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Review article

A comprehensive synthesis of differentiated instruction approaches in mathematics

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Abstract: This study endeavors to provide a comprehensive synthesis of theoretical frameworks in educational research, with a specific focus on investigating and comparing differentiated instruction (DI) approaches across diverse dimensions. This study aims to address the challenge of meeting diverse student learning needs in mathematics by synthesizing various differentiated instruction approaches to provide a clearer framework for educators. Employing a systematic literature review methodology, the research utilized the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) technique from 2013 to 2023. The search for relevant articles over the past ten years was conducted across prominent databases, including ERIC, Scopus, and Google Scholar. A rigorous screening process identified 3220 articles, from which 17 were selected for in-depth analysis, following the PRISMA-P flow chart process as a guide. This study synthesizes research on differentiated instruction in mathematics, highlighting various aspects such as process, product, content, and learning environment. The majority of researchers focus on the process of differentiation, examining how teaching methods are adapted to suit diverse student needs. Meanwhile, fewer studies explore the learning environment's role. The implications of this study suggest that educators should prioritize adapting teaching methods (process differentiation) to address diverse student needs, as this is where most research is focused.

Keywords: differentiated instruction, mathematics, PRISMA, systematic literature review, teachers

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1 Introduction

Every student is entitled to a quality education in their academic journey, and teacher educators play a crucial role in cultivating exceptional and high-calibre students by employing diverse educational approaches. The conventional "chalk and talk" method is no longer pertinent to the contemporary needs of students. Today's learners gravitate towards methods that have a more profound impact on achieving educational objectives, particularly in heterogeneous classroom settings (Smale-Jacobse et al., 2019). All students, especially those in mixed classes, such as the multi-grade classes in Malaysia (Sekolah Kurang Murid or SKM) or their counterparts in low-enrolment schools, deserve a quality education comparable to that of mainstream students. The implementation of combined classes is a

global phenomenon, observed in various countries including Cambodia, China, India, Indonesia, and the Philippines, as noted by UNESCO (2015). This highlights that combined or multi-grade classes are not a new phenomenon for low-enrolment schools worldwide.

To adapt teaching methods to the diverse needs of students, differentiated instruction (DI) was introduced in Malaysia in 2019. This pedagogical approach considers the variations among students during the learning process, enabling educators to tailor instruction according to individual readiness levels, interests, and learning profiles (Mahamod et al., 2015). In the context of teaching multi-grade classes in low-enrolment schools, blended learning approaches present opportunities for implementing DI effectively (Shareefa et al., 2021). However, teachers in Malaysia continue to face significant challenges in addressing the diverse learning needs of students in these settings (Daniel Arif Abdul Muttalip, 2020).

A systematic literature review reveals a comprehensive overview of multiple educational research studies conducted in various countries, highlighting the diversity of educational frameworks and theories under investigation. It underscores the importance of DI as a cornerstone in educational pedagogy, especially in addressing the diverse needs of learners in heterogeneous classrooms. Research indicates a significant number of studies focused on various aspects of DI, including conceptual foundations, instructional strategies, assessment practices, and the effectiveness of DI in enhancing student learning outcomes. Despite the recognition of DI as a promising educational practice, its implementation remains complex due to challenges faced by educators in effectively managing differentiated instruction in the classroom (Smale-Jacobse et al., 2019).

This systematic review aims to fill the gap in existing literature by examining the current state of research on DI, specifically in mathematics education, and providing insights into best practices, challenges, and areas for further exploration. By doing so, it contributes to the ongoing discourse on pedagogical approaches that promote inclusivity and support the academic growth of all students.

1.1 Differentiated instruction in mathematics

Differentiated instruction (DI) is a pedagogical approach that emphasizes the recognition of individual student learning needs and the optimization of their academic potential (Unal et al., 2022). By employing DI, teachers can tailor instruction to match each student's readiness, interests, and learning profiles, thus providing personalized support that fosters academic growth. This approach allows for diverse instructional choices, varied assessments, and continuous monitoring of student progress (Bal, 2023). To implement DI effectively, educators must identify and modify key aspects of content, activities, processes, environments, and assessments. The differentiation process requires careful consideration of students' academic abilities, interests, and skills (Marks et al., 2021).

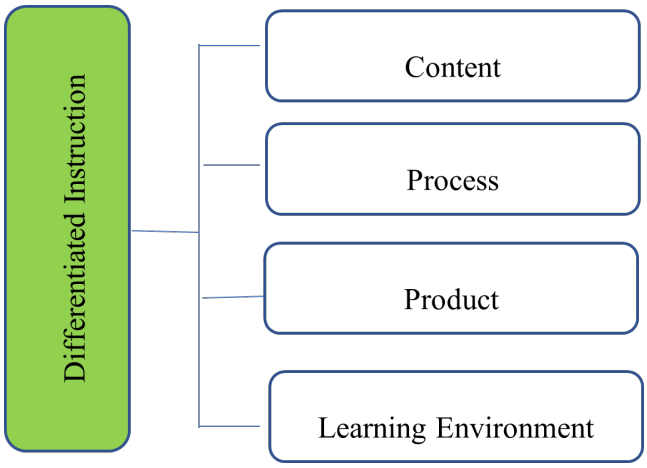
Tomlinson (2003) and Mustaffa et al. (2021), defines it as an approach that creates a learning environment with multiple pathways for students to acquire content, process ideas, and demonstrate understanding. This systematic approach to curriculum and

instruction planning is particularly vital for academically diverse learners. While DI is widely regarded as a well-established educational strategy, and policymakers advocate for its integration into educational systems globally, its implementation is not without challenges. Some educators express reservations about effectively managing DI in the classroom, citing concerns about the practicality and sustainability of tailoring instruction to individual needs (Smale-Jacobse et al., 2019).

