

THE EFFECT OF IMPLEMENTATION DIFFERENTIATED INSTRUCTION FOR ENHANCING MATHEMATICAL COMPETENCE IN THE LAST DECADE

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Abstract

The objective of this research is to describe the effect of implementation Differentiated Instruction (DI) for enhancing mathematical competence in the last decade of primary, secondary, and high/vocational school students. The study method is a Systematic Literature Review (SLR). The dataset comprised 15 articles focusing on the effect of DI on enhancing mathematical competence. The samples were extracted from published indexed which published between 2013 and 2022. The focus of this study is to describe the impact of Implementation DI for enhancing mathematical competence in the last decade, in terms of research period, academic level, sample size, mathematics content, the authors' geographical distribution, and research methodologies. By employing SLR, over the decade, the number of studies increased, except 2019-2020, the most of the studies were conducted on secondary school students, most of the subjects with 30 or more, the most content mathematics were geometry, the most empirical investigations were Indonesia and Philippines, and the most research methodologies conducted by quasi experiment. In accordance with a full-text analysis of 15 published papers, DI potentially could improve mathematical competence, especially achievement and performance, but only a few articles that discuss problem solving, understanding, creative thinking, critical thinking, and mathematics connection.

Keywords: Differentiated Instruction, Effect, Mathematical Competence, Systematic Literature Review.

Abstrak

Tujuan penelitian ini adalah untuk mendeskripsikan pengaruh implementasi Pembelajaran Diferensiasi (PD) dalam meningkatkan kompetensi matematika pada dekade terakhir siswa sekolah dasar, menengah, dan menengah atas/kejuruan. Metode penelitian yang digunakan adalah Tinjauan Literatur Sistematis (SLR). Data penelitian terdiri dari 15 artikel yang berfokus pada efek PD dalam meningkatkan kompetensi matematika. Sampel artikel diperoleh dari publikasi terindeks yang diterbitkan antara tahun 2013 dan 2022. Fokus penelitian ini adalah mendeskripsikan pengaruh implementasi PD dalam meningkatkan kompetensi matematika dalam dekade terakhir, ditinjau dari tahun studi, tingkat studi, ukuran sampel, materi matematika, distribusi geografis penulis, dan metodologi penelitian. Dengan menggunakan SLR, selama dekade tersebut, jumlah studi meningkat, kecuali pada tahun 2019-2020. Sebagian besar studi dilakukan pada siswa sekolah menengah, dengan subjek penelitian sebanyak 30 atau lebih. Konten matematika yang paling banyak diteliti adalah geometri. Indonesia dan Filipina menjadi negara yang paling banyak melakukan penelitian empiris. Metodologi penelitian yang paling banyak digunakan adalah quasi eksperimen. Berdasarkan analisis penuh terhadap 15 artikel yang dipublikasikan, DI berpotensi meningkatkan kompetensi matematika, terutama dalam hal prestasi dan performa, namun hanya sedikit artikel yang membahas pemecahan masalah, pemahaman, berpikir kreatif, berpikir kritis, dan keterhubungan matematika.

Kata kunci: Kompetensi Matematika, Pengaruh, Pembelajaran Berdiferensiasi, Systematic Literature Review.



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INTRODUCTION

The objective of the National Education, as outlined in Article 3 of Law Number 20 of 2003, is to foster individuals who have faith and devotion to God Almighty, possess noble character, maintain good health, acquire knowledge, demonstrate competence, exhibit creativity, independence, and become democratic and responsible citizens (Depdiknas, 2003). The National Education Goals in the "Kurikulum Merdeka" are articulated in the "Profil Pelajar Pancasila" (Kemdikbud-ristek, 2022). These objectives align with the requirements of 21st-century skills that students need to develop, namely critical thinking, creative thinking, collaboration, and communication (Ohio Department of Education, 2015).

According to national education goals, student profiles of Pancasila and 21st century skills, there are many mathematical competencies that students must achieve on learning mathematics. The mathematical competencies in this study referred to are all competencies achieved by students in learning mathematics through DI. These competencies include performance, achievement, problem solving, understanding, creative thinking, critical thinking, connections, and other competencies that appear as an effect of learning.

