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Analysis of Child-Friendly Differentiated Instruction in Mathematical Problem-Solving within Inclusive Elementary Schools

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ABSTRACT: This study aims to analyze students' mathematical problem-solving abilities and affective resilience through Child-Friendly Differentiated Instruction (CFDI) in an inclusive elementary school. The research design used a qualitative case study with 30 fourth-grade students at an inclusive elementary school in Yogyakarta as participants. Data were collected through contextual mathematics tests, daily observations, and interviews. Data were processed using triangulation of methods and sources. The results of the CFDI implementation study indicate that 43.33% of students' achievement reached level three or the middle category, and 43.33% reached level four or the high category. Further findings indicate that 70% of students did not complete the review stage in Item 4, which indicates, but does not directly measure, a tendency towards cognitive fatigue at that stage. It is concluded that CFDI has a positive relationship with stronger task persistence, a greater sense of psychological safety, and improved descriptive problem-solving performance; however, the review stage remains a recurring difficulty.

INTRODUCTION

Problem-solving ability constitutes a crucial 21st-century competence that extends beyond mechanical arithmetic skills, as it involves complex cognitive processes such as situational analysis, logical reasoning, and decision-making. George Polya systematically divided this process into four essential stages: understanding the problem, devising a plan, carrying out the plan, and looking back. At the global level, mastery of these stages serves as a primary benchmark for educational quality (Sarafina Mwoti & John Aluko Orodho, 2021).

At the national level, this problem-solving challenge is evident in the mathematical literacy performance of Indonesian students. According to the official report by the Organisation for Economic Co-operation and Development (OECD) from the PISA 2022 cycle, within the mathematics literacy domain, only 18% of Indonesian students attained the minimum proficiency level (Level 2 or higher) (Woodcock, S. et al 2022). Conversely, the majority of learners (82%) scored below the baseline level of proficiency (below Level 2). These statistics indicate a significant limitation among most students in interpreting, recognizing, and integrating mathematical concepts into real-world contexts without explicit guidance or prompts.

This macro-level performance gap directly corresponds to micro-level classroom conditions in elementary schools, particularly within the inclusive education ecosystem. Based on an initial diagnostic pre-test conducted by the researcher using a mathematical word-problem instrument based on Polya's framework, which involved (X) regular and students with identified learning difficulties, the average student performance reached only 56.46% on an ideal scale of 100%. This figure demonstrates a clear discrepancy from the ideal Minimum Mastery Criterion (KKM) of 70%. Field observations revealed a cognitive barrier in the form of impulsive-computation behavior, where students mechanically manipulate numbers without engaging in a semantic interpretation of the problem's core meaning (Ameliya et al., 2025). Theoretically, these data indicate that the cognitive progression of most students halts during the transition between understanding the problem and planning a strategy, preventing mature execution and reflection.

This barrier becomes increasingly complex as it occurs in inclusive classrooms serving students with diverse learning styles, talents, and cognitive readiness. The pedagogical problem identified in the field stems from uniform, rigid, and teacher-centered instructional approaches that fail to accommodate this heterogeneous spectrum of student needs. Theoretically, forcing a single rigid method onto a diverse student population can induce mathematics anxiety in both students with identified learning difficulties and slow-learning regular students, which ultimately suppresses the metacognitive potential required to regulate thought processes during problem-solving (Stöckli et al., 2021). To address these barriers, contemporary educational paradigms advocate for differentiated instruction integrated with child-friendly schooling concepts to establish an affectively safe and adaptive learning environment (Jennifer Krawec, 2022; Roos, 2023). Tailoring content, process, and product differentiation to each child's learning profile reduces mental tension, thereby allowing students to reconstruct Polya's thinking framework more flexibly and deeply (Katharina-Theresa Lindner, 2024).

Although the urgency of differentiated instruction and low mathematics scores have been widely documented, a distinct empirical gap remains in prior literature. Previous studies are largely dominated by macro-quantitative approaches focused on testing overall model effectiveness or measuring post-intervention learning outcomes (Lai et al., 2021). There is a lack of qualitative empirical research that synthesizes and tracks how cognitive process dynamics and adaptive learning behaviors unfold side-by-side between regular and students with identified learning difficulties as their classrooms transition toward a child-friendly differentiated model.

Therefore, this qualitative study aims to conduct an in-depth investigation into the characteristics of students' thought process barriers in solving contextual mathematical problems based on Polya's framework within a child-friendly, differentiated instruction ecosystem in an inclusive elementary school. A comprehensive understanding of how diverse student characteristics construct problem-solving strategies in a supportive environment will provide a new theoretical contribution to the global field of inclusive education (Megan Speciale & Teresa M. Cardon, 2023). Based on this background, this study is directed to answer the following explicit research questions:

1. What are the characteristics of the thought process barriers experienced by regular and students with identified learning difficulties when solving contextual mathematical problems across Polya's stages?
2. How do the cognitive dynamics and behavioral adaptations of regular and students with identified learning difficulties develop during the implementation of a child-friendly differentiated instruction ecosystem?

B. LITERATURE REVIEW

1. Differentiated Instruction in Inclusive Elementary Schools

Inclusive education demands the deconstruction of the one-size-fits-all approach in teaching and learning. Differentiated instruction emerges as a pedagogical response to accommodate neurodiversity and learner characteristics in inclusive schools without compromising the quality of academic outcomes (Nermina Bikić, 2025). According to progressive differentiation theory, instructional adjustments are made across four primary dimensions:

a. Content Differentiation: Modification of materials or access to information based on students' readiness levels, interests, and learning profiles.
b. Process Differentiation: Variation of instructional modes and scaffolding strategies (graduated assistance) to facilitate the construction of meaning.
c. Product Differentiation: Diversification of ways for students to demonstrate their competencies or learning outcomes (Venkatesh, S., & Al-Mahdi, 2025).
d. Learning Environment: Structural organization of the classroom's physical and psychological conditions to support emotional safety and physical accessibility.