Despite these challenges, the successful integration of DI into teaching can yield significant positive effects on student outcomes (Deunk et al., 2018). However, the complexity of implementing DI in a mathematics classroom, where concepts are often sequential and cumulative, requires further examination. The application of DI in mathematics involves not only modifying curriculum content but also adapting instructional strategies to accommodate students' varying levels of mathematical understanding. For instance, students might require different levels of scaffolding when learning foundational concepts such as fractions or algebraic expressions. Teachers need to be adept at identifying which students need more practice with basic skills and which are ready for more advanced problem-solving tasks (Tomlinson, 2000).

The concept of DI was introduced by Carol Ann Tomlinson in 1995 in the United States, and it has since been adopted globally as a means of addressing student diversity (Mustaffa et al., 2021). Tomlinson's framework (Figure 1) involves teachers engaging in creative and proactive teaching by modifying curriculum content, teaching processes, student products, and learning environments. These modifications are based on three critical aspects of student diversity: readiness (students' existing knowledge and experience), interest (students' engagement with content), and learning profile (students' preferred learning styles, intelligence, background, and other factors) (Rasheed & Wahid, 2018).

Figure 1. Differentiated instruction framework



In the context of mathematics education, DI requires a nuanced approach. Teachers must consider how to differentiate content by providing a range of mathematical problems that cater to different ability levels. For instance, when teaching fractions, some students

may need visual aids and concrete manipulatives, while others might benefit from abstract reasoning tasks(Setambah et al., 2021) . The process of differentiation might involve varying the pace of instruction or employing different teaching methods, such as direct instruction for struggling learners and inquiry-based learning for those who grasp concepts quickly (Tomlinson, 2003).

Furthermore, the product element in DI could involve offering students multiple ways to demonstrate their understanding of mathematical concepts. For example, students could show mastery of a topic through traditional assessments, projects, or presentations (Unal et al., 2022) The environment in which learning takes place also plays a crucial role, as a supportive and flexible classroom setting can enhance student engagement and motivation (Tomlinson, 2003; Rasheed & Wahid, 2018).

However, the successful implementation of DI in mathematics classrooms is contingent upon teachers' ability to manage the increased complexity that comes with personalized instruction (Bal, 2023). This requires not only a deep understanding of mathematical content but also the ability to design and deliver differentiated lessons that meet the diverse needs of students (Unal et al., 2022). Teachers must be equipped with the skills and resources necessary to balance the demands of DI while ensuring that all students achieve the desired learning outcomes.

In conclusion, while differentiated instruction offers a promising approach to meeting the diverse needs of learners, particularly in mathematics education, its successful implementation requires careful planning, ongoing professional development, and a commitment to addressing the challenges that arise in diverse classroom settings (Smale-Jacobse et al., 2019). As educational landscapes continue to evolve, it is essential for educators to critically examine and refine their use of DI to ensure that all students, regardless of their backgrounds or abilities, have access to high-quality, equitable education (Unal et al., 2022). Enhancing mathematics instruction for diverse learners requires a shift from traditional methods to more differentiated and individualized approaches (Daniel Arif Abdul Muttalip, 2020). By focusing on meaningful mathematical discourse, explicit strategy instruction, and addressing early mathematical difficulties, educators can better support all students in achieving mathematics proficiency.

2 Materials and methods

2.1 Inclusion and exclusion criteria

This systematic literature review is dedicated to evaluating the effectiveness of differentiated instruction within mathematics classes. To ensure a precise and comprehensive analysis, a set of inclusion and exclusion criteria has been meticulously established. This includes consideration of primary school, and secondary school research studies published between 2013 and 2023, rigorous study designs such as experimental and quasi-experimental designs, and a focus on outcome measures providing quantitative data on the

impact of differentiated instruction specifically within the realm of mathematics. The review will encompass studies involving diverse primary student populations, conducted in various educational settings, and published in Malay and English. The researcher also placed the condition that the number of citations that exceed 2 is only taken as a good article and used as a reference in this study. Choosing a threshold of two citations indicates a baseline level of recognition, suggesting that the article has made some contribution to the field. This approach also promotes inclusivity in literature selection, allowing valuable but under-cited articles to be included, particularly in niche areas where research activity may be limited. Additionally, this practical threshold can help ensure a sufficient number of references in the literature review, especially for recent publications that may not yet have had time to accumulate more citations.

By strictly adhering to these inclusion and exclusion criteria, this systematic literature review endeavours to offer a focused examination of the effectiveness of differentiated instruction within the unique context of primary school and secondary mathematics classes. The criteria provide a structured framework for the selection of studies, ensuring that the analysis remains current, methodologically rigorous, and directly applicable to mathematics education. This review aims to distill insights from a range of studies, providing valuable implications specifically tailored for mathematics educators, researchers, and policymakers striving to enhance instructional practices and student outcomes through differentiated instruction in the mathematics classroom.

