IMPLEMENTATION OF DIFFERENTIATED INSTRUCTION IN MATHEMATICS LEARNING TO INCREASE STUDENT ENGAGEMENT AT SMAN 1 INDRAMAYU

Rahmatulloh[1], Edward Alfin[2*], Dawud Supriyatno[3], Desi Natalia[4], Agus Nurfatah[5], Nunuk Setyawati[6], Erwin Raka Nugroho[7]

[1,2,3,4,5,6,7] Postgraduate Program in Mathematics and Science, Universitas Indraprasta PGRI, Jakarta, Indonesia

*Correspondence: edwardalfin@gmail.com

ABSTRACT
This study examines the implementation of differentiated instruction in mathematics learning at SMAN 1 Indramayu, focusing on how teachers design and apply differentiation in terms of content, process, and product, as well as its impact on student engagement. A qualitative descriptive exploratory approach was employed. Data were collected through classroom observations, semi-structured interviews with teachers and students, and document analysis of lesson plans and learning materials. The data were analyzed using an interactive qualitative analysis model involving data reduction, data display, and conclusion drawing, supported by triangulation across data sources to ensure credibility. The findings indicate that teachers successfully implemented differentiated instruction, particularly by adapting learning processes and products to students' readiness levels and interests. This implementation led to increased student engagement across behavioral, emotional, and cognitive dimensions. Behavioral engagement improved through more active classroom participation, emotional engagement increased as students showed greater enthusiasm and enjoyment, and cognitive engagement strengthened as students demonstrated improved problem-solving and analytical abilities. Additionally, differentiated instruction promoted inclusivity and collaboration, aligning with the objectives of the Merdeka Curriculum. Despite challenges such as limited preparation time and technological constraints, differentiated instruction proved effective in enhancing classroom dynamics and learning outcomes. Continuous professional development and institutional support are recommended to sustain its implementation in mathematics education.

Keywords: Differentiated Instruction, Mathematics Education, Student Engagement, Qualitative Research, Merdeka Curriculum.

PRELIMINARY

Education plays a fundamental role in shaping adaptive, critical, and creative learners who are capable of solving complex problems and adapting to changing environments. In the 21st century, education is expected not only to impart knowledge but also to develop competencies such as collaboration, critical thinking, creativity, and communication, which

are considered essential skills for learners to function effectively in modern society (Trilling & Fadel, 2009).

Mathematics, as one of the core subjects, holds a central position in achieving these goals. It enhances students' logical reasoning, problem-solving abilities, and quantitative literacy, which are essential for scientific and technological advancement and everyday decision-making (Zainiyah & Marsigit, 2019).

In Indonesia, the issue of heterogeneity among students has become more prominent with the implementation of inclusive education policies, which emphasize equal access to education for learners with diverse backgrounds and abilities (Sunardi et al., 2011). Students come from varied socio-economic, cultural, and academic backgrounds, leading to differences in their readiness and learning pace (Ainscow, 2005). Unfortunately, many classroom practices still rely on traditional teacher-centered methods, where instruction is standardized and uniform for all learners (Tomlinson, 2014). Such approaches often fail to address individual differences and may result in disengagement among students who either struggle with or are not sufficiently challenged by the material (Fredricks et al., 2004). As a result, the gap between high-achieving and low-achieving students tends to widen over time (Hanushek & Woessmann, 2011).

According to the (Programme for International Student Assessment (PISA), 2022), Indonesia's mathematics performance continues to lag behind the global average, with a mean score of 366 compared to the OECD average of 472. This performance gap reflects deeper systemic issues related to teaching strategies, curriculum implementation, and learning equity. Traditional approaches, which emphasize rote learning and procedural mastery, are insufficient for developing higher-order thinking skills. Therefore, educational reform is needed to foster more inclusive, engaging, and student-centered practices that allow learners to explore mathematical concepts meaningfully.

