

Differentiated Mathematics Teaching and Learning Media: Systematic Literature Review 2015-2024

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Abstract. Differentiated Mathematics Teaching and Learning Media Research allows students to actively participate, ask questions, express opinions, and improve their mathematics skills. Teachers can apply differentiated learning with learning media, both concrete and digital learning media. This study aims to examine differentiated mathematics teaching and learning media related to the year of publication, mathematics topics, education levels, regional distribution, and mathematics learning media so that concise literature can be obtained regarding the latest facts regarding the role of media stored in and differentiated mathematics learning over the past 10 years based on the Scopus, ERIC, and Sinta databases. This research is a Systematic Literature Review (SLR) study. The methodology used is Systematic Review and Meta-Analysis (PRISMA), given limitations in the form of inclusion and exclusion criteria. The results of the study showed that in 2015-2024 there were 170 articles related to the research topic; based on the inclusion criteria and exclusion criteria, there were 11 articles that met the criteria. The most widely used topic is the topic of fractions, which is 3 articles, then statistics and geometry each as many as 2 articles; and the topics of measurement, graphs, trigonometry, arithmetic, data, transformation, integers and measurement, and scales each 1 article and the most research was conducted on improving junior high schools, with a percentage of 38%. It was found that Indonesia ranks first with the number of articles as many as 6 articles, and the media most developed or used in differentiated mathematics learning is modules.

INTRODUCTION

Mathematics learning is a process of interaction between learning components to develop students' thinking abilities in problem-solving. Learning mathematics will help students build mathematical concepts based on their abilities [1]. Mathematics learning allows students to participate actively, ask questions, express opinions, and improve their mathematical abilities. Using various types of models, strategies, and learning methods adapted to students' material and characteristics. In the book "How to Differentiate on Different Instruction", there is learning that emphasizes the differences in each student, namely differentiated learning [2]. All students have the same rights; therefore, they should respect and consider all the differences that exist between them. Therefore, differentiated learning is necessary [3]. The differentiated learning approach focuses on adapting open materials and learning materials to students' level of understanding, learning styles, learning speed, interests, and learning needs [4]. To prevent students from giving up and feeling like they have failed in their educational efforts, differentiated learning is a learning process where students can learn content based on the student's talents, what they student likes, and what the student needs [5]. So differentiated learning is an effort that can be made in the learning process to meet the different needs of students, these needs can be in the form of existing knowledge, learning styles, interests, understanding of subjects, learning tools or media and the need for ways to deliver lesson materials from teachers to students.

Differentiated learning aims to coordinate learning that pays attention to students' interest in learning and students' readiness to learn according to their preferences [6]. Teachers can form groups and organize different learning content according to their characteristics, learning needs, interests, and motivation [7]. The concept of differentiated learning is good and ideal, but it makes it difficult for teachers to be creative. Through this learning,

potential is developed according to the needs, characteristics, and ability levels of students. However, to achieve learning that is in line with this idea, teachers must strive to be reliable facilitators. Teachers need to develop learning environments that allow them to assess students' initial knowledge levels [8]. However, there are obstacles related to teaching materials when implementing learning [9]. Most teachers still use reading books as the only source of learning for students. Learning resources are one of the supports for learning activities. Learning resources help educators explain topics and help students understand the topics studied [10]. The learning environment is closely related to the material educators provide [11]. In the 21st century, humans, with technological developments, education is closely related to developments over time, and education must adapt to developments over time. Mathematics is a knowledge field widely used in various fields of life, including science and technology [12]. The teacher, as the main figure, can design alternative learning as a solution to updating forms of language teaching such as electronics, 3D, video, and others [13]. One of the important things that must be paid special attention to when choosing and using learning media is the modality each student has. Media is one of the supporting factors for successful learning in schools because it can support the process of conveying information from teachers to students and vice versa [14]. Bearing this in mind, teachers should combine various media to convey their messages so that learning can occur more optimally [15].