Our inclusion and exclusion are summarized as Table 1.

Table 1. Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Educational Levels	Research studies focusing on primary and secondary school settings.	Studies not focused on primary or secondary education.
Publication Date	Studies published between 2013 and 2023.	Publications outside the 2013 to 2023 range.
Study Design	Rigorous study designs, specifically experimental and quasi-experimental designs.	Studies lacking experimental or quasi-experimental designs.
Outcome Measures	Studies providing quantitative data on the impact of differentiated instruction in mathematics.	Non-quantitative studies.
Diverse Populations	Studies involving diverse primary student populations in various educational settings.	Research that does not involve diverse student populations.
Language	Publications in Malay and English.	Publications in languages other than Malay or English.
Citation Count	Articles with more than two citations will be considered as good articles.	Articles with two or fewer citations.

2.2 Procedures

In the current investigation, the procedural framework for conducting a systematic literature review (SLR) was adopted, drawing upon the recommendations of Bodolica and Spraggon (2018). However, nuanced modifications were incorporated based on the insights proposed by Elmashhara et al. (2022), and the research questions posed by Usman et al. (2022) were instrumental in guiding the analysis phase. The methodology commenced with the clear definition of the research topic and the formulation of specific objectives. A meticulous database search ensued, employing predetermined keywords and selection criteria to systematically identify relevant articles. The subsequent phase involved a judicious filtering process, wherein articles were screened based on predefined inclusion and exclusion criteria. The discerned articles were then subjected to an extraction process to cull pertinent materials, ensuring the derivation of high-quality results. The distinctive feature of this approach, as articulated by Riebe et al. (2016), lies in its departure from traditional literature reviews, emphasizing the adoption of characteristics indicative of robustly designed and replicable research projects. Noteworthy is the method's intention to facilitate the interpretation of research findings, guided by pre-established research questions, a perspective that aligns with the comprehensive and structured nature of systematic reviews elucidated by (Zhao et al., 2021). The integration of insights and adjustments from prior research, as evidenced in the referencing of various scholars, serves to underscore the methodological rigor underpinning the study.

The process involves several key steps:

1. Topic and Research Objectives Determination: Identify and define the topic of interest. Clearly outline the research objectives.
2. Database Search: Conduct a systematic search through relevant databases. Use predetermined keywords and selection criteria to identify relevant articles.
3. Article Filtering and Sorting: Apply inclusion and exclusion criteria to filter articles. Sort out articles that meet the specified criteria.
4. Material Extraction: Extract relevant materials from the selected articles. This step aims to provide high-quality results for the systematic review.
5. Emphasis on Research Project Characteristics: Emphasize the characteristics of robustly designed and replicable research projects. These characteristics contribute to the reliability and validity of the research.
6. Facilitation of Research Interpretation: Stress the role of the systematic review approach in facilitating the interpretation of research findings based on predefined research questions.

References to Bodolica and Spraggon (2018), Elmashhara et al. (2022), Usman et al. (2021), Riebe et al. (2016), and Zhao et al. (2021) indicate that the study integrates insights and adjustments from prior research in the field. To attain the research objectives and pinpoint relevant research papers, researcher utilize relevant databases such as google