In response to these challenges, the Indonesian Ministry of Education, Culture, Research, and Technology introduced the Merdeka Curriculum (Kemendikbudristek, 2022). This curriculum promotes flexibility in teaching and emphasizes student agency, creativity, and contextual learning. One of its key pedagogical principles is differentiated instruction (DI), a concept originally popularized by Tomlinson (2014). Differentiated instruction encourages teachers to adapt the content, process, and product of learning to align with students' readiness levels, interests, and learning profiles. Rather than applying a uniform teaching method, DI provides opportunities for students to learn through varied activities and assessments that match their individual characteristics.

In the context of mathematics learning, differentiated instruction can be implemented in multiple ways. Teachers may vary the level of problem difficulty, provide alternative learning media, or allow students to choose between collaborative and independent tasks. For instance, some students may benefit from visual aids or manipulatives when learning abstract concepts, while others may prefer analytical tasks or digital simulations. By designing instruction that responds to such diversity, teachers can promote active learning and foster deeper conceptual understanding. Research in various educational settings has shown that DI not only improves academic performance but also enhances motivation and self-efficacy among students (Tomlinson & Imbeau, 2019).

Preliminary observations at SMAN 1 Indramayu revealed discrepancies between the expected practices outlined in the Merdeka Curriculum and actual classroom implementation. These findings were obtained through classroom observations, semi-structured interviews with mathematics teachers, and documentation analysis of lesson plans and instructional materials. The observations showed that although approximately 90% of students were expected to experience differentiated learning activities, only 45% received learning materials adapted to their readiness levels. In addition, documentation and observation data indicated that around 50% of lessons remained teacher-centered, relying primarily on lectures, while only 40% incorporated digital or interactive media. Interview data further revealed that teachers were aware of the importance of differentiated instruction but faced significant constraints, including limited preparation time, insufficient professional training, and restricted access to technological resources. These challenges are consistent with previous studies reporting similar barriers in the implementation of differentiated instruction and curriculum reforms (Tundreng et al., 2025); (Reza et al., 2023). However, most prior research has focused broadly on teachers' challenges and perceptions, with limited attention to how differentiated instruction is practically enacted in mathematics classrooms and how it influences student engagement. Therefore, this study seeks to address this gap by providing an in-depth analysis of differentiated instruction practices and their impact on student engagement within the context of the Merdeka Curriculum.

Recent studies indicate that differentiated instruction has gained increasing attention as an effective approach to addressing student diversity and improving learning quality. Research consistently shows that DI enhances student engagement, motivation, and learning outcomes by aligning instructional content, processes, and products with students' readiness, interests, and learning profiles (Tomlinson, 2014)

In the Indonesian context, recent studies highlight that while teachers acknowledge the importance of differentiated instruction within the Merdeka Curriculum, its classroom implementation remains uneven and faces practical challenges such as limited training, time constraints, and insufficient technological support (Tundreng et al., 2025); (Reza et al., 2023). Other studies report that DI supports inclusive and student-centered learning environments, leading to improved collaboration and higher-order thinking skills, yet emphasize that empirical evidence at the classroom level particularly in mathematics is still limited (Porta & Todd, 2022). Therefore, current research suggests a need for in-depth, context-specific studies that examine how differentiated instruction is designed, implemented, and supported in real classroom settings to strengthen its role as a practical strategy for improving the quality of mathematics education in Indonesia.

This study aims to examine how mathematics teachers plan and implement differentiated instruction (DI), analyze its impact on student engagement, and identify the challenges and institutional support required for its sustainable implementation. The findings are expected to contribute theoretically by enriching the literature on differentiated instruction in mathematics education, particularly within the Indonesian context. Practically, this study provides actionable insights for teachers to design inclusive and flexible learning environments that address diverse student needs. Institutionally, the results offer important implications for school leaders and policymakers in developing targeted professional development, strengthening instructional support systems, and promoting innovative teaching practices. By investigating the real classroom application of DI, this study helps bridge the gap between curriculum policy and instructional practice, thereby supporting more equitable and effective mathematics learning experiences.