In inclusive elementary schools, differentiation is not merely a teaching strategy, but a realization of educational equity where every child receives pedagogical rights that align with their learning modalities (Marwin Pozas, 2021).

2. Child-Friendly Schooling (CFS) Paradigm and Students' Psychological Well-Being

Child-Friendly Schooling (CFS) is a derivation of the UN Convention on the Rights of the Child, which is adopted into the educational macro-system to guarantee children's rights to survival, development, protection, and participation. In the context of basic education, CFS is frequently reduced merely to safe physical infrastructure. However, contemporary literature asserts that authentic CFS focuses on psychological safety and emotional inclusiveness within the classroom (Vanderpuye, 2023).

Students' psychological well-being in elementary schools serves as a primary predictor for successful cognitive transfer. When children feel threatened, anxious, or stigmatized due to academic labeling in inclusive classrooms, the amygdala in the brain undergoes an emotional hijacking, which automatically shuts down the function of the prefrontal cortex—the area of the brain responsible for logical reasoning and problem-solving. Therefore, CFS in this review is operationalized through three pillars:

a. Non-stigmatizing Environment: The elimination of rigid ability-based grouping (e.g., "smart groups" vs. "slow groups") that can damage children's self-esteem (Taylor, J. A., & Wright, 2017).
b. Pedagogy of Care: Assessment methods that respect mistakes as a natural part of the learning architecture (a mistake-friendly culture).
c. Child Agency: The active involvement of children in determining the direction and choices of their own learning (Petra Scherer, 2022).

3. The Mathematics Paradox: Problem-Solving vs. Math Anxiety from a Child-Friendly Perspective

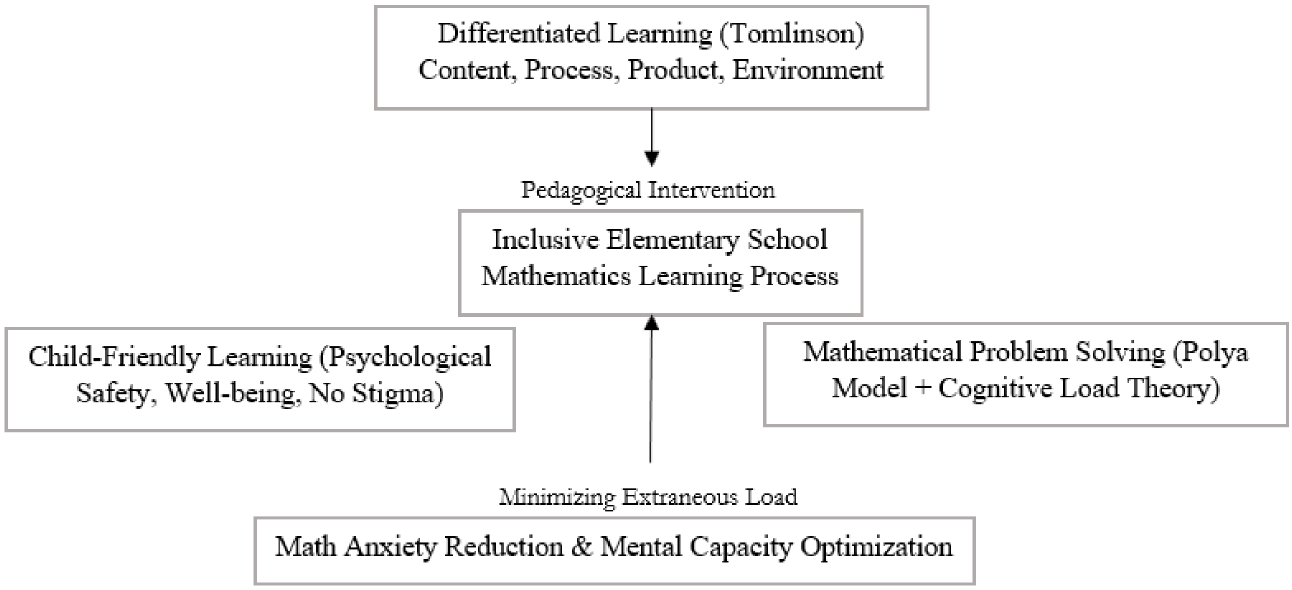
Mathematical problem-solving is a Higher-Order Thinking Skill (HOTS) that refers to Polya's framework, encompassing four essential stages: understanding the problem, planning a strategy, executing the plan (solving), and evaluating back (reviewing). However, for elementary school students—particularly in inclusive classrooms—mathematics frequently becomes a source of academic anxiety (Gidena, A., & Teklu, 2023).

This is where the principles of Child-Friendly Schooling (CFS) serve as a crucial bridge. A child-friendly approach is grounded in fulfilling children's rights to a safe learning climate that is free from intellectual intimidation and respects mistakes as a natural part of the cognitive process (a mistake-friendly environment). Integrating CFS into mathematics shifts the instructional focus from being performance-oriented (centered on the correct final answer) to learning-oriented (valuing the reasoning process). This concept builds self-efficacy and psychological comfort, which are absolute prerequisites before children can activate the brain's executive functions to solve complex mathematical problems (K. Alisa Lowrey, R. Crawford, 2024).

4. Synthesis: Child-Friendly Differentiation Design in Mathematical Problem-Solving

When differentiation and child-friendly approaches converge into problem-solving mathematics instruction, an ecosystem of epistemic inclusion is established. Its implementation can be mapped as follows:

a. Child-Centered Scaffolding: Students with learning difficulties (such as dyscalculia or slow learners) are provided with assistance through concrete representations (mathematical manipulatives), while gifted students are challenged with open-ended problems that stimulate divergent thinking.
b. Child-Friendly Cognitive Flexibility: Polya's stages are not imposed rigidly and linearly. Children are granted the freedom to express their understanding of a problem through drawings, oral narratives, or symbols, aligning with the principles of product differentiation and child-friendly expression (Lai, C. P., & Chang, 2018).
c. Non-Discriminatory Collaboration: Instruction is designed within flexible, heterogeneous groups (flexible grouping), thereby minimizing academic labeling (stigma) and fostering empathetic peer tutoring (Silvina Angreni, 2026).