Differentiated instruction refers to a flexible instructional approach aimed at addressing the unique requirements of students in the classroom, considering their diverse needs (Tomlinson, 2014). Furthermore, Smale-Jacobse et al. (2019) defines differentiated instruction as an educational philosophy grounded in a profound appreciation for students, acknowledging their individuality, and fostering an environment that supports the growth and development of each learner. Differentiated instruction is an instructional approach that integrates a range of strategies, including flexible grouping,

adaptive instruction, and on going assessment, empowering teachers to effectively facilitate student learning (Watts-Taffe et al., 2012). Through the provision of customized learning resources, tasks, and objectives tailored to individual students' learning needs, differentiated instruction ensures that all students can effectively engage with the same classroom materials or curriculum content (Deunk et al., 2018).

The differences in students' readiness, interests, and learning profiles (Tomlinson, 2001:45). Readiness denotes the extent to which a student possesses prior knowledge or skills relevant to a particular comprehension or competency. Interest denotes a student's inclination, inquisitiveness, or aspiration towards a specific subject or set of skills. Learning profile denotes students acquire knowledge, which can be shaped by factors such as IQ preferences, gender, cultural background, or learning style.

The distinctive aspect of Differentiated Instruction lies in its adaptable teaching approach that can be adjusted according to the individual needs of students (Valiandes & Bermúdez Martínez, 2017). By analyzing assessment data, the teacher can modify the content, process, or product in order to meet the specific needs of students (Tomlinson, 2001:4). Contents encompass the subject matter that students desire to learn and the way the material is presented to them. Processes encompass the methods by which students acquire knowledge or grasp concepts, ensuring that they employ essential skills to understand crucial ideas and information. Products encompass the ways in which students showcase and display their acquired knowledge and understanding. (Tomlinson, 1999: 11)

Throughout a lesson or unit, teachers have the flexibility to adjust one or more elements of the curriculum (such as contents, processes, or products) based on

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the individual characteristics of one or more students (including readiness, interest, or learning profile). Nevertheless, it is not necessary to differentiate every single element in every conceivable manner. (Tomlinson, 1999: 11). Only modify a curriculum component when you identify a specific student need or when you are confident that making such changes will increase the likelihood of the learner comprehending essential concepts and utilizing critical skills more effectively as a result (Tomlinson, 1999).

Each study's implementation of DI implies that it improves different kinds of mathematical competencies. The findings of these research vary widely, and there is a possibility that some of them might exhibit bias. It appears that a thorough analysis is required. How to explain the use of DI in mathematics instruction and learning. Therefore, investigation into the effectiveness of DI implementation in enhancing mathematics competences was conducted in the form of a systematic review. A comprehensive literature review was employed as the study methodology (SLR).

In accordance with the issues outlined, the objectives of this study are to provide an account of the effect of implementation Differentiated Instruction (DI) for enhancing mathematical competence, which originates from research articles published within the past ten years. This is connected to the implementation of the Kurikulum Merdeka.

RESEARCH METHOD

The study method is systematic literature review. Systematic literature reviews meticulously document and evaluate the qualities of studies (Littell J H & Pillai V, 2008) and adheres to a protocol (a comprehensive plan) that initially establishes its primary objectives, concepts, and methods (Juandi, 2021). The approach involving the subsequent research procedures.

Research Questions

In this study, the objective of this research is to provide an account of the effect of implementation of differentiated instruction (DI) for improving mathematical competence, in terms of research period, academic level, sample size, mathematics content, the geographical distribution of the authors, and research methodologies. Hence, the crucial phase of SLR involves gathering data in the form of experimental research outcomes on DI aimed at enhancing these mathematical competences. By utilizing the extracted DI research data, the researcher poses a series of pertinent questions as outlined below.

1. What is the depiction of the impact of DI on enhancing mathematical competence according to the research period?
2. What is the depiction of the impact of DI on enhancing mathematical competence according to academic levels?
3. What is the depiction of the impact of DI on enhancing mathematical competence according to sample size?
4. What is the depiction of the impact of DI on enhancing mathematical competence according to mathematics content?
5. What is the depiction of the impact of DI on enhancing mathematical competence according to the geographical distribution of the authors?
6. What is the depiction of the impact of DI on enhancing mathematical competence according to Research Methodologies?
7. What is the impact on enhancing mathematical competence?