METHODS

This study adopted a qualitative descriptive exploratory design to examine the implementation of differentiated instruction (DI) in mathematics classrooms and its influence on student engagement. A qualitative approach was selected to capture in-depth insights into instructional practices and learning experiences within their natural context (Creswell, 2023). Data were collected through classroom observations, interviews, and document analysis. Classroom observations and lesson plan analysis were used to address the first research question concerning how teachers design and implement differentiated instruction. Interviews with teachers and students, supported by observational data, were employed to examine the impact of DI on student engagement across behavioral, emotional,

and cognitive dimensions. The third research question, related to challenges and institutional support, was explored primarily through teacher interviews and document analysis. This integrated use of data collection techniques enabled a comprehensive and contextual understanding of differentiated instruction practices and their implications for mathematics learning.

The research was conducted at SMAN 1 Indramayu, a public senior high school in West Java, Indonesia, characterized by academic excellence and diverse student demographics. The study took place over four weeks, from October 6 to October 30, 2025, focusing on Trigonometry and Linear Programming, which represent both conceptual and procedural domains of mathematics learning. One mathematics teacher and thirty-five students from class XI-9 participated in the study. The teacher was purposively selected based on experience with the Merdeka Curriculum and prior training in differentiated instruction, while the students reflected varied levels of readiness, motivation, and learning preferences. Classroom observations were conducted across four instructional meetings; although limited in number, they were intentionally designed to capture different phases of learning, including lesson introduction, core instructional activities, and assessment stages. This phased observation approach enabled a comprehensive examination of how differentiated instruction was planned, enacted, and evaluated across the instructional cycle, thereby strengthening the depth and credibility of the qualitative findings.

Data Collection Techniques Data collection was conducted through three main qualitative techniques: classroom observation, semi-structured interviews, and document analysis. Each of these methods played a crucial role in building a comprehensive understanding of the instructional practices and learning experiences within the classroom.

Classroom observations were used to capture real-time instructional interactions, focusing on how differentiation was implemented across the dimensions of content, process, and product. The observation checklist included indicators such as the use of varied instructional materials, grouping strategies, questioning techniques, and differentiation of tasks based on students' readiness levels. Observations were conducted during four mathematics lessons and recorded through detailed field notes and photographs. These observations enabled the researcher to identify patterns of engagement, teacher facilitation, and student participation.

Semi-structured interviews provided in-depth insights into participants' perceptions, experiences, and reflections on differentiated instruction. Interviews were conducted with one mathematics teacher and six students representing high, medium, and low academic

achievement levels. The teacher interview explored planning processes, instructional decisions, perceived challenges, and support systems related to DI implementation. Student interviews, on the other hand, aimed to uncover their attitudes toward mathematics learning, their engagement levels, and their responses to differentiated instructional practices. The interviews were conducted in a conversational format to encourage open and honest communication, recorded with permission, and later transcribed verbatim for analysis.

Document analysis served as an additional data source to triangulate findings from classroom observations and interviews. The analyzed documents included instructional materials, student work samples, assessment rubrics, and visual documentation such as photographs of classroom activities. This analysis helped identify how principles of differentiated instruction were embedded in instructional planning and assessment design. It also provided evidence of the extent to which the teacher adapted learning content, processes, and assessment methods to accommodate students' diverse readiness levels and learning needs.

The study followed the interactive analysis model proposed by (Miles & Huberman, 2014), consisting of data collection, data reduction, data display, and conclusion drawing. Data from classroom observations, interview transcripts, and documentation were systematically compiled and reduced by selecting and categorizing information relevant to the research objectives. The data were manually coded using thematic analysis to identify key themes, including instructional adaptation, student engagement, implementation challenges, and support systems. Findings were then organized into matrices and visual representations to clarify relationships among themes. The credibility of the results was ensured through triangulation, peer debriefing, and member checking.
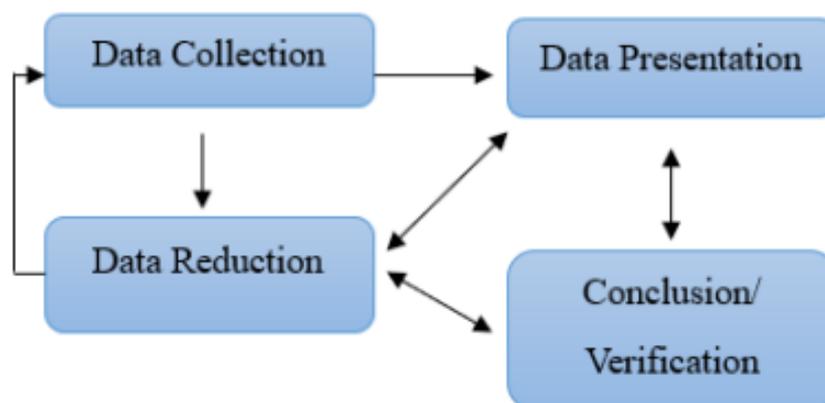