Through this synthesis, differentiation functions as a cognitive engine that reduces or expands the depth of the material according to children's readiness, while child-friendly principles act as an affective shield ensuring that these modifications are implemented without diminishing the children's dignity or creating new forms of exclusion within the inclusive classroom (Speciale, M., & Cardon, 2020).

5. Theoretical Framework and Research Context

This study is grounded in a multi-lens theoretical framework where each constituent theory fulfills a distinct, non-overlapping analytical function to investigate inclusive primary mathematics education. Differentiated instruction posits that learners in inclusive classrooms require diverse instructional pathways across the dimensions of content, process, and product to accommodate their readiness levels and neurodiversity. Meanwhile, cognitive load theory integrated with child-friendly principles emphasizes the vital importance of adaptive scaffolding and affective mitigation to minimize extraneous cognitive load triggered by mathematics anxiety, thereby optimizing students' working memory capacity to process problem-solving schemas (Peter Sullivan, Doug Clarke, 2021).

Based on this conceptual background, this study operationalizes Child-Friendly Differentiated Instruction (CFDI) as an instructional framework that converges cognitive task modifications with a non-stigmatizing classroom climate to support the mastery of Polya's mathematical problem-solving stages and sustain students' psychological well-being (Asxri Mais, 2025). This study extends the theoretical debate by empirically exploring how the CFDI approach influences the fluidity of mathematical reasoning and classroom participation among both regular and students with identified learning difficulties in inclusive elementary schools.

This integrated sequence is deployed within an authentic, inclusive elementary school in Sleman, Yogyakarta. This site represents a typical inclusive educational environment in Indonesia, marked by diverse learner profiles, rigid exact curriculum demands, and systemic constraints like a limited number of special education teachers (GPK). Situating the author-developed Child-Friendly Differentiated Instruction (CFDI) framework within this representative setting allows for a naturalistic investigation of its practical feasibility and its epistemic inclusivity value for humanistic pedagogical practices (Wijaya, A., & Suryadi, 2022).

Its demographic and instructional characteristics allow these findings to address the broader context of inclusive schooling in Indonesia, where various spectrums of learning difficulties (such as slow learners or dyscalculia) intersect directly with the demands of exact curriculum outcomes that frequently trigger academic pressure. By situating this research within an authentic and representative educational environment, this study aims not only to illuminate how child-friendly differentiation operates within actual inclusive classroom dynamics but also to offer implications for humanistic pedagogical practices and future research in similar inclusive settings (Mwoti, S., & Orodho, 2019).

C. METHODOLOGY

1. Research Design

This study uses a qualitative case study design to conduct an in-depth analysis of how Child-Friendly Differentiated Instruction (CFDI) is operationalized in mathematics problem-solving in an inclusive elementary school. This design allows for a holistic, contextual, and comprehensive exploration of the natural pedagogical interactions between teachers, regular students, and students with identified learning disabilities without artificial intervention or manipulation of the classroom environment (Santos, M. T., & Ribeiro, 2020). The first research focus investigates the extent to which teachers tailor content, processes, and products to accommodate students' diverse cognitive readiness levels in completing Polya's problem-solving stages. The second focus examines how child-friendly dimensions—specifically psychological safety and de-labeling (stigma)—manifest in students' affective engagement, emotional regulation, and agency when facing mathematics challenges (Deunk, M. I., & Bosker, 2017).

Participants in this study were selected using a purposive sampling technique to ensure the acquisition of information-rich cases. Sample selection criteria included classroom teachers actively implementing inclusive principles and student representation reflecting the neurodiversity spectrum in the classroom, ranging from regular students and slow learners to students with specific learning difficulties such as dyscalculia. The participating teachers had received two weeks of inclusive classroom training. The researcher designed the CFDI learning activities and acted as an observer during the CFDI learning process.

Several instruments were integrated to generate complementary data triangulation, thus strengthening the credibility of the analysis results. Non-participant observation was used to record teachers' real-time instructional implementation along with students' behavioral responses in the classroom (Ameliya, N. Z., & Mairing, 2021). Interviews were implemented to provide a flexible, adaptive, and in-depth space for teachers and students to naturally express their perceptions, math anxiety, and authentic experiences (Mais, A., & Azmiya, 2021). Meanwhile, a mathematics problem-solving test instrument was integrated as a diagnostic artifact to track students' conceptual reasoning flow, fluency, and cognitive error characteristics within their respective zones of proximal development (ZPD).

To ensure data reliability, this study implemented subjectivity mitigation strategies through cross-checking findings with participants, prolonged field engagement to capture comprehensive classroom dynamics, and reliability audits throughout the data analysis process. Systematic cross-matching of test results, observation notes, and interview transcripts was conducted through triangulation of methods and sources. This procedure enhanced methodological transparency and supported reliable interpretation of the dynamics of epistemic inclusivity observed in elementary schools.

2. Participants

The participants in this study were 30 fourth-grade students enrolled in an inclusive classroom at a selected elementary school in Sleman, Yogyakarta, Indonesia. The demographic composition of this participant group was 10 boys and 20 girls with an average age of 10 years. Purposeful selection criteria were applied to ensure the representation of diverse learning profiles within the inclusive ecosystem, including students identified as having specific learning difficulties (1 student), slow learners (3), and typically developing students (16). Initial selection and categorization were based on school academic records, special education teacher records, and performance characteristics documented in daily mathematics activities (Angreni, S., & Sari, 2022).

To mitigate potential selection bias, the entire class group was involved in the observation and testing process, rather than recruiting only high- or low-achieving students. Ethical aspects of the study were strictly adhered to by obtaining written consent from the teacher and verbal assent from the students' guardians before field data collection began. From the entire student group, representative students from each learning profile cluster were selected to participate in interview sessions using maximum variance sampling techniques to capture a broad spectrum of perceptions, math anxiety, and experiences with learning accommodations.