Inclusion Criteria

The inclusion criteria in this study were determined:

1. The article is a product of research in mathematics education.

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2. Articles that were published between the years 2013 and 2022.
3. The research conducted by implementing DI to enhance mathematical competence.
4. The articles represent the outcomes of research published in Indonesian journal, international journals or proceedings.

Developing the Search Strategy

The approach employed in the research involves gathering articles from the research findings on mathematical literacy analysis of Indonesian students through electronic databases like ScienceDirect, Scopus, and Google Scholar. The search string is ("differentiated instruction" OR "differentiate instruction" OR "differentiating instruction" OR "differentiated classroom") AND ("mathematics education" OR "mathematics learning" OR "mathematics teaching") AND ("impact" OR "effect"). The search string is essential to conduct a more focused search and prevent an excessive number of articles from being filtered.

The Study Selection Process

Journal articles that have been identified are subject to screening or selection criteria. Checking whether the research satisfies the selection criteria is also referred to as screening. It is often done in two parts, with the first step being a check of the research's title and abstract to see if it is relevant to the subject being studied or not.

Assessing the Quality of Studies

The identified data will be assessed by considering the following questions related to quality assessment criteria:

1. QA1, was the journal article represent the outcome of research?

2. QA2, was the journal article get published within the past decade?
3. QA3, did the journal article address a research problem that was relevant to this study?
4. QA4, Did the journal articles portray the impact of DI on enhancing mathematical competence?

Each journal article will be assigned a response value of Y (Yes) or N (No) for each of the questions.

Research Instruments

The research instrument took the form of an observation sheet or protocol that encompassed inclusion and exclusion criteria, with criteria based on research period, academic level, sample size, mathematics content, the geographical distribution of the authors, and Research Methodologies.

RESULT AND DISCUSSION

As a result of the search for research articles related to the analysis of student mathematical literacy in Indonesia, a total of 807 articles were identified using Google Scholar, 61 articles detected through Science Direct, and 5 articles detected through Scopus. The author selected following the application of the inclusion criteria, a total of 41 articles were identified and considered relevant. Subsequently, the author conducted an evaluation of the research findings' quality and identified 15 studies that met the criteria. The analysis and discussion of these 15 articles were conducted to address the research questions. Flow chart of the study selection process can be seen on Figure 1.

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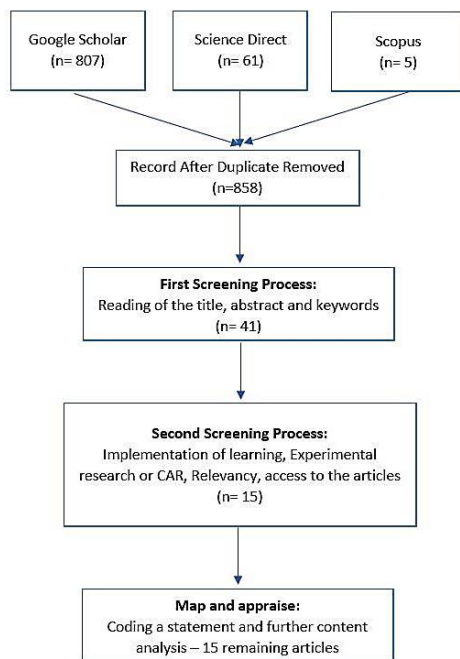


Figure 1. Study selection process diagram.

By employing the inclusion criteria to all pertinent studies, a comprehensive analysis addressing research questions 1-7 can be observed in Table 1.

Studies based on criteria

According to Table 1, they were additionally grouped according to six moderating variables, including the research period, academic level, sample size, content, country, and type of research. The descriptive data is presented in Table 2.