Figure 1. Framework of Differentiated Instruction Research Process

Description: Figure 1 illustrates the cyclical nature of qualitative research, where data collection, reduction, display, and verification are interdependent and continuously refined. This framework ensures that interpretations are grounded in evidence and that conclusions reflect the lived experiences of participants.

Trustworthiness and Ethical ConsiderationsTo ensure the credibility of the findings, the study applied (Lincoln & Guba, 2018) four criteria for trustworthiness: credibility, transferability, dependability, and confirmability. Credibility was achieved through data triangulation across multiple methods and sources, enhancing the accuracy and reliability of interpretations. Transferability was established by providing detailed descriptions of the research context, participant demographics, and instructional settings, allowing readers to assess the applicability of findings in similar contexts. Dependability was maintained through an audit trail that documented research decisions, field notes, interview guides, and coding processes. Confirmability was strengthened through reflective journaling, peer review, and consultation with academic supervisors to minimize researcher bias.

Ethical clearance was obtained from the university's research ethics committee prior to data collection. Participants were briefed about the study's purpose, procedures, and their rights to withdraw at any point without consequence. Informed consent was secured from all participants, including parental consent for students under 18 years of age. Pseudonyms were used to protect identities, and all data were stored securely and used exclusively for research purposes.

Limitations of the MethodologyAlthough the qualitative approach provided rich and contextual insights, it also had limitations. The small sample size limits generalizability to other schools. Moreover, the study relied heavily on teacher self-report and classroom observations, which may not fully capture the range of instructional practices. Nevertheless, triangulating multiple data sources helped to mitigate these limitations and strengthen the study's validity.

In summary, the methodological design of this study provided a systematic and comprehensive framework to examine the implementation of differentiated instruction in mathematics classrooms. The integration of multiple data collection techniques, rigorous analysis procedures, and strong ethical protocols ensured that the research findings were both credible and contextually relevant. The detailed approach adopted in this study underscores the complexity of educational research and reinforces the importance of reflective and ethical inquiry in improving teaching and learning practices.

RESULT AND DISCUSSION

Results

Classroom observations revealed that differentiated instruction (DI) was consistently implemented through tiered content, flexible grouping, and varied assessment products. Observation notes showed that students with lower readiness relied on visual representations and guided worksheets to understand core concepts, while higher-readiness students justified solution steps and applied mathematical models to contextual problems. Teacher and student interviews indicated that DI improved students' conceptual understanding, as learners were able to explain mathematical ideas using their own representations rather than memorizing formulas. Document analysis of instructional materials and student work confirmed that tasks and assessments were intentionally aligned with different readiness levels.

Differentiation of learning processes supported students' mathematical reasoning and problem-solving strategies. Observations showed that peer discussion in heterogeneous groups encouraged students to articulate reasoning and evaluate alternative strategies, while homogeneous grouping allowed deeper focus on specific problem-solving techniques. Students reported becoming more confident in selecting strategies and checking the validity of their solutions.

Students' mathematical achievement was examined by comparing average scores obtained under conventional instruction and after the implementation of differentiated instruction. Table 1 presents the comparison.

Table 1. Comparison of Students' Average Scores Before and After Differentiated Instruction

Learning Type	Average Score	Improvement (%)
Conventional Learning	77.1	–
Differentiated Instruction	83.6	+8.4%

As shown in Table 1, students' average mathematics score increased from 77.1 under conventional instruction to 83.6 following the implementation of differentiated instruction, representing an improvement of 8.4%. This descriptive increase indicates that instructional adaptation through differentiated strategies was associated with improved academic performance.