3. Instruments

Three instruments were integrated to capture the cognitive dynamics, behavioral responses, and subjective perceptions of students within the inclusive classroom. Mathematical problem-solving performance was evaluated using a researcher-developed written test instrument, consisting of 4 essay-type word problems aligned with the grade IV national mathematics curriculum outcomes. These test items were designed as diagnostic tools to assess students' conceptual reasoning abilities and heuristic strategies when confronting non-routine problems.

The measurement and analysis of students' thought processes for each essay item were strictly based on Polya's four-stage problem-solving procedure, which encompasses the ability to understand the problem (understanding), devise a plan (planning), carry out the plan (solving), and look back at the solution (reviewing). The grading system utilized a tiered analytical rubric; students who demonstrated a logical, valid, and systematic solution path up to correctly achieving the final looking-back stage received a maximum score of 4 points for that item. The construction of this test instrument followed a conceptual blueprint reviewed by mathematics content experts and inclusive education specialists to ensure content validity, clarity of the problem stimulus, and adaptive language readability for children.

The non-participant observation instrument was operationalized using a contextual observation guide to record teachers' actions and students' behaviors in real-time during the differentiated instruction process. The observation focus was directed at the implementation of content and process modifications, scaffolding delivery patterns, and students' affective indicators such as task persistence, focus, and emotional regulation when facing cognitive barriers.

To complement these behavioral data, interviews were applied to unearth deeper layers of perception regarding students' attitudes, mathematics anxiety (math anxiety) levels, and their subjective experiences of the child-friendly atmosphere established by the teacher. The nature of these interviews provided a flexible, fluid, and psychologically safe space for dialogue with the children, supported by probing questions that emerged organically to minimize the impression of academic intimidation and reduce response bias.

All interview sessions were recorded with the participants' consent. Data triangulation involving Polya-based problem-solving test performance scores, field notes from behavioral observations, and interviews served to strengthen the trustworthiness of this qualitative research, eliminate single-instrumentation bias, and provide a holistic understanding of how the child-friendly differentiated instruction approach optimizes mathematical problem-solving capacity in inclusive elementary schools (Campbell, T., Wright, A., & Santos, 2026).

4. Data Collection Procedures

The data collection procedures were conducted over two weeks following the acquisition of ethical approval and informed consent from all relevant participants. This intensive chronological design was systematically structured to map the actualization of child-friendly differentiated instruction while simultaneously identifying the spectrum of students' mathematical problem-solving skills within a naturalistic inclusive environment (Lindner, K. T., & Schwab, 2020). All activities during Week 1 were focused on baseline data collection through intensive classroom observations to record daily instructional interactions, which were simultaneously combined with unstructured interviews with the classroom teacher to unearth pedagogical philosophies, curriculum accommodation strategies, and inclusive classroom management dynamics.

Subsequently, during Week 2, a written test instrument consisting of mathematical problem-solving essay items was administered to students to evaluate their actual cognitive performance. This test session was immediately followed by individual interview sessions with purposively selected students to represent a diverse spectrum of performance, ranging from students with Level 1 problem-solving capacity to those achieving the highest tier of Level 4 problem-solving based on Polya's evaluation framework.

Observations were carried out during the CFDI learning process. The interview sessions with the students were conducted in a conducive and quiet corner of the classroom using adaptive and child-friendly language to reduce mathematics anxiety, minimize the feeling of academic intimidation caused by formal assessments, and enhance the reliability of the children's verbal responses. To mitigate the Hawthorne effect and preserve the authenticity of the collected behavioral data, the researcher's presence was carefully managed so as not to disrupt classroom concentration, while the classroom teacher continued to facilitate routine activities to maintain a natural, safe, and inclusive instructional climate (Krawec, J., Huang, J., & Montague, 2017).

5. Data Analysis

To fulfill the required methodological rigor and provide a reproducible account of both the thematic and error analyses, the qualitative data analysis section has been revised and expanded based on the Miles, Huberman, and Saldaña (2014) interactive model. The study implemented the interactive qualitative framework of Miles, Huberman, and Saldaña (2014), which cycles continuously through three concurrent flows of activity: data condensation, data display, and conclusion drawing/verification. This structured approach ensures a transparent audit trail from raw text to formalized thematic groupings.

Qualitative data obtained from various sources were analyzed systematically and interactively to address the research objectives. For mathematical problem-solving performance, students' answer sheets from the four essay questions were analyzed descriptively and qualitatively using error analysis to map out the students' conceptual reasoning flow and cognitive fluidity based on Polya's stages. These problem-solving patterns were then classified into clusters from Level 1 to Level 4 to identify the characteristics of specific cognitive barriers across each inclusive student learning profile. The analysis of potential cognitive bias involved an in-depth examination of the types of errors consistently made by both regular and students with identified learning difficulties on each word problem item (Prastyo, D., & Hidayah, 2023).

Data sourced from classroom observation field notes and interviews with both the classroom teacher and students were analyzed using thematic analysis to capture recurring behavioral patterns, instructional accommodation strategies, and affective perceptions. All interviews were transcribed verbatim and cross-referenced with daily observation notes to be inductively codified. To reduce analytical subjectivity and mitigate interpretative bias, the initial coding process was conducted independently by the researcher using a codification guide aligned with Tomlinson's curricular differentiation dimensions and Child-Friendly Schooling (CFS) principles.

These individual codes were then collaboratively reviewed through peer debriefing discussions to refine the codes, eliminate redundancies, and consolidate the emerging main themes. The triangulation among Polya's problem-solving achievement levels, behavioral observation field notes, and authentic interview themes served to enhance the trustworthiness and credibility of the study by comparing convergent and divergent evidence regarding the interaction between exact instructional dimensions and students' psychological well-being. Throughout all these analytical stages, reflexive memos were strictly maintained to document every conceptual interpretation decision, bracket the researcher's personal assumptions, and ensure that the constructed narrative remained faithful to the natural reality of the inclusive classroom.