Table 1. The content analysis on reviewed articles

No.	Author	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6	RQ7
1.	Canque, et. al.	2021	SS	76	SPM	GEO	PHL	QE
2.	Cabellero, et. al.	2022	PS	132	SPM	NA	PHL	QE
3.	Masinading, et.al	2022	SS	60	SPM	GEO	PHL	QE
4.	Obafemi	2022	PS	78	SAM	NA	NGR	QE
5.	Ogunkunle	2014	SS	100	SAM	GEO	NGR	QE
6.	Musa	2022	SS	180	SPM	NA	NGR	QE
7.	Fernandez	2020	HS	80	SPM	ALG	PHL	TE
8.	Fatimah	2016	HS	48	SPS	GEO	INA	QE
9.	Defitriani	2018	SS	60	SMC	GEO	INA	QE
10.	Yuliana	2017	HS	30	SAM	GEO	INA	CAR
11.	Simanjuntak	2020	PS	25	UMC	NUM	INA	CAR
12.	Azizah	2016	SS	>30	CTS	GEO	INA	QE
13.	Njagi	2015	SS	374	SAM	DAP	KEN	QE
14.	Suhana	2022	SS	32	CT	NA	INA	CAR
15.	Prast	2018	PS	5.658	SAM	NUM	NLD	CH

Note. RQ: Research question; PS: Primary School; SS: Secondary School; SPM: Student's Performance in Mathematics; SAM: Student's Academic Achievement in Mathematics; SPS: Student's Problem Solving; SMC: Student's mathematical connection; UMC: Understanding of Mathematical Concepts; CTS: Creative thinking skills; CT: Critical Thinking Skills; GEO: Geometry; ALG: Algebra; DAP: Data Analysis and Probability; NA: Not applicable; PHL: Philippines; INA: Indonesia; NGR: Nigeria; KEN: Kenya; NLD: Netherlands; QE: Quasi-Experimental; TE: True Experimental; CAR: Classroom Action Research; CH: Cohort.

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According to Table 2 within a timeframe of 10 years, the research has predominantly focused on enhancing Student's performance and academic achievement in Mathematics and has been successfully published in various indexed journals. Implementation of DI to improve problem solving,

understanding, creative thinking, critical and connection was insufficient. This presents a significant challenge for researchers who strive to enhance mathematical competence through DI. To gain a clearer understanding, the discussion will subsequently focus on the predetermined moderator variables.

Table 2. Number of studies based on criteria

Category	Criteria	SPM	SAM	SPS	UMC	CTS	CT	SMC	Total
Study Year	2013-2014		1						1
	2015-2016		1	1		1			3
	2017-2018		2					1	3
	2019-2020	1			1				2
	2021-2022	4	1				1		6
Study Level	Primary School	1	2		1				4
	Secondary School	3	2			1	1	1	8
	High School	1	1	1					3
Sample Size	<30				1				1
	>=30	5	5	1		1	1	1	14
Content	Number		1		1				2
	Algebra	1	1						2
	Measurement								0
	Geometry	2	1	1		1		1	6
	DAP		1						1
	Calculus								0
	NA	2	1				1		0
Country	Philippines	4							4
	Indonesia		1	1	1	1	1	1	6
	Nigeria	1	2						3
	Kenya		1						1
	Netherlands		1						0
Research Methodologies	Quasi Experiment	4	3	1		1		1	9
	True Experiment	1							1
	CAR		1		1		1		3
	Cohort		1						1
Total		5	5	1	1	1	1	1	

Research Period

There are only five time periods included in the grouping based on study time. The data below were collected during that time. The data is presented in Figure 2.

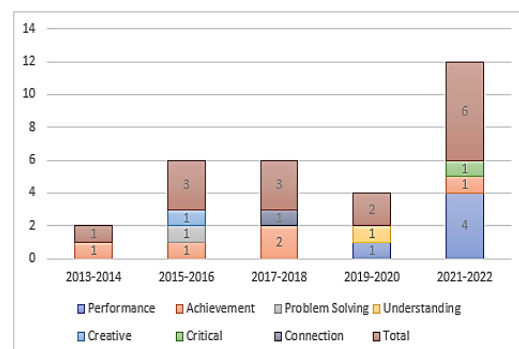


Figure 2. Data based on study year

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Based on Figure 2, it can be concluded that DI research to improve mathematical competence tends to increase from each period, except 2019-2020. This is due to the covid-19 pandemic and because learning takes place online and is not optimal. But, in the period 2021-2022 DI research to improve mathematical competence is the highest, especially on enhancing student's performance in mathematics. Based on the table it can be seen that since 2015-2016 researchers began to conduct DI research to improve 21st century competencies that must be possessed by students, namely critical thinking, creative thinking, collaboration, and communication (Ohio Department of Education, 2015). According to the research's findings, DI has increased both the amount of student participation and the quality of learning outcomes (Palieraki & Koutrouba, 2021).

