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Differentiated Instruction in Mathematics Education: A Systematic Literature Review

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Abstract.

This study aims to examine scientific journals by collecting reliable sources related to differentiated instruction in mathematics education. Differentiated instruction is a teaching approach that recognizes the diversity of students' learning based on their abilities and interests. The method used to write this article is a literature review. The approach used to analyze journal articles is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The research began by searching for articles related to the topic to be investigated through Scopus, ERIC, and Proquest databases. The criteria for scientific articles used as information are those from international journals updated in the last 5 years, from 2018 to 2023. The analysis of 11 scientific articles shows that research has been conducted worldwide. The subjects in differentiated instruction research consist of students, teachers, and pre-service teachers. Most of the studies use qualitative research methods and aim to improve the understanding, development, and implementation of differentiated instruction practices in mathematics education.

Keywords: differentiated instruction, mathematics education, systematic literature review

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1. INTRODUCTION

Differentiated instruction is an instructional approach that considers students abilities, interests, and characteristics within a classroom (1). Such an approach offers elements that build a pleasant learning environment, embracing diversity in a way that allows individual growth in learning based on students' abilities, interests, and readiness levels (2).

Differentiated instruction is described as a teaching strategy that values students diversity while considering their strengths and weaknesses. It is student-centered, proactive, reflects the quality of learning rather than quantity, is based on appropriate assessment, employs multiple approaches to content, process, and product, and combines whole-class, group, and individual instruction, where learners and learning are monitored and adjustments are made as needed. The fundamental principle of

differentiated instruction is to provide conditions that enable each student to succeed (1). Teachers have a significant responsibility to provide opportunities for every student to learn and effectively implement differentiated instruction. Before initiating the process of differentiated instruction, teachers should review the curriculum, understand students characteristics, and conduct initial assessments of their students (3).

There are five essential components that teachers can utilize for differentiated instruction in the classroom: content (the knowledge, understanding, and skills we want students to acquire), process (how they comprehend the content), product (how they demonstrate what they have learned, understood, and can do after learning), environment (the learning style arrangement in the classroom), and affective (how students' emotions and feelings influence their learning) (4).

Research on differentiated instruction needs to be conducted to help teachers understand the steps involved in the process of differentiated instruction and to have a comprehensive knowledge of the design of differentiated instruction that can be applied in their classrooms. Although the theory of differentiated instruction is not new in the field of education, research on the practice or implementation of differentiated instruction in the classroom is still limited.

Regarding the existing literature reviews on differentiated instruction, several systematic literature reviews (SLR) have been conducted, including a literature review describing the research trends in differentiated instruction for all subjects (5) and a literature review describing the challenges in differentiated instruction.

This literature review specifically focuses on research on differentiated instruction in mathematics education. The purpose of this literature review is to enhance knowledge by providing a comprehensive overview of research on differentiated instruction in mathematics education, encompassing studies conducted on students as well as teachers.

The research questions are: in which countries was the research conducted?; Who were the subjects in the study?; What methods were used by the researchers?; What were the aims of the study?

Differentiated instruction is an educational strategy that involves tailoring teaching methods to suit the diverse capacities of students, employing a systematic process to monitor their academic progress and make informed decisions based on data. This approach, commonly known as cognitive or readiness differentiation, underscores the

importance of adapting teaching to match the current level of each student's achievement (6). Teachers, according to this concept, are encouraged to monitor the intellectual development of their students, identify their educational needs, and subsequently adjust lesson plans to meet those needs.

According to the teacher's perspective, the current status of differentiated instruction can be characterized by five key elements: 1) Embracing a growth-minded, ethical, and flexible approach to learning theories and practices; 2) Utilizing flexible grouping strategies; 3) Applying principles of input and output matching; 4) Delivering instruction tailored to students' interests and readiness; and 5) Incorporating Learning Profiles to ensure that lesson plans consider students' interests, readiness, and learning profiles, aiming for the most effective learning experience (7).

In the realm of mathematics education, the implementation of differentiated instruction must be thoughtfully designed to position all students as competent and capable learners, ensuring equal opportunities for meaningful engagement in mathematics learning. This goal can be accomplished through the incorporation of purposeful, inquiry-based tasks aligned with a constructivist, reform-oriented approach to mathematics education (1).