Learning media themselves were known long before the emergence of the Industrial Revolution 4.0, and since 1800, concrete mathematics learning media, or designed to express abstract mathematical ideas explicitly and concretely, have been used since 1800, abstract learning media explicitly and concretely [16]. Learning media is essentially something that can be used to convey messages and information about learning materials so that a learning process occurs between students to achieve their goals. There are six basic forms of learning media. 1) Text in the form of letters and numbers, displayed in books, posters, or written on a whiteboard or computer screen. 2) Speech includes everything that can be heard. Examples: human voice, music, mechanical sound, etc. 3) Visual materials such as diagrams, posters, paintings, photos, and graphs. 4) Motion media that can show movement Video, anime, TV, etc. 5) Artificial media in the form of three-dimensional media that can be touched or held, 6) Sources of information such as people, namely instructors, students, material experts, and so on [17]. Learning media include: 1) Printed materials such as books, educational magazines, LKS, etc. 2) Audio media such as audio cassettes, radio broadcasts, sound films, and educational Audio CDs. 3) Audio-video media such as television, video, and internet-based e-learning [18].

Selecting inappropriate or completely irrelevant learning media can reduce students' understanding of the media used in the teaching materials [19]. There are several criteria in determining which learning media to use, including 1) appropriateness, 2) level of sophistication, 3) cost, 4) availability, and 5) technical quality [20]. Learning media is now not just concrete learning media, but since the development of technology, digital atau virtual learning media is a form of web-based virtual representation that helps represent dynamic objects and build mathematical understanding [21] As expectations for student understanding increase, finding innovations that make learning more effective and efficient is increasingly important. One alternative innovation educator can use to achieve the above goals is using learning media. There are advantages and disadvantages of concrete and digital learning media. The advantage of concrete learning media is that concrete learning media helps increase student enthusiasm during mathematics learning [22, 23] increasing students' learning outcomes or mathematics achievements [24–27]. The disadvantage of concrete learning media is that students are too focused on paying attention to concrete media, so they do not listen to instructions from the teacher [28].

Teachers can overcome this deficiency by controlling the class and being the center of students' attention. The advantage of digital learning media is that many websites offer digital learning media to help students understand mathematical concepts. They are free and easy to access [21] and can improve students' ability to understand concepts, learning outcomes, interest, and motivation to learn, preventing misconceptions in learning [29–31]. However, digital learning media has several disadvantages, namely digital learning media, especially media that requires an internet connection to operate and an internet connection that may be unstable or disconnected [32]. Each student has different abilities in owning digital devices, so not all students can own or access cell phones or other digital devices [33]. These two types of learning media do not have to be used separately but can be integrated according to learning needs and student characteristics. For example, using a physical model to introduce a concept, then followed by a digital simulation to deepen it. This integrity utilizes the advantages of each medium to create a richer and more effective learning experience for students.

Teachers as educators need an understanding of educational innovation in the form of concrete and digital learning media specifically to increase the effectiveness and efficiency of mathematics learning. Therefore, this research will conduct an assessment of differentiated mathematics teaching and learning media to obtain concise literature regarding the latest facts regarding the role of media in the pursuit and learning of differentiated mathematics over the last 10 years. So that it can be a reference for developing learning and teaching media that already exist or will be created. The research questions come from the following research objectives:

RQ1: How much research related to media in differentiated mathematics teaching and learning in the Scopus, ERIC, and SINTA databases between 2015-2024?

RQ2: What mathematics topics are often conveyed using media in teaching differentiated learning?

RQ3: What levels of education have used media in teaching and learning, especially in differentiated mathematics learning?

RQ4: Where is the distribution of research areas that develop media in differentiated mathematics teaching and learning?

RQ5: What media types are used or developed in differentiated mathematics teaching and learning?