Academic level

There are three categories for grouping depending on study level: primary school, secondary school, and high/vocational school. The figure 3 illustrates the distribution of experimental studies based on the academic level.

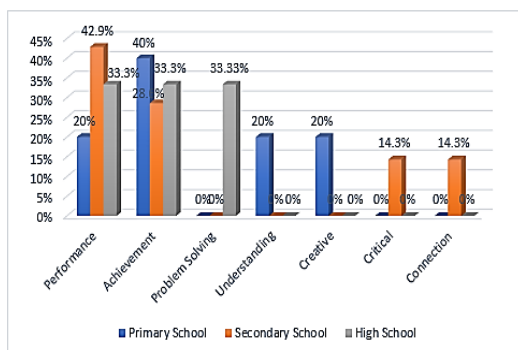


Figure 3. Data based on Academic level

Based on Figure 3, the implications can be drawn that mathematical competence, especially performance and achievement, are studied at every study level. While problem solving research published only in high school. In contrast to understanding and creative thinking, research is published only in primary schools. While Critical and Connection, research published only in secondary schools. There is very little research related to DI to improve 21st century competencies and problem solving.

Sample Size

The study was divided into two groups depending on sample size: samples with a size of less than 30 and samples with a size of 30 or more. The data is presented in Figure 4.

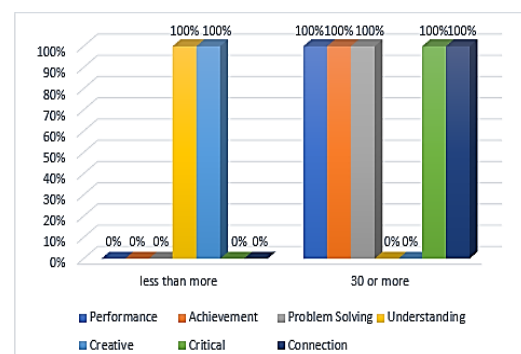


Figure 4. Data based on sample size

Based on Figure 4, the findings indicate that DI research has a positive impact on performance, achievement, problem solving, critical thinking and mathematical connection between the years 2013 and 2022 were conducted by research with a substantial sample size, typically consisting of 30 or more individuals, while understanding and creative thinking skills were conducted by research with a small sample or less than 30. This suggests that the researchers generally use large samples to conduct research related to DI to improve mathematical competencies.

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Mathematics Content

There are six categories for grouping depending on mathematics content: number, algebra, measurement,

geometry, data analysis and probability, and calculus. Figure 5 presents the distribution of experimental studies based on different mathematics content.