2. METHOD

2.1. Research Design

The research design conducted to answer the research questions is a comprehensive SLR (Systematic Literature Review). An SLR is a method used to gather relevant information pertaining to a specific topic that meets predetermined inclusion criteria (8). This study focused exclusively on journal publications between 2018 and 2023. The approach used to analyze the journal articles followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. PRISMA sets standards for peer review, utilizing a checklist-based approach to aid in quality control and replicable revision processes. Identification, screening, eligibility assessment, and inclusion are fundamental elements of PRISMA. Identification represents the initial phase, and subsequent subsections provide further information on these steps. This method was employed as it aids in synthesizing significant journal articles. By following PRISMA recommendations, the study aimed to identify best practices in differentiated instruction within mathematics education.

Table 1: Alternative Terms for the Main Search.

Differentiated Instruction	Mathematics Education
Differentiated Learning	Mathematics
	Mathematics Learning
	Mathematics Instruction

Table 2: Criteria for Articles.

Inclusion criteria	Exclusion criteria
Published between 2018 and 2023	<2018
Indexed journal	Non-indexed journals, chapter in book, conference proceeding.
English Language	non-English
Specific to maths or mathematics learning	Common themes (social, health, environment and engineering)

2.2. Systematic Review Process

Identification. The search was conducted in Scopus, ERIC, and ProQuest. The two main terms in the primary search based on the research topic are “Differentiated Instruction” and “Mathematics Education.” A list of synonyms and alternative terms was then compiled based on the most popular searches (Table 1).

Therefore, term expansion was used to analyze as many potentially relevant studies as possible. Keyword terms were formed by combining the words found in Table 1, as follows: (“Differentiated Learning” OR “Differentiated Instruction”) AND (“Mathematics” OR “Mathematics Education” OR “Mathematics Learning” OR “Mathematics Instruction”). A total of 640 articles met the criteria using search techniques through.

Screening. The selection process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles. Inclusion and exclusion criteria were used in this approach. No unindexed journals, books, or conference proceedings were included in the literature selection. The focus of the search was on English-language journals published between 2018 and 2023. There were no exceptions regarding specific countries. In the final phase of screening, 606 articles were identified as not meeting the research criteria, leaving 34 articles remaining.

Eligibility. In this eligibility phase, journal articles that did not meet the criteria for differentiated instruction in mathematics education were rejected. Then, each article title and abstract were carefully examined to ensure that they all met the criteria and research objectives. A total of 23 articles were disregarded because they did not

sufficiently explain the findings on differentiated instruction in mathematics education. The 11 selected articles resulting from the final phase of review.

Inclusion and Exclusion Criteria. After collecting all the articles from recognized sources, selection criteria such as time frame, document type, language, and subject field were used to filter out irrelevant articles for the research. To ensure that the selected articles align with the research objectives, it is important to identify inclusion and exclusion criteria before making the selection. Table 2 lists the inclusion and exclusion criteria for this review study, as well as the research findings. 11 relevant articles were found, and full-text versions of these articles were obtained.

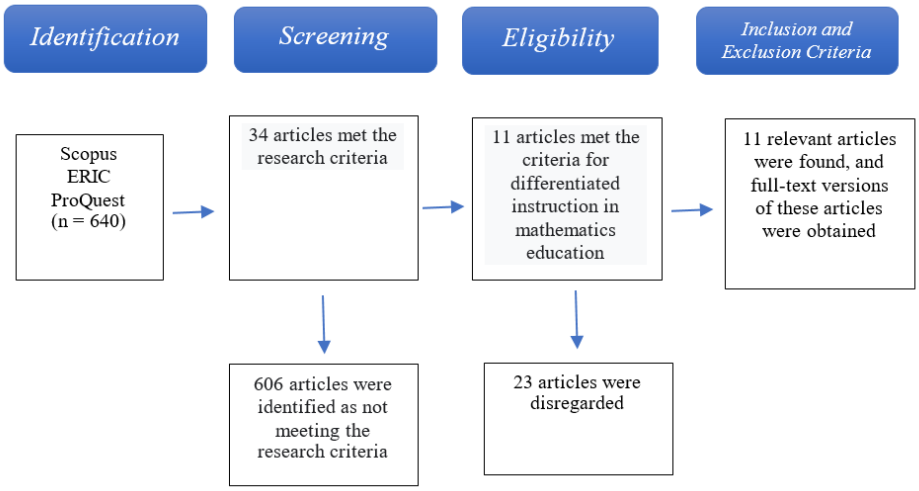

Figure 1: Flowchart of PRISMA.