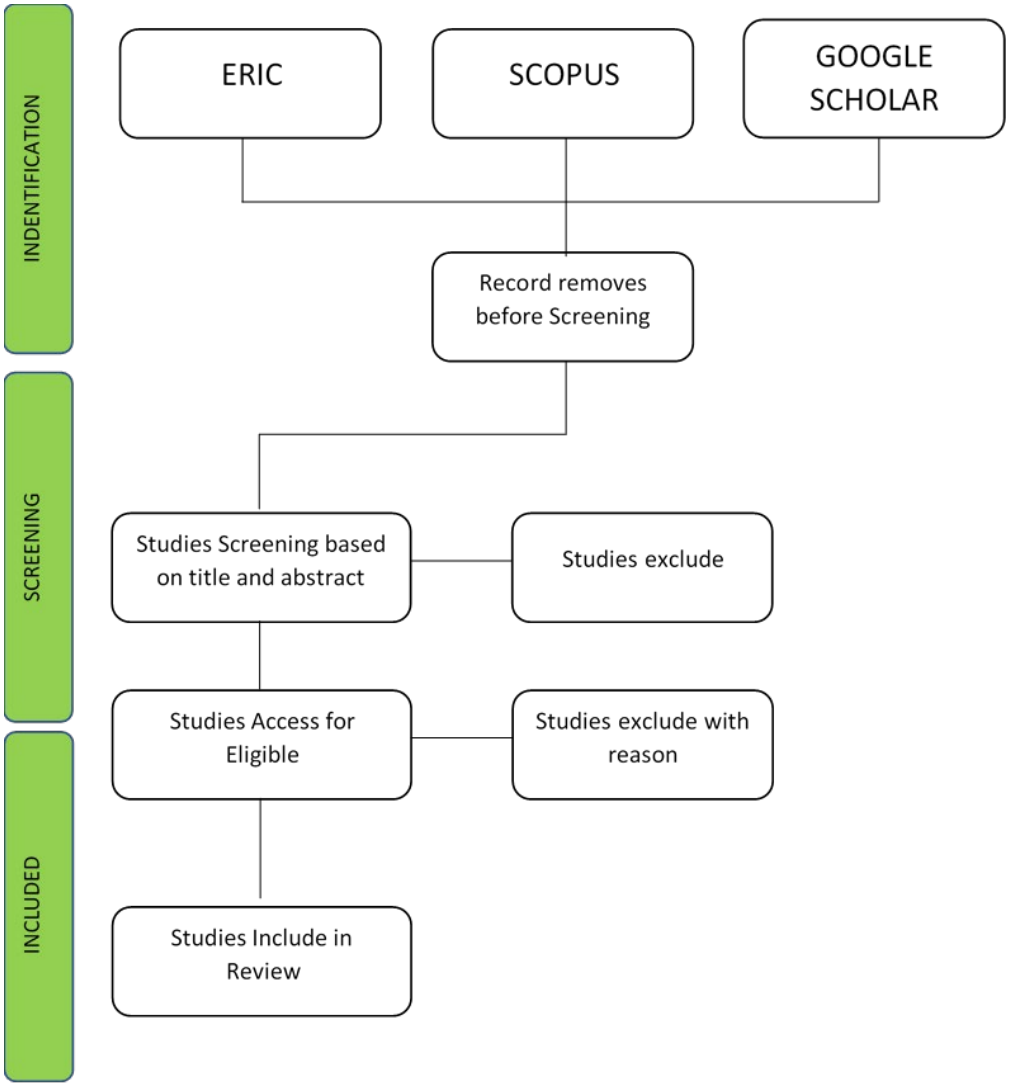
scholar, ERIC, and Scopus. The Scopus online database was employed. Recognized for its expert curation, the Scopus database was selected owing to its credibility (Bodolica & Spraggon, 2018). Due to limitations in accessing the Scopus database, the researcher used the Google Scholar search engine. One limitation of Scopus is that it primarily indexes English-language publications, which can exclude significant research published in other languages, leading to potential biases in literature reviews. Additionally, access to Scopus often requires institutional subscriptions, which may not be available to all researchers, restricting access to essential literature for independent researchers or those at underfunded institutions. Google Scholar is widely recognized for its accessibility and user-friendly interface, making it a valuable tool for researchers and academics. Some of the positive aspects and advantages of Google Scholar include:

- Free Access: Google Scholar provides free access to a vast range of scholarly literature, including articles, theses, books, conference papers, and more.
- Comprehensive Coverage: It indexes a diverse array of academic disciplines, offering a broad scope of research materials across various fields.
- User-Friendly Interface: The interface is intuitive and easy to use, allowing researchers to quickly and efficiently search for scholarly content.
- Quick Results: Google Scholar often provides quick access to citation information, abstracts, and full-text PDFs, streamlining the research process.
- Alerts and Metrics: Researchers can set up alerts to stay informed about new publications in their field of interest. Additionally, Google Scholar Metrics provides a measure of the scholarly impact of journals and articles.
- Linking to Library Resources: It often provides links to institutional repositories and library resources, facilitating access to full-text articles.
- Citations and Author Profiles: Google Scholar tracks citations, making it useful for evaluating the impact of scholarly work. It also provides author profiles, displaying their publications and citation metrics.

While Google Scholar has many advantages, it's important to note that it may not be as comprehensive as some subscription-based databases like Scopus or Web of Science. Researchers often use a combination of tools and databases to ensure thorough coverage of the literature relevant to their work (Tulljanah & Amini, 2021; Tzenios et al., 2022; Canova-Barrios & Machuca-Contreras, 2022).

A meticulous analysis of keywords in the Google Scholar, Scopus and Eric database was conducted to broaden the inclusivity of differentiated instruction research. The study adhered to a criterion favouring peer-reviewed journal publication, acknowledged as a more reliable source of scientific knowledge (Salam et al., 2019). Exploring the factors impacting group work in higher education amidst the fourth industrial revolution, this research utilized a modified technique based on the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P), as suggested by Page et al. (2022), alongside Microsoft Excel in Figure 1.

Figure 2. PRISMA-P search flow chart



In this research, a systematic search was conducted using specific queries to explore the impact of instructional strategies on mathematics achievement among K-12 students. The queries encompassed terms such as “differentiated instruction,” “individualized instruction,” and “personalized learning” to identify various teaching methodologies aimed at meeting diverse student needs. Additionally, the search included outcome measures like “mathematics achievement” and “mathematics performance” to evaluate student success in mathematical tasks. The target population was narrowed down to “K-12 students,” “primary education,” and “secondary education” to ensure a comprehensive review across different educational levels. The keywords were developed manually through a detailed process that included conducting a literature review to identify relevant themes, brainstorming potential keywords, categorizing them, refining their relevance, and seeking feedback to ensure their effectiveness. The critical phase of study selection, integral to a systematic literature review, involved screening articles (Page et al., 2022). For 47 studies were chosen for further scrutiny, and any duplicate content was eliminated using the Elicit.org.

2.3 Data extraction

To ensure adherence to quality assurance (QA) standards throughout the review, a systematic approach was taken to exclude irrelevant papers. The data extraction process involved gathering key information from each selected study, guided by the inclusion and exclusion criteria outlined in a subtopic. Each study was succinctly summarized, focusing on its strategy, methods, conclusions, and scope of application. Initially, a comprehensive search was conducted across Google Scholar, ERIC, and Scopus, yielding 3,220 articles. After eliminating duplicate entries, 200 unique articles remained. These articles were then screened according to the predefined inclusion and exclusion criteria, which were designed to filter out irrelevant studies based on the titles and abstracts. This process narrowed the selection down to 47 articles for full-text review.