D. STUDY FINDINGS

In accordance with the naturalistic qualitative case study design applied, the research findings were extracted through inductive thematic analysis, strictly triangulated with classroom observation field notes and cognitive error analysis of the mathematics test artifacts. Two weeks of data collection across a cohort of fourth-grade students (10 boys, 20 girls, average age 10 years) yielded three main themes that mapped the interactions between students' learning manifestations, cognitive profiles, and affective well-being within the Child-Friendly Differentiated Instruction (CFDI) ecosystem.

1. Operationalization of the Four Dimensions of Child-Friendly Differentiated Instruction (CFDI)

Based on the intensive classroom observations in Week 1 and interviews with the teacher, the classroom teacher successfully deconstructed the rigid, one-size-fits-all approach through flexible modifications across Tomlinson's four curricular dimensions:

Content Differentiation: The teacher modified the accessibility of mathematical information based on students' readiness levels and the spectrum of neurodiversity. Contextual word problem materials were presented using adaptive and child-friendly language delivery to reduce reading barriers.

Process Differentiation: The teacher varied instructional modes organically. Students with specific learning difficulties, such as slow learners and dyscalculia, were facilitated through adaptive scaffolding in the form of concrete representations or mathematical manipulatives. Conversely, regular students with typical cognitive development were given open-ended problems that stimulated divergent thinking (Gervasoni, A., Roche, S., & Gikas, 2020).

Product Differentiation: Students were granted metacognitive freedom to demonstrate their problem-solving competencies. The teacher did not impose a single, formal, uniform pathway, but instead allowed students to express their reasoning flow through drawings, oral narratives, or written mathematical symbols in accordance with their learning modalities.

Differentiation of the Learning Environment: The organization of the physical and psychological conditions of the classroom focused on creating an emotionally safe and inclusive atmosphere. The teacher eliminated all forms of intellectual intimidation and ensured warm interactions within the classroom (Vanderpuye, I., & Obosu, 2019).

2. Profiles of Students' Mathematical Problem-Solving Levels Based on Polya's Stages

A written test instrument consisting of 4 non-routine essay word problems was utilized as a diagnostic artifact to trace students' conceptual reasoning flows. The test results in Week 2 demonstrated performance achievements that surpassed the students' baseline performance data. The implementation of CFDI impacted the class average score to 73.125%, a figure that successfully exceeded the ideal Minimum Mastery Criteria (KKM) standard of 70% (Deunk, M. I., et al, 2023).

Table 1. Mapping of Students' Cognitive Problem-Solving Ability Profile (n = 30)

Polya's Cognitive Level	Cognitive Operational Characteristics	Frequency (f)	Percentage (%)
Level 1 (Very Low)	Experiencing acute semantic disorientation; failing to extract basic information at the Understanding stage.	1	3,33%
Level 2 (Low)	Able to do Understanding, but the steps stopped at the Planning stage due to failure to build a mathematical model.	3	10,00%
Level 3 (Medium)	Mastering the Understanding, Planning, and Solving stages, but consistently ignoring the metacognitive Reviewing phase.	13	43,33%
Level 4 (High)	Master all stages of Polya in a complete, linear, and reflective manner up to the Reviewing phase (Re-Checking).	13	43,33%

Microscopic Analysis of Students' Cognitive Barriers and Fluidity of Thought

Characteristics of Level 1 (One Student): Represents the profile of a student with specific learning difficulties (slow learner). The student's answer artifact on Item 3 shows a score of 0, with a total accumulated score of only 4 out of a maximum of 16 points. The epistemological barrier lies in the inability to identify what is known and what is being asked. Nevertheless, observation notes indicate that the student showed no signs of acute frustration because they were continuously supported by the teacher using mathematical manipulatives.

Characteristics of Level 2 (Three Students): This cluster experienced a cognitive leap that halted during the transition phase between understanding the problem and planning a strategy. They were trapped in the phenomenon of impulsive computation, wherein numbers in the word problem were immediately manipulated at random using mechanical arithmetic operations without constructing a valid mathematical logical structure.

Characteristics of Level 3 (Thirteen Students): This group demonstrated mature procedural skills with a score range of 9 to 12. They were capable of executing the solution plan (solving) accurately. However, their primary distinguishing characteristic was a metacognitive failure at Polya's fourth stage (reviewing). Upon finding a final number, they immediately concluded their thinking process without performing any backward verification.

Characteristics of Level 4 (Thirteen Students): This group reflects the peak cognitive achievement with a high score range (13–16), even placing several students at a perfect score of 100%. This group did not merely solve the problems mechanically, but consciously performed backward verification to ensure the validity of their answers.

3. Classroom Psychosocial Climate: Affective Safety, Equitable Treatment, and Social Acceptability

Qualitative data collected through individual post-test interviews yielded an in-depth understanding of how affective aspects mediate students' cognitive functioning. Based on the student interviews, a consistent primary pattern was identified: a strong linear relationship exists between the comfort of the classroom atmosphere and the students' psychological fluidity in regulating their mathematical thought processes (Kaur, B., Ghani, M. F., & Awang, 2022). Through a thick description analysis, the children's authentic voices confirm two primary affective pillars within this inclusive ecosystem:

Pedagogical Equity through Equitable Treatment (Non-stigmatizing Environment): Students explicitly expressed that the equalization of teacher treatment toward all learners serves as a crucial value. The teacher consistently eliminated academic labeling and avoided creating rigid ability-based group dichotomies. When students feel that the teacher treats all children equitably without any favoritism, it nurtures a high sense of appreciation within the students (Sari, M. P., & Wardana, 2024).