3. RESULTS AND DISCUSSIONS

A total of 11 articles on differentiated instruction in mathematics education published between 2018 and 2023. This section discusses the following research questions:

i. In which countries was the research conducted?

ii. Who were the subjects in the study?

iii. What methods were used by the researchers?

iv. What were the aims of the study?

Table 3 above shows that research on differentiated instruction in mathematics education has been conducted in various countries, including the United States, Australia, Sweden, the Netherlands, Turkey, Ghana, and Southeast Asia with Malaysia and

TABLE 3: Research Findings related to Differentiated Instruction in Mathematics.

Studies; Country	Subjects	Method	Aims of Study
Mellroth & Bergwall, (2021) (9) Swedia	8 senior high school teachers.	Qualitative	To determine the task design in differentiated instruction within professional learning communities.
Kyeremeh et al., (2022)(10) Ghana	50 junior high school maths teachers	Quantitative and qualitative	To evaluate the knowledge of mathematics teachers in the implementation of differentiated instruction in junior high schools in Tano, Ghana.
Nurasiah et al., (2020)(11) Indonesia	70 junior high school students in Grade 8	Quantitative	Analyzing the mathematical communication skills of students before and after differentiated instruction. Analyzing the differences between students who use differentiated instruction and students who use conventional instruction.
Kamarulzaman et al., (2022) (5) Malaysia	400 gifted and talented students	Quantitative	To determine whether differentiated instruction helps enhance the mathematical thinking process of talented and gifted students.
Courtney, (2021) (4) Ohio, United States	Grade 6-12 Maths Teacher	Qualitative	To investigate teachers' efforts in implementing differentiated instruction on a daily basis in dynamic learning environments (such as remote and hybrid learning).
Gervasoni et al., (2021)(1) Australia	Grade 1 EMU Intervention Program students (students who are not progressing in mathematics)	Qualitative	To explore how engagement in a mathematics intervention program can enhance learning and positive attitudes among first-grade students who experience difficulties in learning mathematics (The intervention program is a differentiated instructional approach strategy implemented by several schools.)
Herner-patnode & Lee, (2021)(12) United States	Teachers who obtain early childhood education license.	Qualitative	To study the methods and approaches of differentiated instruction used by prospective teachers to address the academic and cultural needs of students.
Prast et al., (2018) (6) Netherland	30 primary schools (5658 students in grades 1 - 6)	Quantitative	To determine how a professional development program for teachers on differentiated instruction impacts students' mathematics learning outcomes.
Bal et al., (2022) (3) Turkey	572 teachers	Qualitative	To develop a scale that can be used to measure self-efficacy levels in differentiated instruction.
Marks et al., (2021) (2) Australia	Math teachers in secondary schools	Qualitative	To bridge the gap between theory and practice in differentiated instruction and assist teachers in developing and implementing differentiated instructional methods in mathematics education.
Hapsari et al., (2018) (13) Indonesia	62 Junior High School Students in Grade 8	Qualitative	To discuss differentiated instruction, including how students are expected to learn mathematics in relation to differentiated instruction itself, how it is implemented, and how students respond to it.

Indonesia. This indicates that the implementation of differentiated instruction has been carried out worldwide in response to the diverse needs of students.

In the United States, differentiated instruction has been a focus of the Individuals with Disabilities Education Act. This law mandates that students with special needs receive education tailored to their specific needs, including through differentiated instructional approaches. In Australia, differentiated instruction has become an integral part of the National Effective Teaching Principles. Teachers are encouraged to understand the needs and abilities of their students and use appropriate strategies to help them reach their full potential. Specific support is provided for students with special educational needs.