METHOD

Design and Protocol

This research is a Systematic Literature Review (SLR) research. The methodology used is Systematic Review and Meta-Analysis (PRISMA) [34]. The PRISMA protocol is an evidence-based approach to accurately reporting article findings [35]. In Systematic Review and Meta-Analysis (PRISMA), there are 2 stages: the first stage is planning, and the second stage is action [36]. At the planning stage, research objectives and questions will be determined using the inclusion and exclusion criteria to determine the articles and books in the database the researcher has determined. In this research, the databases used are Scopus, ERIC, and Sinta. Next, at the action stage, a survey was carried out on articles obtained from the database and analyzed so that they met the research inclusion criteria. The only articles analyzed were English language articles. In the final stage, the research results are explained, and the results are presented in tables and graphs.

Eligibility Criteria

Articles and proceedings that are eligible for inclusion in this research are said to be eligible if they fulfill the following requirements:

TABLE 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Research conducted in 2015-2024	Research conducted other than 2015-2024
This is research related to differentiated mathematics learning media	The research is not related to differentiated mathematics learning media
The research lists the learning media that are applied or developed	The research does not include the learning media implemented or developed
The research lists the mathematical topics used	The study did not list the mathematical topics used

Information Sources and Search

Data sources were obtained from three databases, Scopus, ERIC, and Sinta. This analysis was carried out in April 2024 in Indonesia using. The data search process uses the keywords: Scopus and ERIC: “differentiated AND mathematics AND "learning media" OR teaching” dan "differentiated instruction" AND mathematics AND "learning media" OR teaching”, Sinta: “differentiated AND mathematics AND "learning media" OR teaching” dan "differentiated instruction" AND mathematics AND "learning media" OR teaching”, “media pembelajaran berdiferensiasi”.

Study Identification and Selection

After searching keywords, 170 data were obtained, divided into Scopus 160 articles, ERIC 2, and Sinta 8 articles. However, after the search was carried out, we entered the filtering and analysis of articles and books in the database that were per the research questions and inclusion criteria. Scopus 4 and Sinta 7 articles.

The data obtained is presented as descriptive statistics, which aims to present the extracted and tabulated data. In the section, the results obtained from the research questions are presented in narrative form. There is a process flow for selecting samples from a database that complies with the PRISMA protocol:

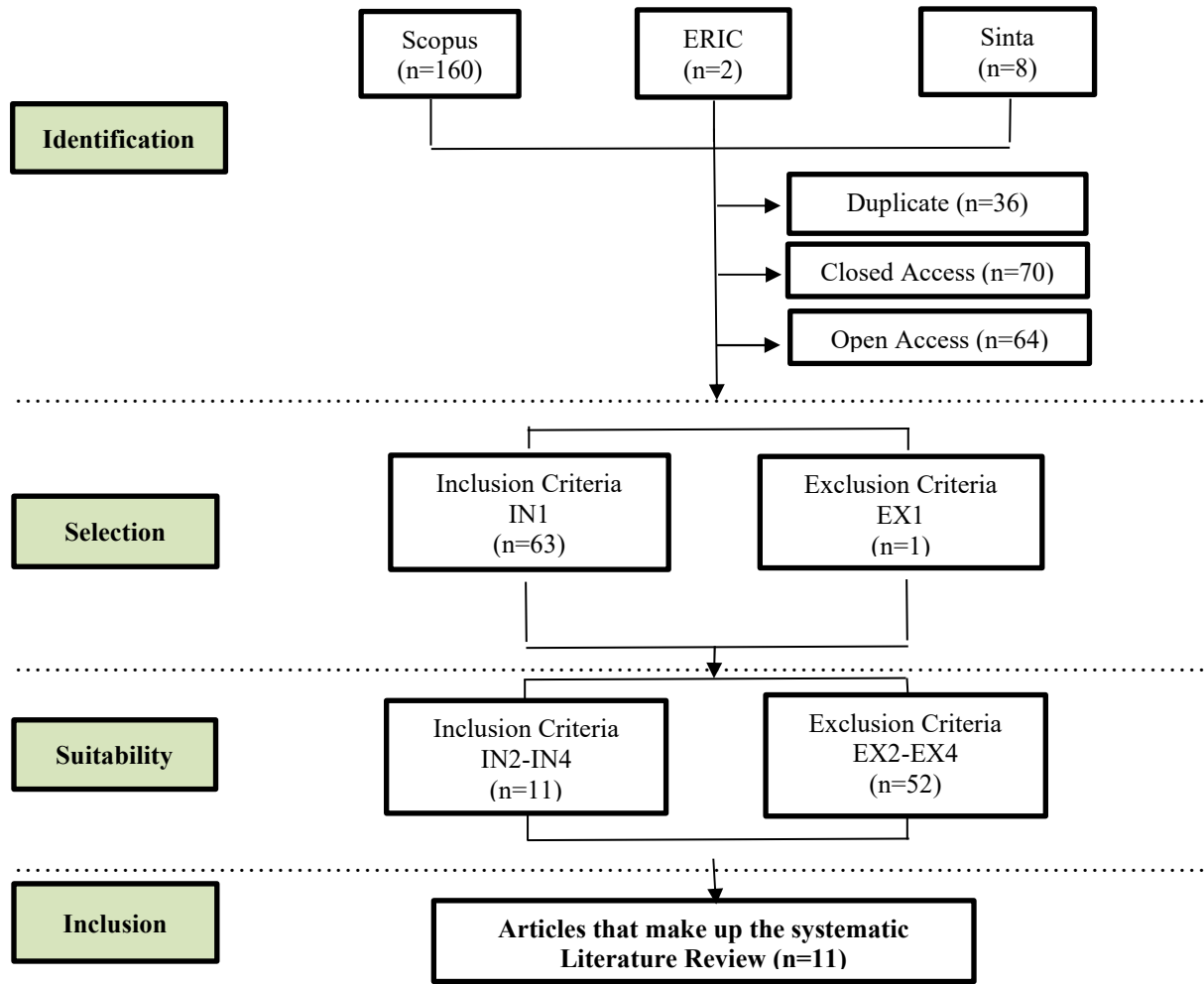


FIGURE 1. PRISMA protocol flowchart

RESULTS

RQ1: How much research related to media in differentiated mathematics teaching and learning in the Scopus, ERIC, and Sinta databases between 2015-2024?

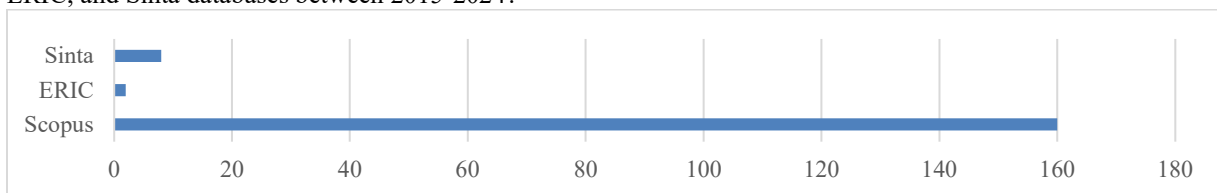


FIGURE 2. Many studies related to media in differentiated mathematics teaching and learning are based on the Scopus, ERIC, and Sinta databases between 2015-2024