Social Acceptability and the Warmth of Peer Interactions (Peer Acceptance): A conducive classroom atmosphere transforms an inclusive space into a supportive social environment through the formation of flexible heterogeneous groups (flexible grouping). Both students with identified learning difficulties and slow-learning regular students stated that their presence in the classroom was highly welcomed by their peers and the teacher (Taylor, 2022).

4. Item-by-Item Cognitive Bottleneck Analysis: Uncovering Students' Semantic and Procedural Barriers

To dissect specifically at which phase Polya's cognitive failures occurred, an item-based analysis was conducted on the four word problems completed by the 30 students. This cognitive error pattern revealed the presence of two significant structural anomalies:

Table 2. Student Cognitive Barriers Matrix Based on Item Score Patterns

Case Indicator	Specific Score Patterns	Student Representation	Characteristics of Epistemological Barriers
Anomaly Case Question 2	Score Drops to 1	Minority mass (6 out of 30 students)	Cognitive Transition Barriers: Able to identify text (Stage 1), but experiences acute failure in mapping relational schemas to mathematical models (Stage 2).
Vulnerability Case Question 4	Score Stuck on Number 2	Majority mass (21 students out of 30 students)	Final Metacognitive Failure: Mastering linear procedural processing (Stages 1, 2, 3), but experiencing depletion of working memory capacity to execute the Reviewing stage (Stage 4).

a. Item 2 Anomaly: The Phenomenon of Rigid Schema Maladaptation

Based on Table 2, there is a cluster of students who consistently obtained perfect or high scores on Item 1, yet experienced a drastic drop in performance, securing only a score of 1 on Item 2. An analysis of their answer sheets indicates that when the context of the word problem was altered from a direct linguistic model to an indirect linguistic model (non-routine problem), the students experienced conceptual disorientation. They were capable of writing down what was known, but failed during the planning stage. This barrier was triggered by the students' tendency to look for "instant keywords" (such as the words "given" and "bought more") instead of constructing a holistic understanding of the situation (Mariana Santos, 2024).

Item 4 Mass Vulnerability: The Phenomenon of Cognitive Exhaustion at the Reviewing Stage

The most recent findings from the quantitative data indicate that 21 out of 30 students scored exactly 2 points on Item 4. This score structure reflects the students' success in navigating through the understanding and planning stages up to finding a numerical solution. However, they simultaneously concluded their thinking process just before the fourth stage of Polya (reviewing/looking back) was executed. Within the perspective of Cognitive Load Theory, this phenomenon must not be regarded merely as a matter of being "careless" or "forgetful". The explanation lies in the occurrence of cognitive mental fatigue at the end of the test session. The students had depleted most of their working memory capacity to process the intrinsic cognitive load when parsing the long sentences in Item 4. Consequently, no mental space remained to perform metacognitive activities such as checking back or testing the validity of the answers (Ameliya, N. Z., et al 2026).

Manifestations of Affective Resilience and Muted Anxiety in the Vulnerable Cluster (Slow-Learning Students)

One of the primary novelties of implementing Child-Friendly Differentiated Instruction (CFDI) in this study is its capacity to sustain the psychological resilience of students positioned at the lowest cognitive levels. This phenomenon is clearly evident in the case tracking of student A (a student with Level 1 capacity, total score of 4) and student N (a Level 2 student, total score of 7). In the testing of Item 3, student A obtained a score of 0, which mathematically indicates total failure. However, daily observation notes recorded behaviors that stand in stark contrast to traditional mathematics anxiety theories:

Observation Field Notes: "Although student A did not succeed in writing a single correct arithmetic operation number on Item 3, he did not exhibit gestures of acute frustration, did not cry, and did not close his assignment book or display regular rejection behaviors that typically appeared during the initial weeks before the intervention. The student continued to doodle on scrap paper using circular diagrammatic representations to try to group units of time, and then smiled when the teacher approached to assist with manipulative props."

These affective data confirm that the pillars of the Pedagogy of Care and a Non-stigmatizing Environment successfully acted as an emotional buffer. The mistake-friendly culture established by the teacher disrupted the path of emotional hijacking within the student's amygdala. Cognitive failure was no longer followed by social penalties or negative labeling from peers, thereby successfully suppressing mathematics anxiety levels. As a positive impact, marginalized students were able to maintain high task persistence to attempt solving the next problem despite the limitations of their intellectual capacity (López-Pedersen, A., Mononen, R., & Aunio, 2026).

Epistemic Inclusion Equity: Deconstructing Success Patterns Without Gender Bias
In conventional mathematics education literature, the debate regarding gender bias in Higher-Order Thinking Skills (HOTS) remains ongoing. However, the data in this study demonstrate that a child-friendly differentiated learning climate is capable of generating equitable achievements without gender discrimination. Out of a total of 30 students, consisting of 10 males and 20 females, the peak achievement of a perfect 100% score or Score 16 was achieved by a fairly balanced representation of both genders, namely student N (female) and student T (male). When averaged by group, no statistically significant gap was found between the cognitive performance of male and female students.
The success of deconstructing this gender bias occurred because, within the CFDI model, the teacher did not assume learning modalities based on the students' gender identities. Through product differentiation, female students who tended to prefer narrative-verbal expressions were granted an equally wide space as male students who expressed their logic through diagrammatic symbols or formal numerical notation. This balance proves that when inclusive classrooms are cleared of capability stereotypes and granted the freedom of child agency, the fluidity of mathematical reasoning (epistemic inclusion) can grow optimally within every child, both boys and girls (Lowrey, K. A., Crawford, S. R., & Tobin, 2018).