The subjects in differentiated instruction research primarily consist of teachers and prospective teachers who are expected to understand and implement differentiated instructional practices. They are individuals directly involved in the teaching and learning process and have a vested interest in enhancing student learning experiences. Teachers serve as subjects in differentiated instruction research because the effectiveness of their teaching and their response to diverse student needs are of interest. The aim is to explore new strategies and approaches that can help meet individual student needs.

Meanwhile, prospective teachers are also involved in differentiated instruction research to gain a deeper understanding of inclusive teaching practices. They need to equip themselves with the knowledge and skills necessary to address student diversity in their learning environments.

Involving teachers and prospective teachers as subjects in differentiated instruction research has numerous benefits. Firstly, it ensures that the research is based on real-world experiences and has direct relevance to the classroom context. Secondly, their participation can help identify challenges and barriers that may arise in implementing differentiated instruction. Thirdly, it encourages knowledge exchange and collaboration among education professionals.

Some differentiated instruction research also involves students as research subjects. In the context of differentiated instruction research, students become the primary focus for understanding their needs, preferences, and responses to different learning strategies.

Involving students as subjects in differentiated instruction research has several important benefits. Firstly, it helps researchers understand students' needs and preferences directly. By interviewing, observing, or administering questionnaires to students,

researchers can gain valuable insights into students' learning preferences, learning styles, interests, and challenges they face in the context of differentiated instruction.

Secondly, it allows for evaluating the effectiveness of various instructional strategies applied to students. By involving students as subjects, researchers can gather direct data on students' responses to specific teaching methods, their understanding of the material, levels of engagement, and learning achievements. This information helps researchers evaluate the most effective instructional strategies and provides valuable input for the development of improved differentiated instructional practices.

Thirdly, it provides students with an opportunity to contribute to their own learning process. They can provide feedback, make suggestions, or share their personal experiences that can enhance understanding and implementation of differentiated instructional practices. Additionally, involving students as subjects also helps increase their awareness of their own learning styles, individual needs, and the importance of appreciating diversity within the learning context.

Table 3 also indicates that the majority of recent studies have investigated differentiated instruction using qualitative research methods. Some studies have used quantitative and mixed methods as well. These qualitative methods are employed to delve into in-depth information about experiences, understandings, and practices within the context of differentiated instruction. They help understand the complex dynamics and contextual factors influencing differentiated instruction and formulate findings that support the development and improvement of more effective differentiated instructional practices. On the other hand, quantitative methods are used to measure students mathematical communication abilities, mathematical thinking processes, and mathematics achievement in differentiated instruction. Additionally, a combination of quantitative and qualitative methods can be utilized to provide a more comprehensive insight into understanding differentiated instruction.

The overall research objectives of studies on differentiated instruction in mathematics education are generally aimed at enhancing understanding, development, and implementation of instructional practices that meet the diverse individual needs of students. By identifying students' needs in terms of learning styles, interests, ability levels, or challenges faced, researchers assist in informing the development of teaching approaches that can address the individual needs of each student. Furthermore, researchers help inform the development of task designs that can assist teachers in facilitating effective

differentiated instruction for all students, including those with special needs or different learning styles.

Research on differentiated instruction in mathematics education also aims to enhance students' overall learning achievement. Through the development and implementation of differentiated instructional practices, researchers strive to improve students' mathematical communication abilities, mathematical thinking processes, and mathematics achievement. Additionally, research on differentiated instruction aims to provide insights and recommendations that can be used by educational practitioners, teachers, prospective teachers, or education policymakers.

4. CONCLUSION

We present the findings from the analysis of 11 research publications published between 2018 and 2023, exploring how differentiated instruction is implemented in mathematics education. The research contributions come from various countries worldwide, including Europe, Australia, Africa, Asia, and the United States. This indicates that the implementation of differentiated instruction has been carried out globally in response to the diverse needs of students.

The conclusion of this article is that differentiated instruction is an effective approach to enhancing students mathematical communication abilities, mathematical thinking processes, and mathematics achievement. However, the implementation of these practices requires sufficient time and resources. Teachers face challenges in planning and resource gathering. Furthermore, teachers perceptions of these practices vary. The article also emphasizes the need for further research exploring differentiated instruction practices in mathematics education as well as teacher implementation and its impact on student learning outcomes.

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