During the full-text review, each of the 47 articles was thoroughly examined to ensure they met the specific inclusion criteria related to methodology, relevance, and quality. As a result, 17 papers were identified as relevant and included in the final analysis. This rigorous selection process followed the guidelines of the PRISMA framework, ensuring transparency and replicability in the review methodology. Figure 2 provides a visual summary of the search strategy, adapted from Page et al. (2022), which outlines the identification, screening, eligibility, and inclusion stages of the systematic literature review. This structured approach ensures the reliability of the findings and the relevance of the selected literature to the research objectives.

3 Results and discussion

Data were collected from 17 articles across 16 distinct publications. Table 1 provides information on the number of papers meeting the inclusion criteria from each database. A total of 17 studies underwent analysis for eligibility against the backdrop of the research question, as outlined in Table 2. This table offers a glimpse into the collected data and results. The chosen studies exhibit diverse characteristics and specifications. Geographically, they span four continents, including Europe (Cyprus, Finland, Turkey, Netherlands), North America (USA), Africa (Kenya), and Asia (Hong Kong, Philippines, Australia, Indonesia). The wide-ranging nature of the selected studies highlights variations in their features. Figure 2 shows the study pattern related to differentiate instruction in mathematics education by year. The up-and-down pattern is observed in this study of differentiated instruction. However, in the last 2-3 years, an increasing trend is evident, rising from 1 article to 4 articles starting from 2021.

Figure 3. Data extraction process

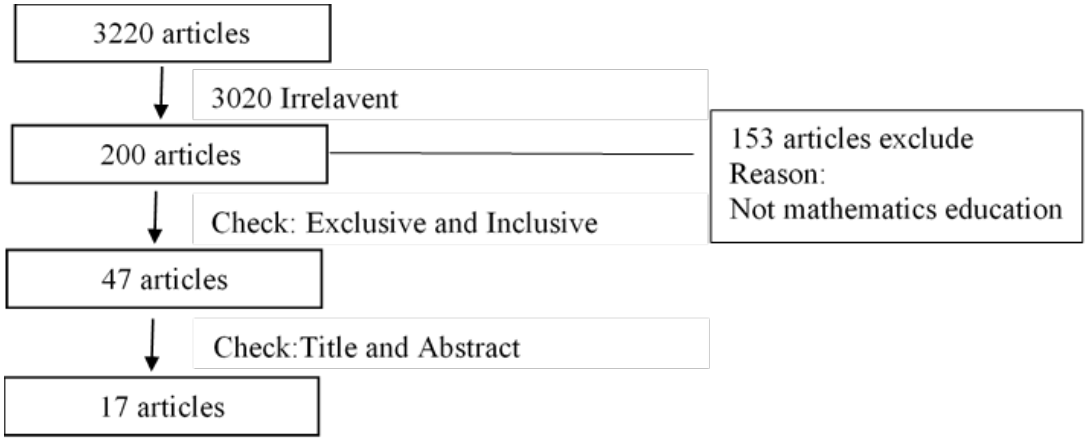


Table 2. The number of papers meeting the inclusion criteria

Bil	Authors	Title	Year	Source	Publisher
1	Eissa & Mostafa	Integrating Multiple Intelligences and Learning Styles on Solving Problems, Achievement in, and Attitudes towards Math in Six Graders with Learning Disabilities in six graders with learning disabilities in cooperative groups	2013	U.S. Department of Education (.gov)	ERIC
2	Eissa & Mostafa	The effects of differentiated instruction by integrating multiple intelligences and learning styles on solving problems, achievement in, and attitudes towards math in six graders with learning disabilities in cooperative groups	2013	Psycho-Educational Research Reviews	perrjournal.com
3	Konstantinou-Katzi et al.	Differentiation of teaching and learning mathematics: an action research study in tertiary education	2013	International Journal of Mathematical Education In Science & Technology	Taylor &Francis
4	Njagi	The effects of differentiated instruction on student's achievement in mathematics by gender in secondary schools in Meru County in Kenya	2015	International Journal of Education and Research	ijern.com
5	Taylor	Differentiating instruction: Challenges in the secondary classroom	2016	Journal of Education and Social Science	scholar.archive.org
6	Ekstam et al.	The impact of teacher characteristics on educational differentiation practices in lower secondary mathematics instruction	2017	LUMAT: International Journal on Math, Science and Technology	University of Helsinki
7	Wan	Differentiated instruction: Are Hong Kong in-service teachers ready?	2017	Teachers and Teaching	Taylor &Francis
8	Deunk et al.	Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education	2018	Educational Research Review	Elsevier
9	Faber et al.	Differentiated instruction in a data-based decision-making context	2018	International Journal of Research, Policy and Practice	Taylor &Francis
10	Tambaoan & Gaylo	Differentiating instruction in a mathematics classroom: Its effects on senior high school learners' academic performance and engagement in basic calculus	2019	International journal of English and education	ijee.org
11	Iterbeke et al.	The effect of ability matching and differentiated instruction in financial literacy education. evidence from two randomised control trials	2020	Economics of Education Review	Elsevier
12	Ndia et al.	The Effect of Learning Models and Multiple Intelligences on Mathematics Achievement.	2020	International Journal of Instruction	ERIC
13	Fernandez & Tangalin	Effects Of Differentiated Instruction On The Grade 11 Students'academic Performance In Mathematics	2020	International Journal of Advanced	https://iaeme.com/