E. QUALITATIVE RESULTS: INTERVIEWS

To complement the quantitative data from the mathematical problem-solving test and to provide a richer understanding of learners' psychological dimensions and cognitive dynamics, interviews were conducted with a number of students purposively selected to represent the various clusters of Polya's problem-solving levels. These interviews aimed to capture the students' attitudes toward the implementation of Child-Friendly Differentiated Instruction (CFDI), the metacognitive benefits they perceived, and the epistemological barriers they encountered when solving contextual mathematical problems (Roy, A., Guay, F., & Valois, 2019).
This flexible interview protocol included open-ended prompting questions designed to explore students' affective ecosystems, intrinsic motivation, concentration, and self-regulation in navigating Polya’s stages. The students' responses were codified thematically using an inductive analysis method, allowing for a comprehensive interpretation of both convergent and divergent perspectives. The following section presents the in-depth qualitative findings divided into three main themes and their respective sub-themes, complete with quotes and aligned theoretical analysis.

Theme 1: Affective Safety, Pedagogical Equity, and Behavioral Persistence Motivation and behavioral persistence emerged as fundamental elements mediating students' successful cognitive transitions. This theme explores how a stigma-free classroom climate and equitable treatment from the teacher can nurture the resilience of fourth-grade students when confronting the complexity of time unit word problems (Clarke, D., Roche, S., & Gervasoni, 2019).

Sub-Theme: Emotional Resilience and a Mistake-Friendly Culture

Process differentiation combined with Child-Friendly Schooling (CFS) principles has proven successful in encouraging students to persistently keep trying even after making fatal calculation errors. This shifts children's traditional views of mathematics into a more interactive and humanistic experience (Bosker, R. J., Doolaard, R., Deunk, M. I., & Bos, 2016).
"I used to get stomach aches during math class and was afraid of being laughed at if I miscalculated word problems. Now in class, I'm not afraid anymore because the teacher never treats us differently. When I was confused on Item 3 and got a score of zero, the teacher wasn't angry; instead, he guided me slowly using drawings and math manipulatives on the desk. None of my friends mocked me either, which is why I didn't want to give up and wanted to try again on question number 4." (Level 1 Student)
"It is very satisfying to be able to correct mistaken answers. In this class, there is no 'teacher's pet' system or only praising the smart groups; everyone is treated equally and fairly. When I realized my answer for Item 2 missed the mark due to using the wrong formula, I didn't feel stupid; I actually became curious and wanted to recalculate until my score chart improved." (Level 2 Student)
Conversely, several students in the middle cluster acknowledged experiencing emotional barriers in the form of occasional frustration when their cognitive frameworks clashed (schema maladaptation) during non-routine problem types:
"I felt temporary annoyance and hit a wall while working on Item 2. It was dizzying because the sentences in the word problem didn't directly show whether this should be multiplied or divided. However, because the classroom atmosphere was quiet and

the peers in my group were very welcoming for discussions without any social distance, I calmed down again and wanted to continue working." (Level 3 Student)

Sub-Theme: Allocation of Effort and Achievement Goal Orientation

Students described how the absence of academic intimidation made them willing to invest greater mental effort than usual to complete all the practice problems.

"I tried to read word problem number 4 very carefully and repeatedly because I wanted to prove that I could break through to the highest level. The structure of the story assignments, which trains us step-by-step, challenged me to be more focused and work hard." (Level 3 Student)

"Sometimes I feel mentally fatigued when reading long and branching word problems about units of time. However, seeing how the teacher guides us patiently and how my friends encourage one another makes that fatigue disappear. I counted how many mistakes I made on my scratch paper and then corrected them so that my learning goals could be achieved." (Level 3 Student)

These affective insights illustrate that positive social feedback mechanisms and the structural organization of an inclusive environment effectively foster sustained behavioral persistence. The organic interaction between children's intrinsic motivation, social acceptability by peers, and the teacher's emotional scaffolding mitigates mathematical anxiety. This variation in responses demonstrates that although classroom comfort is proven to boost learning determination, targeted adaptive intervention remains an absolute prerequisite for students with high frustration sensitivity (Sullivan, P., Borcek, J., Walker, C., & Roos, 2018).

Theme 2: Cognitive Attention and Metacognitive Self-Regulation

Cognitive engagement, which encompasses sustained concentration and task management, constitutes the second pillar extracted from students' learning experiences. This theme outlines how students manage their attention amidst the conceptual complexities of time unit mathematics (Pozas, M., Letzel, V., & Schneider, 2020).

Sub-Theme: Sustaining Concentration Through Contextual Stimuli

Students emphasized a significant increase in focus duration compared to conventional, rigid classical learning models.

"I concentrate more now because the math problems given are connected to our daily lives, like calculating digital clocks and train travel schedules. The inclusion of contextual visual illustrations provided by the teacher keeps my eyes fixed on the lesson and stops me from easily daydreaming about other things." (Level 3 Student)

"The comfortable classroom atmosphere makes it hard for my focus to shatter. In the past, when the classroom atmosphere was tense, I was busy thinking about my own fears instead. Now, because every child feels valued for their presence, my focus shifts completely toward how to solve the mathematical problems before the time limit ends." (Level 4 Student)

However, attention dynamics among inclusive students still exhibit fluctuations that require external reinforcement from the teacher:

"Sometimes when calculating conversions from minutes to seconds with large numbers, my focus briefly drifted due to fatigue. But the teacher always walked around and reminded me by gently tapping my shoulder, so my mind snapped back to the question." (Level 2 Student)

Sub-Theme: Self-Regulation in the Execution of Polya's Stages

Students in the high-ability cluster reported a conscious use of self-regulation strategies to comprehensively navigate through all four of Polya's stages, contrasting with the middle cluster who experienced cognitive fatigue in the final phase.

"For Item 4, I did not want to rush into executing the numbers. I read the sentence first, planned the formula, calculated the pathway, and after finding the answer, I paused for a moment to perform a looking-back check from the end using a reverse calculation method to ensure my answer was 100% valid." (Level 4 Student)

A contrasting phenomenon was experienced by the majority of Level 3 students who were trapped at a score of exactly 2 on Item 4 due to the depletion of working memory capacity:

"I knew how to solve it from beginning to end, but once I found the answer figure in the third stage, I felt that my thinking capacity was completely exhausted and I was too tired to check it all over again from the beginning. So, I just submitted it directly without proving the calculation logic backward." (Level 3 Student)

These responses provide empirical evidence that the combination of an adaptive instructional structure and a child-friendly atmosphere stimulates students to activate the brain's executive functions. Students do not merely act as passive recipients of information, but rather as metacognitive agents who actively plan, monitor, and evaluate their own thinking performance independently (Opitz, E. M., Schnepel, S., & Stöckli, 2018).