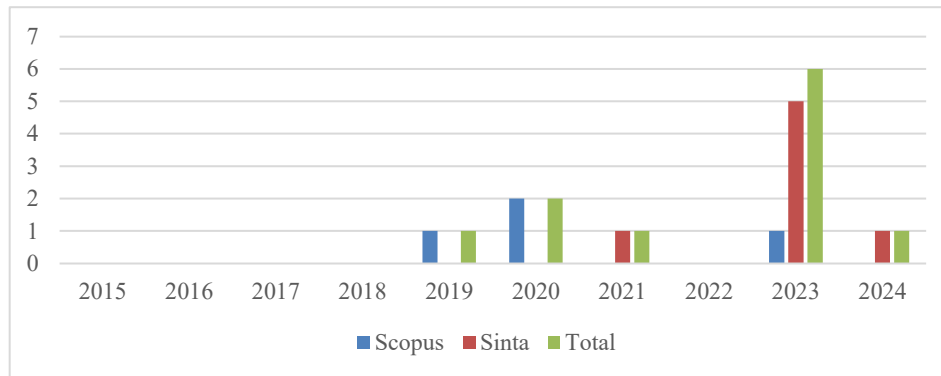


FIGURE 3. Many studies related to media in differentiated mathematics teaching and learning on the Scopus, ERIC, and Sinta databases between 2015-2024 after going through inclusion and exclusion.

Research on differentiated learning media has become a focus of attention in recent years. This is reflected in the increasing number of scientific publications discussing this topic in various international and national databases. Based on a literature review conducted using Scopus, ERIC, and Sinta databases, there has been a significant increase in the number of publications related to differentiated learning media since 2015. However, there is a buildup in the number of publications from year to year. Further analysis shows that the Scopus and Sinta databases are the main sources of publications on this topic. In 2023, this second database recorded a significant increase in the number of publications, with a total of 6 articles. This phenomenon indicates an increase in researcher interest in developing and studying various types of differentiated learning media. However, it should be noted that most of the publications in 2023 came from the Sinta database. This indicates that research in this field is still dominated by domestic researchers. However, publications in Scopus show that research in Indonesia is starting to receive attention at the international level. It is important to note that as of May 2024, the number of publications that meet the research criteria is still relatively low. This shows that there is still great potential for further research in this area.

RQ2: What mathematics topics are often conveyed using media in teaching differentiated learning?

Analysis of various scientific publications shows that various mathematical topics that are often delivered using media in learning are differentiated. These topics include measurement, fractions, graphs, trigonometry, arithmetic, statistics, data, transformations, geometry, integers, comparisons and scales, and algebra. Of the many topics, fractions are the topic most often associated with the use of differentiated learning media. This shows that the concept of fractions is still a challenge for many students, so various innovative media are needed to help them understand the concept. In addition to fractions, statistics and geometry are also topics that are quite often discussed in the context of differentiated learning. This second topic involves data visualization and spatial concepts that can be better explained through the use of media. The topics of measurement, graphs, trigonometry, arithmetic, data, transformations, integers, comparisons, and scales are also often found in research related to differentiated learning media. However, the frequency of media use for these topics is still relatively lower compared to fractions, statistics, and geometry. The results of this analysis have several important implications for mathematics learning practices. First, the use of differentiated learning media can improve students' understanding of complex mathematical concepts, especially in topics such as fractions, statistics, and geometry. Second, variations in the use of media can help meet the different learning needs of each student. Third, further research is needed to explore the use of differentiated learning media in other mathematics topics, as well as to develop more effective learning models.

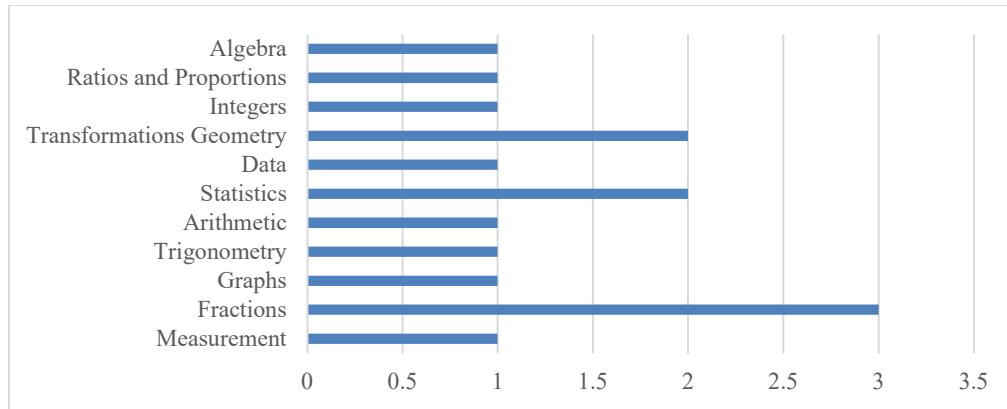


FIGURE 4. Mathematics topics that are often conveyed using media in differentiated teaching and learning

RQ3: What levels of education have used media in teaching and learning, especially in differentiated mathematics learning?