Student engagement was measured across three dimensions: behavioral, emotional, and cognitive engagement. Table 2 presents the comparison of engagement levels before and after the implementation of differentiated instruction.

Table 2. Student Engagement Levels Before and After Implementation

Engagement Dimension	Before Implementation (%)	After Implementation (%)	Increase
Behavioral	68	88	+20
Emotional	72	90	+18
Cognitive	65	84	+19

The data reveal consistent increases across all engagement dimensions. Behavioral engagement increased by 20 percentage points, emotional engagement by 18 points, and cognitive engagement by 19 points. These findings demonstrate that the implementation of differentiated instruction was accompanied by substantial improvements not only in academic outcomes but also in students' participation, emotional involvement, and depth of thinking in mathematics learning.

Discussion

The findings indicate that differentiated instruction is positively associated with improvements in both mathematical achievement and multidimensional engagement. The 8.4% increase in average mathematics scores suggests that adapting instructional content, processes, and task complexity to students' readiness levels enhances access to core mathematical concepts. Recent research confirms that differentiated instruction improves conceptual understanding and academic performance when learning tasks are aligned with student readiness (Tomlinson, 2022; Smale-Jacobse et al., 2023). In heterogeneous classrooms, uniform instruction often widens performance gaps, whereas responsive differentiation reduces disparities by matching cognitive demand with learner capability (Kassa et al., 2023).

The significant rise in behavioral engagement reflects greater student participation in collaborative problem solving, structured discussion, and active task involvement. Contemporary engagement research emphasizes that observable participation is a strong predictor of academic growth, particularly when instructional design promotes autonomy and structured interaction (Fredricks et al., 2022). Similarly, empirical evidence shows that adaptive classroom strategies significantly increase students' active involvement and persistence in mathematics learning (Gebremeskel & Ayele, 2025). The present findings align with these studies, suggesting that differentiated task structures encourage sustained behavioral engagement.

The improvement in emotional engagement indicates that differentiated instruction contributes to a more supportive and motivating classroom climate. Studies conducted between 2022 and 2024 highlight that emotionally responsive instructional environments

reduce mathematics anxiety and increase learning motivation (Rittle-Johnson et al., 2023). When students encounter tasks that are challenging yet attainable, they are more likely to experience positive academic emotions. The provision of multiple entry points in DI allows lower-achieving students to avoid frustration while ensuring that higher-achieving students remain intellectually stimulated, thereby fostering balanced emotional engagement.

The increase in cognitive engagement is particularly important because it reflects deeper investment in reasoning, strategy comparison, and conceptual explanation. Cognitive engagement has been identified as a critical mediator between instructional quality and achievement outcomes (Gebremeskel & Ayele, 2025). Research further demonstrates that instructional approaches encouraging explanation, justification, and comparison of strategies significantly strengthen conceptual understanding in mathematics (Baumgartner et al., 2025). During the implementation of DI in this study, students were encouraged to articulate reasoning and explore alternative solution pathways, practices that align with evidence-based recommendations for promoting higher-order thinking.

Taken together, the simultaneous increase in achievement and all three engagement dimensions supports the theoretical proposition that engagement functions as a mediating mechanism linking instructional design to academic outcomes. Behavioral participation ensures exposure to mathematical reasoning processes, emotional stability sustains motivation, and cognitive effort transforms activity into meaningful knowledge construction (Fredricks et al., 2022; Rittle-Johnson et al., 2023). This multidimensional interaction strengthens the interpretation that differentiated instruction exerts systemic instructional influence rather than isolated effects.

From a pedagogical perspective, the 8.4% improvement in average score represents meaningful classroom progress. Even moderate percentage gains in mathematics often reflect substantial conceptual advancement due to the cumulative structure of mathematical knowledge. Technology-supported adaptive differentiation has also been shown to enhance learning outcomes when instructional pathways are personalized (Verma & Kulkarni, 2025). Although the present study did not employ digital adaptive systems, its structured tiered assignments and flexible grouping reflect similar principles of responsiveness and alignment.