				Research in Engineering and Technology	
14	Marks et al.	Differentiating instruction: Development of a practice framework for and with secondary mathematics classroom teachers	2021	International Electronic Journal of Mathematics Education	iejme.com
15	Unal et al.	Differentiated Instruction and Kindergarten through 5th Grade Teachers.	2022	Georgia Educational Researcher	ERIC
16	Obafemi	Effect of differentiated instruction on the academic achievement of pupils in mathematics in Ilorin West Local Government Area, Kwara State	2022	KWASU International Journal of Education (KIJE)	kije.com.ng
17	Bal	Assessing the impact of differentiated instruction on mathematics achievement and attitudes of secondary school learners	2023	South African Journal of Education	ajol.info

Figure 4. Number of differentiated instruction research in mathematics education

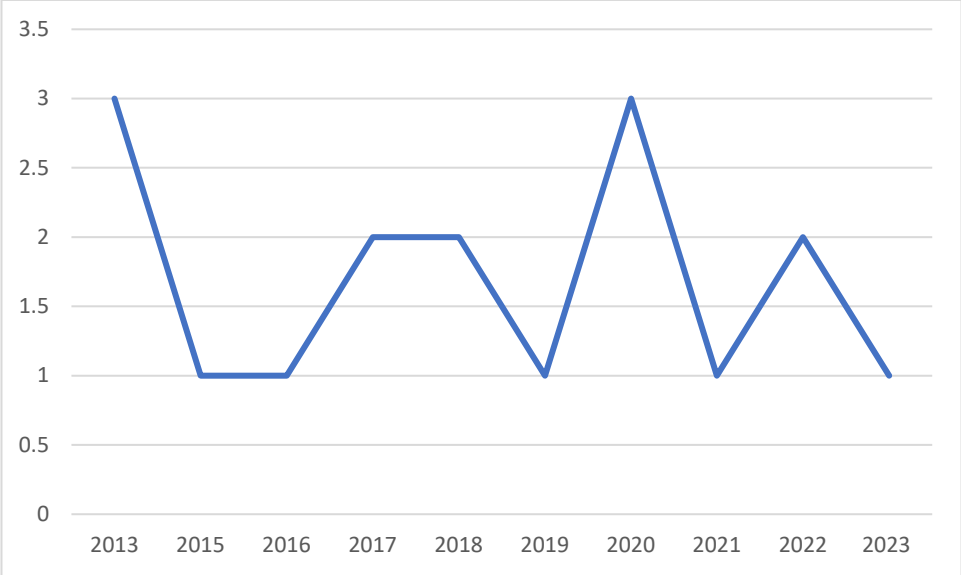


Table 3. The element of the research

Author	Framework	Design	Country	Practice	Element
(Eissa & Mostafa, 2013)	Gardner's theory of multiple intelligences and Sternberg's theory of thinking styles,	Quasi Experimental	United States	On the basis of the findings, the study advocated for the effectiveness of using differentiated instruction by integrating multiple intelligences and learning styles on solving problems , achievement in , and attitudes towards math in learning disabled students.	Process
(Eissa & Mostafa, 2013)	Gardner's theory of multiple intelligences and Sternberg's theory of thinking styles,	Quasi Experimental	United States and United Kingdom	teachers' practice of both content differentiation and product differentiation	Content and Product
(Konstantinou-Katzi et al., 2013)	theory of social constructivism, Vygotsky's Zone of Proximal Development, and the philosophy of teaching defined by Tomlinson	Observational Study	Cyprus	use Different strategy and integrate with technology (Process)	Process
(Njagi, 2015)	differentiated instruction as proposed by Boaler (2002) and Tomlinson (2003).	Quasi-experimental design, Solomon Four-Group design	Kenya	implementation of strategies that genuinely address the unique needs and strengths of students of all genders	Process
(Taylor, 2016)	cognitive psychology	systematic literature review (SLR)	United States	implementation of technology in the educational setting	Process