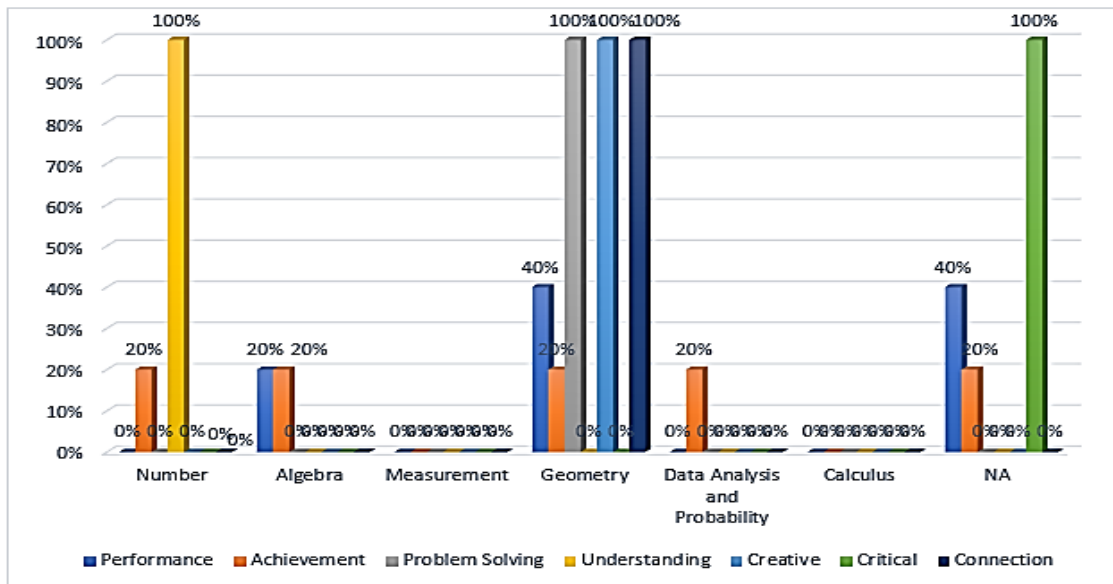


Figure 5. Data based on mathematics content

Based on the data depicted in Figure 5, it can be deduced that research on DI to enhance performance, achievement, problem solving, critical thinking and mathematical connections during the period of 2013-2022 primarily focused on numbers, algebra, geometry, and data and probability analysis. However, research generally on geometry. No research was conducted on calculus and measurement. DI research to improve achievement and understanding were only conducted on number content. DI research to improve performance and achievement were only conducted on algebra content.

The authors' geographical distribution

There are five geographical distributions of the authors: Philippines, Indonesia, Nigeria, Kenya, and Netherlands. The data is presented in Figure 5.

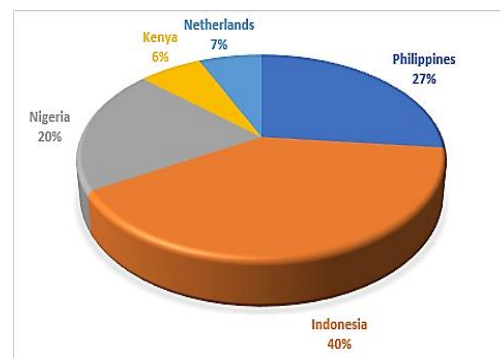


Figure 6. Data based on the authors geographical distributions

The geographical distribution of authors was examined in the fifth research question (Figure 6). Indonesia emerged as the dominant contributor with 40% of the empirical investigations, followed by the Philippines (27%) and Nigeria (20%). The Netherlands (7%) and Kenya (6%) had fewer investigations in comparison.

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Research Methodologies

There are four Research Methodologies: Quasi Experiment, True Experiment, Classroom Action Research (CAR), and Cohort Study. The data is presented in Figure 7.

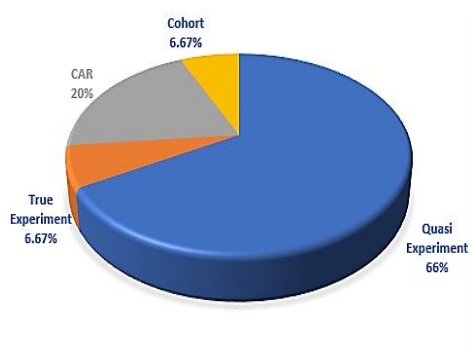


Figure 7. Data based on research methodologies

The sixth research question focused on research methodologies, including Quasi Experiment, True Experiment, Classroom Action Research (CAR), and Cohort Study. Figure 6 illustrates the distribution of these methodologies in the reviewed papers. The findings showed that the quasi-experiment approach was the most used research method for data collection (66%). It was followed by CAR (20%), cohort study (6.67%), and true experiment (6.67%).

The Impact DI on enhancing Mathematical Competence

Research DI on enhancing Mathematical Competence at Primary School Level

Four research articles have examined the use of DI to enhance mathematical competence at primary school level. These studies were conducted by Caballero et al. (2022), Obafemi (2022) Simanjuntak & Listiani, (2020), and Prast et al. (2018). Based on that research, at primary school level, DI

can improve Student's performance, achievement, and understanding of concepts in Mathematics. DI can improve that competencies because the implementation of DI is based on the pupils' readiness level and use technology as a tool for interactive multimedia. This aligns with the viewpoint expressed by Shareefa & Moosa (2020), who argue that DI is well-suited to addressing the diverse needs of students in the classroom. In addition, by using interactive multimedia, DI offers learning resources, learning assignments, and learning objectives that specifically suit the learning needs of each student (Deunk et al., 2018). Therefore, DI has the potential to encourage Student's performance, achievement, and understanding of concepts in Mathematics.