Instructional coherence appears to have played an important role in strengthening outcomes. Research in mathematics education emphasizes that alignment among objectives, tasks, and assessment significantly predicts student achievement (Smale-Jacobse et al., 2023). When students clearly understand learning goals and experience consistent cognitive

demands across activities, they develop stronger self-regulation and academic confidence. The structured differentiation observed in this study likely reinforced such coherence.

Despite these positive interpretations, the findings should be approached with methodological caution. Because the study relied on descriptive comparative analysis, causal relationships cannot be definitively established. Recent methodological discussions recommend experimental or longitudinal approaches to examine mediation effects between engagement and achievement more rigorously (Kassa et al., 2023; Gebremeskel & Ayele, 2025). Future research incorporating inferential statistical testing and extended implementation periods would provide stronger evidence regarding the long-term and causal impact of differentiated instruction.

CONCLUSION

This study concludes that the implementation of differentiated instruction (DI) in mathematics learning at SMAN 1 Indramayu meaningfully improved student engagement, motivation, and learning outcomes. By adapting instruction to students' readiness levels, interests, and learning preferences, DI created a more inclusive and supportive learning environment aligned with the student-centered orientation of the Merdeka Curriculum. The findings show that DI supported students' conceptual understanding, mathematical reasoning, and problem-solving abilities, while also fostering confidence, collaboration, and creativity in the classroom.

The study further demonstrates that differentiated instruction positively influenced the three dimensions of student engagement. Behavioral engagement increased through more active participation, emotional engagement improved as learning became more relevant and less intimidating, and cognitive engagement developed through analytical and problem-solving tasks. These qualitative findings were supported by descriptive quantitative data showing an increase in average student performance from 77.1 before implementation to 83.6 after DI was applied. Similar conclusions have been reported in previous studies, which indicate that instructional approaches addressing students' emotional and cognitive needs can reduce learning barriers and improve mathematics performance (Lisfianisa & Hasanah, 2025); (Noprizal et al., 2024).

Despite these positive outcomes, the study identified challenges related to time constraints, limited digital resources, and the complexity of assessing diverse learning products. Consistent with prior research, institutional support through professional learning communities and teacher working groups was found to be essential for sustaining

differentiated practices (Arantini et al., 2024). These findings align with (Ryan & Deci, 2020) self-determination theory, which emphasizes autonomy, competence, and relatedness as key drivers of motivation and effective learning.

Based on these conclusions, it is recommended that schools and policymakers provide continuous professional development, flexible planning time, and adequate learning resources to support the sustainable implementation of differentiated instruction. Future research could explore DI across multiple schools, involve longitudinal designs to examine long-term impacts on mathematical reasoning, or integrate mixed-method approaches to further strengthen empirical evidence. Overall, differentiated instruction represents a promising framework for advancing equitable and meaningful mathematics education in Indonesia.

REFERENCES

Ainscow, M. (2005). Developing inclusive education systems: What are the levers for change? *Journal of Educational Change*, *6*(2), 109–124. https://doi.org/10.1007/s10833-005-1298-4

Arantini, N., Tindangen, M., & Rizki, M. (2024). Differentiated instruction and students' engagement in mathematics learning: An Indonesian classroom perspective. *International Journal of Educational Research and Practice*, *12*(1), 44–58. https://doi.org/10.1016/ijer.2024.12.008

Baumgartner, E., Daguati, R., & Kapur, M. (2025). Problem-solving before instruction for learning linear functions: Effects on conceptual understanding and engagement. *Educational Studies in Mathematics*, *108*(1), 1–24. https://doi.org/10.1007/s10649-024-10345-x

Creswell, J. W. (2023). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (5th ed.). SAGE Publications.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2022). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. *Learning and Instruction*, *78*, 101527. https://doi.org/10.1016/j.learninstruc.2021.101527

Gebremeskel, A., & Ayele, B. (2025). Student engagement, conceptual understanding, and mathematics achievement: A structural equation modeling approach. *International Journal of Mathematical Education in Science and Technology*, *56*(2), 289–307. https://doi.org/10.1080/0020739X.2024.2298743

Hanushek, E. A., & Woessmann, L. (2011). The economics of international differences in educational achievement. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the Economics of Education* (Vol. 3, pp. 89–200). Elsevier. https://doi.org/10.1016/B978-0-444-53429-3.00003-0

Kassa, T., Ding, M., & Zhu, Y. (2023). Describing and interpreting the space of classroom differentiation in mathematics instruction. *ZDM–Mathematics Education*, *55*(4), 789–804. https://doi.org/10.1007/s11858-023-01462-9

Kemendikbudristek. (2022). *Panduan implementasi Kurikulum Merdeka*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.

