-2023

Based on FIGURE 2. Analysis of the distribution of articles discussing multi-representation learning media from 2015 to 2023 shows a fluctuating trend in the number of publications. A significant increase occurred in 2020 when the number of articles published jumped to 6 articles. This surge may reflect increased interest and attention towards the development of multi-representational learning media, which may have been triggered by the urgent need for innovation in distance learning during the COVID-19 pandemic. The pandemic has encouraged educators and researchers to explore and develop more effective and interactive learning methods. The COVID-19 pandemic situation that forced learning to be done online encouraged many educators and researchers to explore and develop more effective and interactive learning methods, including the use of learning media that can support distance learning more optimally. This condition increased the use of technology and various multi-representation-based learning aids, which can provide a more interesting, flexible, and modern learning experience.

However, in 2021, the number of articles published again decreased to 2 articles. Various factors, including a reduction in the initial drive for rapid research or a change in research focus to other areas, could cause this decline. 2022 shows a sharp increase, with eight articles published. This increase can also be interpreted as a reflection of efforts to restore education after the pandemic, which encourages increased support for research in multi-representational learning media. In 2023, the number of articles will fall again to 2 articles. This decline can be caused by the natural cycle of research. After an increase, there is a decline phase for various reasons, such as the closure of research projects, policy changes, or shifting focus within the academic community.

Overall, this data shows that interest in developing physics learning media with multiple representations fluctuates from year to year. While there have been some periods of significant increase, there have also been periods of decline that reflect the dynamics in research and publications in this field. This trend is important for researchers and learning media developers to pay attention to understand when and how investment and research focus can be made to produce maximum impact.

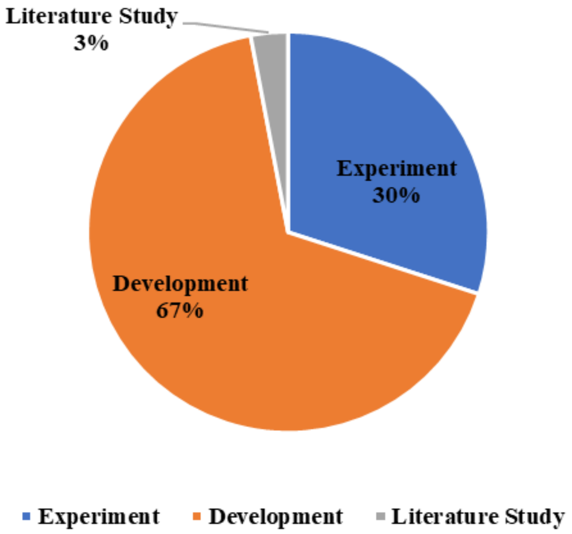

FIGURE 3. Circle diagram of distribution of types of learning media research with multiple representations

Based on FIGURE 3, it can be seen that the most dominant type of research in the study of learning media with multiple representations is development research, with a percentage of 67%. The dominance of this development research shows a strong focus on creating and perfecting new learning media that can help students understand physics concepts through various forms of representation. One of the reasons why development research dominates is because of the high need to design learning media that are appropriate to student characteristics and rapid technological developments. Development research usually includes learning media's design, implementation and evaluation stages to ensure its effectiveness in improving student learning outcomes. With the increasing development of technology, this kind of research is very important to create learning tools that can accommodate the need for more interactive and engaging learning and support the improvement of the overall quality of education.

Experimental research is in second place with a 30% percentage. This type of research is generally used to test the effectiveness of learning media that has been developed. Through experiments, researchers can evaluate how well the media helps students understand physics material compared to conventional learning methods. Experiments often involve control and experimental groups to obtain valid and reliable data regarding the impact of multi-representational learning media on learning outcomes.

Only 3% of the research is a literature study. Literature studies usually aim to collect and analyze existing research to identify trends, gaps, and future research recommendations. Even though the percentage is small, literature studies are very important in providing a strong theoretical and empirical foundation for further research, as well as helping researchers understand the context and current developments in the field of multi-representational learning media.

Overall, these data reflect that most research focuses on the development and practical evaluation of learning media, with little research aiming to analyze existing literature. This indicates a continued need for innovation in learning media and empirical assessment of their effectiveness in physics education.