Research on enhancing Mathematical Competence at Secondary School Level

Eight research articles have examined the use of DI to enhance mathematical competence at secondary school level. These studies were conducted by Canque et al. (2021), Masinading & Gaylo (2022), Ogunkunle & Henrietta (2015), Musa & Hassan (2022), Defitriani (2018), Azizah (2016), Njagi (2015), and Inovasi et al. (2022). Based on that research, at secondary school level, DI can improve Student's performance, achievement, problem solving, connection, creative thinking skills, critical thinking skills in Mathematics. DI can improve that competencies because the teachers employ a range of teaching approaches to cater to diverse learners, avoiding reliance on a single strategy, method, approach, or technique during instruction. By effectively incorporating students'

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interests, they facilitate meaningful connections during group discussions. Additionally, they prioritize assessing students' readiness levels before introducing new mathematical concepts in lessons.

DI can improve that competencies because before the implementation of DI, researcher identified student's readiness level. From that information, teachers implementing DI in the mixed-ability classroom utilized multiple strategies, methods, approaches, and techniques to address the diverse needs of students. So that, teachers implemented DI that meets the varying requirements of students in the educational setting (Shareefa & Moosa, 2020). In addition, using student's interest in learning activities can improve student motivation and liveliness. These findings align with the research conducted by Palieraki & Koutrouba (2021), which determined that differentiation in instruction led to improved learning outcomes and increased student engagement due to the personalized approach.

Research DI on enhancing Mathematical Competence at High School Level

There are three research articles that analyze DI to improve mathematical competence at high school level. These studies were conducted by Fernandez & Tangalin (2020), Fatimah (2016), and Yuliana (2017). Based on that research, at secondary school level, DI can improve Student's performance, achievement, and problem solving in Mathematics. DI can improve that competencies because the researchers use differentiated on groups, task, and content. So that, students can choice the task and content according their learning style and ability. Hence, DI can cater to diverse student needs in the

classroom. (Prast, Weijer-Bergsma, et al., 2018). By providing tailored learning resources, assignments, and goals, DI enables all students to access the same classroom materials or curriculum learning based on their individual needs (Deunk et al., 2018). In addition, with differentiated on groups students can choose groups according to student learning profiles (individually, in pairs, small groups or large groups). So that it can meet the diverse needs of students in class (Shareefa & Moosa, 2020).

CONCLUSION AND SUGGESTION

The research focusing on the impact of DI on enhancing mathematical competencies has received significant attention. Through a comprehensive analysis of 15 published research papers, DI has the potential to improve mathematical competences, especially achievement and performance, while for problem solving, understanding, creative thinking, critical thinking, and mathematics connection are still less published. The research was conducted in all related classes. Samples were taken from indexed journals published in the 2013-2022 period. By employing the Systematic Literature Review (SLR) approach, it was discovered that the quantity of studies had risen over the course of a decade, except 2019-2020, most of the studies were conducted on secondary school students. Most of the studies were conducted on subjects with 30 or more, on geometry content, the most empirical investigations were in Indonesia and Philippines, and research methodologies conducted by quasi experiment.

The research was carried out across various educational levels, including primary, secondary, and high/vocational school. The impact of DI on enhancing mathematical Competence has the potential to improve mathematical

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competence, especially achievement and performance, but only a few articles discuss problem solving, understanding, creative thinking, critical thinking, and mathematics connection.

Some suggestions that researchers can do are, first, the impact of DI on enhancing mathematical competences on problem solving, understanding, creative thinking, critical thinking, and mathematics connection are still less published, so researcher in future may conducted the research to improve mathematical competences on problem solving, understanding, creative thinking, critical thinking, and mathematics connection. Second, most of the studies were conducted on secondary school students. In the future researchers may conduct the research not only in secondary school but also on other study levels. Furthermore, most of the studies were conducted on geometry, in the future researchers may conduct the research not only on geometry but also on other contents. Third, this systematic review suggests further exploration using a more robust method, such as meta-analysis, while considering various moderating variables. The crucial question for a significant meta-analysis is whether DI has a notable impact on enhancing mathematical skills.

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