Lincoln, Y. S., & Guba, E. G. (2018). *Naturalistic Inquiry*. Sage Publications.

Lisfianisa, S., & Hasanah, A. (2025). Problem-solving ability based on math anxiety in senior high school students during the computer-based written exam. *Mathline: Jurnal Matematika Dan Pendidikan Matematika*, *8*(3), 874–885. https://doi.org/10.31943/mathline.v10i4.1006

Miles, M. B., & Huberman, A. M. (2014). *Qualitative Data Analysis: An Expanded Sourcebook* (3rd ed.). Sage Publications.

Noprizal, M., Sadat, A., & Harisuddin, M. (2024). Pengaruh penerapan pembelajaran berdiferensiasi terhadap kemampuan pemecahan masalah matematis siswa SMP. *Jurnal Pendidikan Matematika*, *13*(1), 35–47. https://doi.org/10.26737/jpm.v13i1.9123

Porta, C., & Todd, R. (2022). Differentiated instruction in practice: Improving engagement and learning outcomes. *Educational Review*, *74*(5), 614–632. https://doi.org/10.1080/00131911.2021.1916023

Programme for International Student Assessment (PISA). (2022). *PISA 2022 results: What students know and can do*. OECD Publishing. https://doi.org/10.1787/9789264986972-en

Reza, F., Ahmad, H., & Lestari, S. (2023). Teachers' perspectives on differentiated instruction implementation in Indonesia. *Journal of Teacher Education and Practice*, *8*(2), 45–59. https://doi.org/10.5195/jtep.2023.118

Rittle-Johnson, B., Fyfe, E. R., & Loehr, A. (2023). Improving conceptual and procedural knowledge in mathematics learning. *Journal of Educational Psychology*, *115*(2), 289–304.

Ryan, R. M., & Deci, E. L. (2020). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. Guilford Press.

Smale-Jacobse, A. E., Meijer, A., Helms-Lorenz, M., & Maulana, R. (2023). Differentiated instruction in secondary education: A systematic review of research evidence. *Teaching and Teacher Education*, *121*, 103918. https://doi.org/10.1016/j.tate.2022.103918

Sunardi, S., Arifin, Z., & Rahman, M. (2011). Implementing inclusive education in Indonesia: Policy and practice. *International Journal of Inclusive Education*, *15*(9), 961–975. https://doi.org/10.1080/13603116.2010.492329

Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners* (2nd ed.). ASCD.

Tomlinson, C. A. (2022). *How to differentiate instruction in academically diverse classrooms* (3rd ed.). ASCD.

Tomlinson, C. A., & Imbeau, M. B. (2019). *Leading for Differentiation: Growing Teachers Who Grow Kids* (2nd ed.). ASCD.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. Jossey-Bass.

Tundreng, D., Hartono, S., & Prasetyo, A. (2025). Challenges in differentiated instruction implementation in Indonesian classrooms. *Indonesian Journal of Curriculum Studies*, *5*(1), 33–47. https://doi.org/10.22219/ijcs.v5i1.2025

Verma, S., & Kulkarni, P. (2025). Adaptive learning algorithms for differentiated instruction in secondary mathematics education. *Computers & Education*, *201*, 104813. https://doi.org/10.1016/j.compedu.2024.104813

Zainiyah, S., & Marsigit, M. (2019). The role of mathematics in developing critical thinking and problem-solving skills. *Jurnal Pendidikan Matematika*, *10*(2), 120–132. https://doi.org/10.26737/jpm.v10i2.154