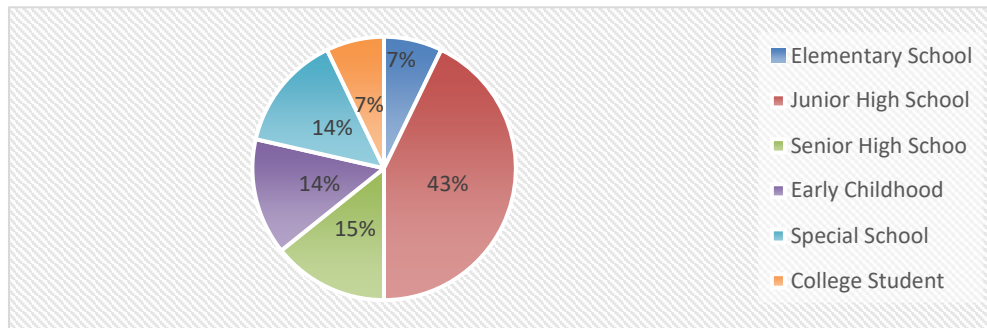


FIGURE 5. Levels of education that have used media in teaching and learning, especially in differentiated mathematics learning

Effective and engaging mathematics learning relies heavily on the use of appropriate media. In recent years, the differentiated learning approach has become increasingly popular at various levels of education. This approach allows teachers to tailor learning to the needs and learning styles of each student. The use of learning media in this approach has proven to be very effective in improving understanding of mathematical concepts. Data analysis on the use of differentiated learning media from 2015 to 2024 shows that junior high school is the level of education that most often applies this approach, with a percentage of 43%. This indicates that educators at the junior high school level have realized the importance of using media in improving the quality of mathematics learning.

RQ4: Where is the distribution of research areas that develop media in differentiated mathematics teaching and learning?

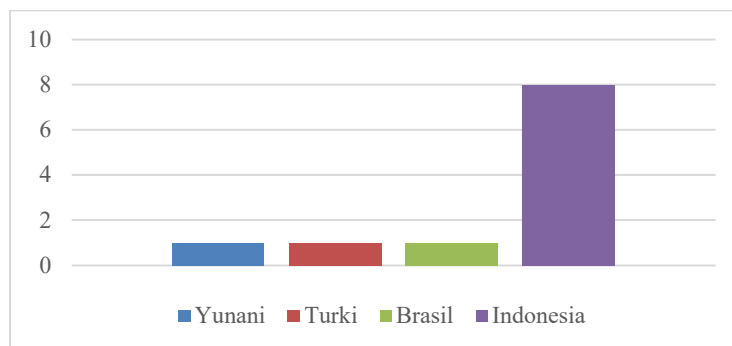


FIGURE 6. Distribution of research areas that develop media in differentiated mathematics teaching and learning

Research in the field of developing differentiated mathematics learning media is still relatively new on the global stage. However, the data obtained shows an interesting trend related to the geographical distribution of this research. Indonesia has emerged as a leader in the development of differentiated mathematics learning media. With a total of 6 articles published, this country is in the leading position compared to other countries. This fact shows the absence of significant commitment and attention from Indonesian researchers towards efforts to improve the quality of mathematics learning through the use of media that is tailored to the individual needs of students. On the other hand, countries such as Greece, Turkey, and Brazil have also shown interest in this field, with each country contributing one article. Although the number of publications is still limited, the presence of research from these countries indicates a global awareness of the importance of differentiated learning media in improving the effectiveness of mathematics learning.