(Ekstam et al., 2017)	teacher characteristics and their impact on teaching practices, self-efficacy theory, and mathematics teaching efficacy	observational study	Finland	focus on how teacher characteristics are related to the use of differentiation practices.	Process, Content, Product and Learning Environment
(Wan, 2017)	five-dimensional model of differentiation.	exploratory mixed methods study	Hong Kong	focus on how teacher characteristics are related to the use of differentiation practices	Process, Content, Product and Learning Environment
(Deunk et al., 2018)	teaching, aptitude-treatment interaction, Vygotsky's Zone of Proximal Development,	SLR	United States	Implementation of technology in the educational setting	Process
(Faber et al., 2018)	Data-based decision making in education	observational study	Netherland	observation for the teachers in class (instruction and evaluation)	Process and Product
(Tambaoan & Gaylo, 2019)	differentiated instruction, constructivist perspectives, and Vygotsky's theory of zone of proximal development.	quasi-experimental pre-test-posttest design with two intact classes assigned as the experimental and control groups	Philippines	experiment to implementation different activities	Process
(Iterbeke et al., 2020)	Differentiated instruction, ability matching, student learning outcomes in financial education	randomized controlled trial with a parallel design	Belgium	different versions of the material were designed and all of them resulted in the same set of learning outcomes	Content
(Ndia et al., 2020)	foundation of other sciences, the objective and practical nature of mathematics, and the constructivism learning theory as the basis for knowledge construction and the development of innovative learning models.	quasi-experimental design	Indonesia	experiment with different approach	Process
(Fernandez & Tangalin, 2020)	Not explicitly mentioned, but the paper is based on the importance of mathematics in real life, promotion of learning through mathematical activities, and adaptation to different learning environments.	experimental research design involving the Solomon Four-Groups Design with a control and experimental group	Philipines	implementation technology, different material and rubric	Process, Content and Product
(Marks et al., 2021)	Tomlinson's four guiding principles of differentiated instruction, REACH principles of Rock et al. (2008), DBIR principles of Fishman et al. (2013)	Designed-Based Implementation Research (DBIR)	Australia	developing model for differentiated instruction	Product, Content, Process
(Unal et al., 2022)	Vygotsky's socio-cultural theory and Zone of Proximal Development	non-controlled observational study with convenience sampling	United States _Gergia	focus on how teacher characteristics are related to the use of differentiation practices	Product, Process and Content
(Obafemi, 2022)	Concept of differentiated instruction	Quasi-Experimental (factorial design 2x2)	Nigeria	doing experimental for differentiated Instruction but not mention how they do	Product, Process and Content
(Bal, 2023)	Differentiated instruction, Social constructivist approach, Zone of proximal development theory by Vygotsky	quasi-experimental study with 2 control groups and 1 experimental group	Turkeye	implementation of module in experimental (lesson plan and material)	Process

The study provides a comprehensive overview of multiple educational research studies conducted in various countries, highlighting the diversity of educational frameworks and theories under investigation. Here are some key points of analysis about differentiated instruction:

1. Theoretical Frameworks: The statement mentions studies that delve into prominent educational theories such as Gardner's theory of multiple intelligences, Sternberg's thinking styles (Eissa & Mostafa, 2013), social constructivism, Vygotsky's Zone of Proximal Development (Konstantinou-Katzi et al., 2013), cognitive psychology (Taylor, 2016) and differentiated instruction proposed by Boaler and Tomlinson (Njagi, 2015). This indicates a rich theoretical landscape in mathematics education research.
2. Methodological Variety: The studies employ various research designs, including quasi-experimental designs (Eissa & Mostafa, 2013; Obafemi, 2022; Bal, 2023; Ndia et al., 2020;Tambaoan & Gaylo, 2019; Njagi, 2015), observational studies (Faber et al., 2018; Ekstam et al., 2017; Konstantinou-Katzi et al., 2013), systematic literature reviews (Deunk et al., 2018; Taylor, 2016), randomized controlled trials (Iterbeke et al., 2020), and experimental research designs (Fernandez & Tangalin, 2020). This diversity in methodologies reflects a broad attempt to address research questions and contribute to the understanding of educational practices.
3. Focus Areas: The studies cover a wide array of focus areas, such as differentiated instruction (Bal, 2023; Obafemi, 2022)), cognitive psychology (Taylor, 2016; Unal et al., 2022), teacher characteristics (Wan, 2017; Ekstam et al., 2017), data-based decision-making (Faber et al., 2018; Deunk et al., 2018), and the impact of various theories on teaching practices (Marks et al., 2021) and efficacy (Ekstam et al., 2017). This diversity in topics suggests a multidimensional exploration of the educational landscape.
4. Cultural and Contextual Considerations: The inclusion of studies from different countries implies a recognition of the importance of cultural and contextual factors in educational research. It highlights the understanding that educational practices and outcomes are often influenced by the unique social, cultural, and regional contexts in which they are applied. By incorporating diverse perspectives, researchers can gain a more comprehensive understanding of how theories and strategies might need to be adapted to suit specific local needs, ultimately enhancing the relevance and effectiveness of educational interventions across various settings. Different regions may face unique challenges, and these studies can provide valuable insights into how educational theories and practices can be adapted to suit local contexts. This study found that differentiated instruction, when combined with multiple intelligences and learning styles, significantly improved students' problem-solving skills, academic achievement, and attitudes toward mathematics. By understanding the specific obstacles in various areas, researchers can

tailor educational strategies, ensuring they are more relevant and effective in addressing local needs.

5. Varied Sampling and Design Approaches: The studies employ different sampling techniques, including convenience sampling and factorial designs. This diversity in sampling and design approaches reflects a pragmatic acknowledgment of the practical constraints and opportunities in each research context.

The statement highlights the richness and diversity of contemporary educational research, emphasizing a global perspective, a variety of theoretical frameworks, and a range of research methodologies to deepen our understanding of teaching and learning processes in different cultural and educational settings.