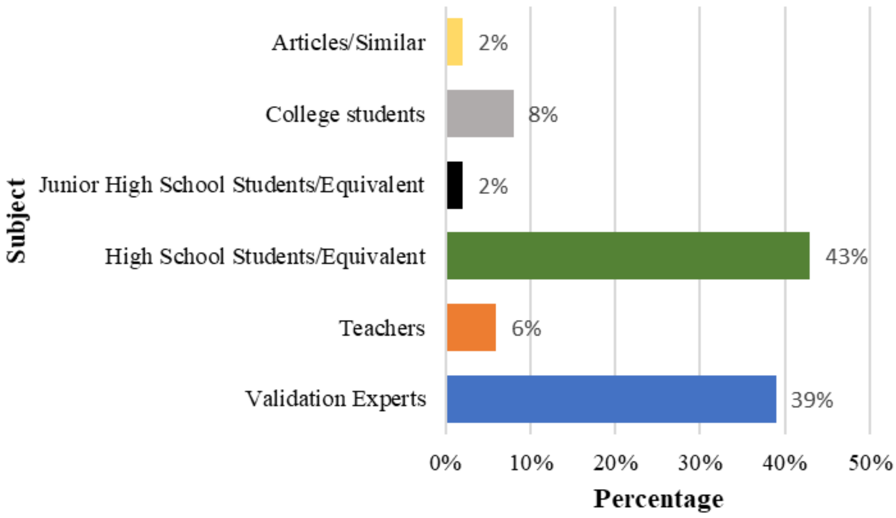

FIGURE 4. Bar diagram of distribution of learning media research subjects with multiple representations

Based on FIGURE 4, data regarding research subjects shows a diverse distribution in the study of learning media with multiple representations. The most dominant subjects were high school students or equivalent, covering 43% of all research subjects. This suggests that much research focuses on upper-intermediate level students because the physics curriculum at this level is more complex and requires multiple forms of representation to facilitate understanding of abstract concepts. This reflects the need for learning media that can support students in understanding more challenging physics topics, such as dynamics and thermodynamics. With more complex concepts at this level, multiple representations can provide new ways to illustrate and explain physics phenomena so that students can more easily understand material that is often abstract and difficult to reach with just plain text or images.

Validation experts are the second most numerous subject, with a 39% percentage. Validation experts, including lecturers, researchers, or education experts, play an important role in evaluating and validating the learning media being developed. Their involvement ensures that the media is of high academic and pedagogical quality before being implemented in the learning environment.

Students accounted for 8% of the research subjects, indicating that some studies also focus on using multirepresentational learning media in higher education. This is important because students often face more complex and abstract physics concepts, requiring innovative and effective learning media. Teachers only covered 6% of the research subjects. This may reflect a need for more focus on teachers' perspectives and experiences in implementing multi-representational learning media in the classroom. Teachers are the primary implementers who can provide valuable feedback regarding the effectiveness and obstacles to using this media in daily practice. Although few studies have involved teachers, they play an important role in implementing multi-representational learning media in the classroom and provide insight into the practical challenges of using such media. The results of the data analysis showed that the multi-representational ability of high school physics teachers in teaching the concept of Newton's Laws was in the moderate category (55.7%), with the highest achievement occurring in the mathematical representation type and the lowest in the pictorial diagram representation type for both genders (Masrifah et al., 2020). This reinforces the importance of teachers' understanding in using various forms of representation in learning media but also highlights the need to improve teachers' skills in using diagrammatic representations to illustrate physics concepts, especially more complex ones, to be more effective in addressing the challenges students face.

A very small percentage, 2%, are middle school students. This shows that research on learning media with multiple representations focuses less on the lower secondary education level. However, introducing more basic physics concepts at this level is also important.

The same percentage, 2%, is also found on subjects in the form of articles or similar, which may include literature studies or content analysis of existing articles. Although the numbers are small, this research is important for identifying trends, gaps, and recommendations for future research.

Overall, these data indicate that most studies focused on high school students and involved validation experts, with a small portion of studies involving teachers, college students, middle school students, and article analysis. This distribution reflects the priority in developing and evaluating learning media for physics education at the upper secondary and tertiary levels and the importance of validation by experts to ensure the quality of the learning media developed.