RQ5: What media types are used or developed in differentiated mathematics teaching and learning?

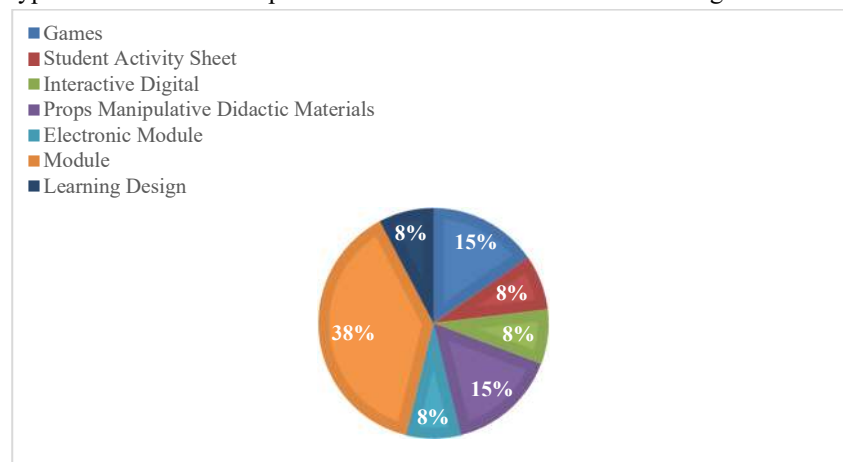


FIGURE 7. Types of media used or developed in differentiated mathematics teaching and learning

The use of learning media in the mathematics learning process has undergone significant development, especially in the context of differentiated learning. This approach recognizes that students have different learning styles and levels of understanding, so a variety of media are needed to meet individual needs. Based on the results of the analysis, various media have been developed and used to support differentiated mathematics learning. The types of media found include games, interactive digital media, electronic modules, printed modules, student activity sheets, manipulative teaching aids, and learning designs. Of the various media, modules are the most frequently used type of media, with a percentage of 38%. This shows that printed modules are still the main choice for educators in delivering learning materials. On the other hand, games and manipulative teaching aids also have an important role, each with a percentage of use of 15%. This type of media can provide a more concrete and interactive learning experience for students. Interactive digital media, electronic modules, learning designs, and student activity sheets are also used in differentiated learning, each with a percentage of 8%. Although the percentage of use is still relatively low, the existence of these media shows that there are efforts to integrate technology into the learning process.

Overall, this study shows that various media can be used to support differentiated mathematics learning. However, further efforts are still needed to increase the use of digital and interactive media to utilize the potential of technology to increase learning effectiveness. Thus, the selection of appropriate learning media must be adjusted to student characteristics, learning objectives, and subject matter. The use of diverse media can help create a rich learning environment and support the success of all students in achieving mathematics competency.