The focus seems to be on implementing differentiated instruction, integrating technology, understanding the role of teacher characteristics, and experimenting with various approaches to enhance the effectiveness of teaching and learning, especially for students with learning disabilities. This indicate a comprehensive approach involving content, process, product, and the learning environment. Here a summarize the number of researchers focusing on each aspect as follows:

1. Process: The process of differentiation refers to teaching methods that are adapted to suit the diverse needs of students (Muhammad, Mukhtar, & Faruk, 2023). In the context of your literature review, it suggests that 15 researchers specifically focused on how differentiated instruction is implemented in terms of teaching methods. This could involve tailoring instructional strategies to accommodate different learning styles, paces, or preferences among students. Understanding the varied ways in which teachers implement differentiation in the instructional process is crucial for gaining insights into effective pedagogical practices
2. Product: The differentiation of products refers to the skills acquired by students as a result of the differentiated instruction (Ndia et al., 2020). These skills are not only acquired but also highlighted by the students themselves and assessed by teachers. This aspect suggests that 8 researchers examined the outcomes or products of differentiated instruction, emphasizing the importance of assessing and recognizing the skills developed by students. This could include both academic and non-academic skills that are cultivated through tailored instruction
3. Content of Learning: The content of learning in the context of differentiation refers to modifications in the curriculum content (Njagi, 2015). This involves adapting learning materials and sources to meet the specific needs of students. The fact that 8 researchers focused on the content of learning suggests a recognition of the importance of tailoring educational materials to suit the diverse learning preferences, abilities, and interests of students. This could involve selecting different resources or adjusting the complexity of materials to meet individual student needs.

4. Learning Environment: The learning environment, in the context of differentiation, refers to any conducive learning place that provides comfort to student (Obafemi, 2022). In literature review, two researcher explains the learning environment in their study. This implies that there is relatively less emphasis on investigating how the physical or virtual learning environment impacts the effectiveness of differentiated instruction. Exploring this aspect further could involve examining factors such as classroom layout, use of technology, and overall atmosphere that contribute to a supportive and comfortable learning space for students.

In summary, literature review suggests that researchers have explored different facets of differentiated instruction, including the process of implementation, the outcomes or products of instruction, modifications to curriculum content, and, to a lesser extent, the impact of the learning environment. Further research in each of these areas contributes to a more comprehensive understanding of how differentiation can be effectively applied in teaching and learning contexts. This provides an overview of the distribution of research focuses among different aspects in the context of differentiated instruction. While the number of researchers is not balanced across each aspect, each focus contributes uniquely to the understanding of the use of differentiated instruction in the learning context.

4 Future research on differentiated instruction

Future research on differentiated instruction should delve into the underexplored areas of learning environments and their impact on students' academic success. Although many studies have focused on content and instructional processes, few have examined how the physical and virtual spaces in which learning occurs affect the effectiveness of differentiated instruction. Investigating how classroom layouts, technological tools, and the overall atmosphere contribute to or hinder tailored teaching strategies is crucial. This exploration can help identify best practices for creating conducive learning environments that promote engagement and success for all students.

As the educational landscape shifts towards more technology-driven and blended learning models, understanding how differentiation can be adapted for virtual environments becomes increasingly important. Future studies should focus on how digital platforms and tools can facilitate personalized learning experiences that cater to diverse needs. Research in this area could provide valuable insights into the effectiveness of virtual differentiation strategies, particularly for students with unique learning requirements. By addressing this gap, educators can enhance their approaches to teaching in online settings, ensuring that all students receive the support they need.

Additionally, as educational strategies become more global, it is essential to understand how cultural and contextual factors shape the implementation and effectiveness of differentiated instruction. Future research could explore how local customs, values, and educational practices influence the adoption and adaptation of differentiated strategies in various settings. By considering the cultural context,

researchers can provide guidance on how to tailor differentiation to meet the specific needs of diverse student populations, ultimately improving educational equity and effectiveness.

Finally, future studies should investigate the role of teacher characteristics and professional development in the successful implementation of differentiated instruction. Understanding how teachers' beliefs, experiences, and adaptability affect their ability to implement differentiated strategies can inform more effective training programs. Research that focuses on building teachers' capacity to differentiate instruction will not only enhance their teaching practices but also improve student outcomes. By addressing these critical areas, future research can contribute to a more comprehensive understanding of differentiated instruction, its challenges, and its potential to transform learning experiences across diverse educational contexts.

Conclusions

In conclusion, this article has highlighted the critical role of differentiated instruction in enhancing student learning outcomes and fostering a positive educational experience. By examining various theoretical frameworks, methodologies, and focus areas, we can appreciate the complexity and diversity of approaches to differentiation in different educational contexts. The findings emphasize that tailoring instruction to meet individual students' needs is not merely an instructional strategy but a necessary practice for promoting equity and accessibility in education.

However, significant gaps remain in the current research landscape, particularly concerning the influence of learning environments, cultural contexts, and teacher characteristics on the effective implementation of differentiated instruction. Future research should address these areas to provide a more comprehensive understanding of how to optimize differentiation strategies. By exploring the interplay between physical and virtual learning spaces, as well as the role of teacher training and professional development, we can equip educators with the tools they need to implement effective differentiation practices.

Ultimately, fostering an educational environment that values diversity and inclusivity requires ongoing exploration and adaptation of differentiated instruction. As the educational landscape continues to evolve, researchers, educators, and policymakers must collaborate to refine these strategies, ensuring that all students, regardless of their unique needs, can thrive academically and personally. By prioritizing further investigation into the nuances of differentiation, we can enhance teaching practices and create more equitable learning opportunities for all students.

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Conflicts of interest

The authors declare no conflict of interest.

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