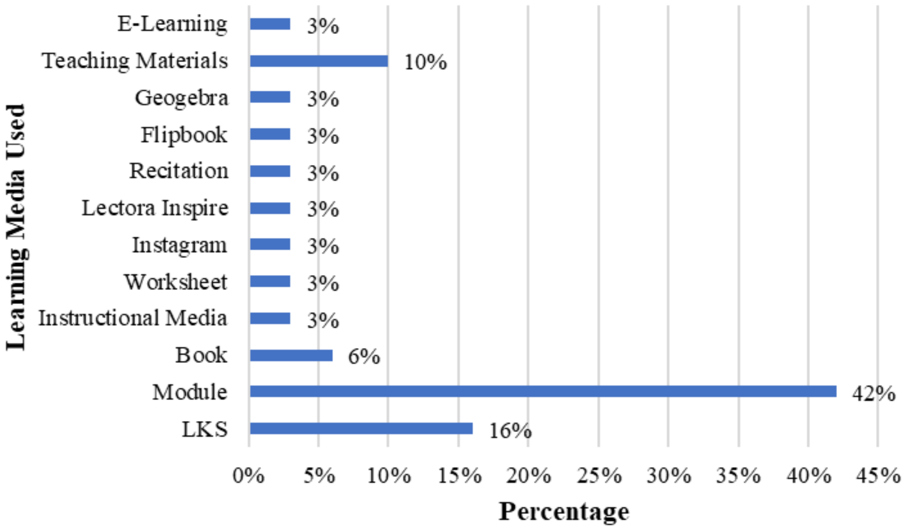

FIGURE 5. Bar diagram of distribution of learning media with multiple representations used

Based on FIGURE 5, the distribution of learning media with multiple representations from 2015 to 2023 shows variations in the types of media used by educators and researchers. From the data presented, it can be seen that modules are the most dominant media, with a usage percentage of 42%. The advantages of the module lie in its ability to provide structured and comprehensive information and flexibility in integrating various representation formats such as text, images, and interactive exercises, which allow students to learn more in-depth and actively. This makes the module very effective in improving student understanding, especially in physics materials requiring a more conceptual understanding.

Smaller percentages were found in other media such as books (6%), special learning media (3%), worksheets (3%), Instagram (3%), Lectora Inspire (3%), recitations (3%), flipbooks (3%), Geogebra (3%), e-learning (3%), and PowerPoint iSpring (3%). Even though the percentage is relatively small, this media diversity shows that there are efforts to explore various tools and technologies that can support physics learning with multiple representations. The use of these varied media also opens up new potential for further research that examines the effectiveness of each media in delivering physics material more interestingly and interactively. In addition, these media have great potential to be studied using a multi-representation approach, which can open up new opportunities for developing more relevant and effective physics learning media. This diversity of media reflects the rapid development of technology, the need to adapt learning tools to various student learning styles, and the development of more interactive teaching methodologies.

Based on the analysis of articles related to physics learning media with multiple representations, several suggestions for further research were obtained. Further research can be carried out to develop and test multi-representation-based teaching materials on various other physics topics (Damayanti, Mahardika & Indrawati, 2016; Malika, Sarwanto & Budiharti, 2022). This will help expand the application of this learning model to various physics concepts. Further work can be done by involving a more extensive and more diverse sample to test the effectiveness of multi-representation-based teaching materials (Mirzatullah, Halim & Hamid, 2020; Annisa, Miriam & Suyidno, 2022). This will provide more comprehensive data and better generalization. Further research is also recommended to develop and test multi-representation-based teaching materials using new technology and media (Khairunnisa, Ishafit & Fayanto, 2020; Ramadayanty, Sutarno & Risdianto, 2021).

Further research can be carried out to test the effectiveness of multi-representation-based teaching materials at various levels of education, from elementary school to university (Laili, Mahardika &

Ghani, 2015; Zulaiha, Sinaga & Rusli, 2019). Considering the differences in characteristics of learners at various levels of education, this study will provide deeper insights into the application of multiple representations in broader and more diverse contexts. Further research can also be conducted to evaluate the long-term impact of multi-representation-based teaching materials on student learning outcomes (Sari & Siahaan, 2022). This will provide insight into the continued effectiveness of the teaching materials. These findings can be the basis for further, more comprehensive, and applicable research and can guide the development of more effective teaching aids in the future.

CONCLUSION

The Systematic Literature Review was carried out using articles published from 2015-2023 related to physics learning media with multiple representations. This research highlights the dominance of development research (67%) on new learning media innovation. Most research involved high school students (43%) and validation experts (39%) to ensure media quality. Modules were the most used medium (42%), with a significant spike in publications in 2020, possibly due to the COVID-19 pandemic driving distance learning innovation. Although it offers many advantages, the development of this media needs to be improved in practical design. Interactive media that encourages active student involvement has proven to be more effective. This article emphasizes the need for further research to develop and test media on various physics topics involving more diverse samples and the use of new technologies. Practical recommendations are presented for developers and educators so that the resulting media is innovative and effective.

This article emphasizes the need for further research to develop and test media on various physics topics, involving more diverse samples and using new technologies more adaptive to student needs and learning contexts. Further research must highlight the relationship between the use of multi-representation media and increased understanding of physics concepts and students' critical thinking skills. Practical recommendations are presented for developers and educators so that the resulting media is innovative and effective in supporting more active and in-depth learning. This article makes a significant contribution to understanding trends, challenges, and opportunities in developing multi-representation-based physics learning media in the future, as well as providing a significant contribution to understanding trends, challenges, and opportunities in developing multi-representation-based physics learning media in the future.

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