TABLE 3. Teaching and learning media results

Article	Teaching and Learning Media	Results
Educational escape room for approaching the concept of length on blind students [37]	Escape room (game or educational game)	Escape room activities have proven effective in introducing the concept of length to visually impaired students
Assessing the impact of differentiated instruction on mathematics achievement and attitudes of secondary school learners [38]	Student activity sheet	The results showed that the experimental group that received differentiated learning significantly increased mathematics learning achievement compared to the control group.
The use of manipulative didactic material to teach concepts related to the treatment of information for visually impaired students [39]	Manipulative didactic materials, Haptic devices, Audio-based materials	The use of manipulative learning materials has proven effective in helping students with visual impairments understand concepts related to information processing
The Development of Trigonometry E-Modules for Senior High School Using a Differentiated Instruction (DI) Approach [40]	Module electronics	This e-module facilitates students to learn according to their respective learning styles and abilities, increasing their interest and motivation to learn
The Design and Development of Differentiated Mathematics Teaching Modules Based on Multiple Intelligence [41]	Module	Teaching modules can increase the effectiveness of mathematics learning by facilitating students according to their dominant intelligence
Development of differentiated learning-based teaching modules on statistics material [42]	Module	The development of teaching modules based on differentiated learning has proven to be effective in improving the quality of statistics learning
Development of differentiated learning-based teaching modules on "using data" material [43]	Module	The development of teaching modules based on differentiated learning has proven to be effective in improving the quality of learning using data
Contribution of the Application of Differentiated Learning Models Assisted by Teaching Aids to Problem-Solving Abilities in Mathematics Learning [44]	Props manipulative didactical material	The application of the differentiated learning model assisted by teaching aids makes a significant contribution to increasing students' problem-solving abilities in mathematics learning
Development of differentiated teaching modules on geometric elements phase c [45]	Module	The development of differentiated teaching modules on phase C geometry elements has proven to be effective in increasing learning effectiveness
Efforts to Increase Students' Learning Independence through Differentiated Learning Based on Content [46]	Student activity sheet	Differentiated learning based on content is effective in increasing students' learning independence

Differentiated instruction (DI) based learning planning design in algebra courses [47]	Learning Design	The DI-based learning planning design in the Algebra course has proven to be effective in accommodating student diversity
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DISCUSSION

In this study, researchers departed from an analysis of differentiated mathematics teaching and learning media in the last 10 years by identifying the number of studies from 2015-2024, mathematics topics, depth of education in which research was conducted, distribution of research areas, and media used or developed in teaching and learning, differentiated mathematics. Considering the importance of implementing differentiated learning to prevent students from becoming discouraged or feeling like they have failed in their educational efforts, differentiated learning is a learning process that allows students to learn content based on their talents, what they like, and their special needs. By presenting learning according to students' interests, understanding of concepts will be achieved. Concept development occurs by providing learning experiences to students. Concepts are introduced in stages, from the simple and concrete to the complex and abstract. Concepts cannot be conveyed through definitions alone; they are concepts based on experience. Using learning media will make learning more meaningful. Based on the results obtained, it can be seen that over the last 15 years, little research has been conducted regarding learning media in differentiated mathematics learning. The topics used are still small and can be further developed into other mathematics topics. The level of education where the research is carried out can be continued again with media. -learning media that is more innovative and can develop existing media or create new learning media that are more creative and innovative in the field of mathematics because the distribution of research areas included in this research analysis can be expanded and redeveloped.

CONCLUSION

Learning media plays an important role in education in the era of the Industrial Revolution 4.0, especially in mathematics learning, because it is one of the educational innovations that can support improving students' skills. Learning media can be divided into tangible (concrete) and digital learning media. Digital and real learning media have the advantage of helping students understand mathematical concepts, thereby improving student learning outcomes. These two media can also increase students' enthusiasm and motivation when learning mathematics. There is much research related to media in differentiated mathematics teaching and learning in the Scopus, ERIC, and Sinta databases between 2015-2024. 170 articles match the keywords. Through inclusion and exclusion criteria, 11 articles were obtained to be researched, 5 in the Scopus database and 6 in the Sinta database. The most widely used topic is the topic of fractions, with 3 articles, then statistics and geometry 2 articles each; and the topics of measurement, graphs, trigonometry, arithmetic, data, transformations, integers and comparisons, and scales 1 article each. educational levels that have used media in teaching and learning, especially in differentiated mathematics learning from 2015 to 2024, is mostly done at junior high school level with a percentage of 43%, then high school with 15%, early childhood, and special school. 14% and college elementary school students 7%. Distribution of research areas that develop media in differentiated mathematics teaching and learning, Indonesia is in first place with 6 articles, followed by Greece, Turkiye, and Brazil with 1 article. The media used or developed in differentiated mathematics learning he media most frequently used are modules at 38%, games and props, manipulative didactic materials at 15% each, interactive digital and electronic modules, learning design, and student activity sheets at 8% each.

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