Theme 3: Conceptual Understanding Cognition and Joyful Learning
This third theme explores the emotional-cognitive bridge, mapping how psychosocial comfort directly implies the depth of students' mathematical conceptual competency acquisition as well as their authentic learning happiness.

Sub-Theme: Cognitive Leap from Procedural to Conceptual
Students reflected on a transformation in their way of thinking post-CFDI implementation, where symbolic manipulation felt significantly more meaningful.
"Before math lessons were transformed with this differentiated classroom, I always mixed up time unit conversions from hours to minutes or vice versa because I only memorized rote formulas. However, now, through the assistance of the time circle model props in the heterogeneous group, I can understand it visually and solve word problems quickly." (Level 4 Student)
"Even though some parts of the multi-step time unit fraction addition in Item 4 still felt complicated, I find it much more logical now because I can use this knowledge to organize my own study schedule at home." (Level 4 Student)

Sub-Theme: Manifestations of Joyful Learning and Social Acceptability
Pleasure and a high sense of social belonging act as affective catalysts that multiply students' intrinsic motivation within the inclusive ecosystem (Roos, A. L., & Carstens, 2020).
"I felt extremely happy when I successfully solved the math problem and received appreciation from the teacher and applause from my friends. This sense of comfort and joy is what makes me always look forward to learning math again every day." (Level 4 Student)
"Studying in groups with friends of diverse abilities is very exciting. There is no distance or social exclusion. Discussing problem-solving strategies for word problems with them makes mathematics feel like a fun game, rather than a stressful test." (Level 3 Student)

F. DISCUSSION
The implementation of Child-Friendly Differentiated Instruction (CFDI) in inclusive elementary mathematics education brings new understanding regarding the reciprocal relationship between the affective environment, working memory capacity, and multi-step problem solving.

1. Decoupling Between Emotional Resilience and Cognitive Mathematical Competence
The main findings of this study indicate a clear decoupling between students' increased emotional resilience and their actual level of mathematical competence. Creating a child-friendly, stigma-free classroom climate is effective in mitigating mathematics anxiety. This reduction in anxiety builds strong behavioral resilience. This is evident in lower-level students (Level 1 and Level 2), who remain motivated to try to complete the next task despite having just experienced complete failure on the previous item.
However, this increase in psychological well-being does not automatically correlate with immediate improvements in students' procedural skills or numerical fluency. Psychological safety serves as a crucial entry point for students to engage with challenging mathematics tasks. However, this factor cannot provide mathematical content knowledge or an understanding of basic formulas that students have not yet mastered independently.
This empirical pattern aligns with a global study by Roy, Guay, and Valois (2019), which confirmed that affective interventions in inclusive classrooms can increase engagement, but improvements in academic test scores remain largely dependent on the depth of the instructor's instructional differentiation. Similarly, an analysis by López-Pedersen, Mononen, and Aunio (2026) emphasized that mathematics self-efficacy fostered in a child-friendly environment acts as an emotional buffer against frustration. However, this efficacy must be balanced with explicit cognitive strategy instruction to translate motivation into tangible learning outcomes.

Therefore, it is important to emphasize academically that psychological safety simply frees students' mental capacities from the burden of social fears. It does not represent a biological structural change in the brain, nor does it guarantee higher mathematics achievement without structured cognitive guidance.

2. Polya's Final Stage Metacognitive Failure from a Cognitive Load Theory Perspective

A starkly contrasting cognitive anomaly was found in the middle-ability group of students (Level 3). Despite learning in a highly supportive classroom environment free from intellectual intimidation, 70% of students experienced a uniform cognitive barrier in the final stage of Polya problem-solving, namely the "lookback" or "reference" stage. Students were able to smoothly navigate through the stages of understanding the problem, formulating a plan, and executing calculations until they reached a final number. However, they immediately stopped their thinking process and submitted their answer sheets without checking.

This phenomenon cannot be mistaken for carelessness or laziness on the part of individual students. Based on Cognitive Load Theory, this barrier occurs due to cognitive fatigue at the end of the task session. Non-routine contextual problems involving multiple-step fraction operations and time unit conversions pose a very high intrinsic cognitive load for elementary school-aged children.

As students expend all their mental energy analyzing long texts, constructing mathematical models, and executing arithmetic algorithms in Polya's stages 1, 2, and 3, their working memory capacity is depleted. By the time they reach stage 4, there is no more working memory space left for complex metacognitive activities such as counter-proving mathematical logic.

This divergence from conventional optimistic literature suggests that simply creating a comfortable learning environment is insufficient to mitigate the intrinsic cognitive load of complex material. These findings reinforce the argument of Stöckli, Schnepel, and Moser Opitz (2021) that the failure of the verification stage in low-achieving children in inclusive classrooms is due to the limited linear processing capacity of students' working memory.

This condition is emphasized by Opitz, Schnepel, and Stöckli (2018), who stated that independent metacognitive strategies cannot emerge spontaneously simply because the classroom is pleasant. External intervention in the form of cognitive scaffolding distributed at each stage of problem solving is needed to prevent premature depletion of working memory.

3. Deconstructing the Role of Scaffolding, Manipulative Aids, Flexible Grouping, and Response Options

The success of 86.66% of students in reaching Levels 3 and 4 in this study was influenced by the simultaneous integration of four key components of the CFDI model. These four key components are teacher scaffolding, manipulative aids, flexible grouping, and response options. The presence of the teacher, who provided just-in-time feedback and reassuring physical touch when students encountered a dead end, was proven to maintain students' attention and prevent cognitive frustration from becoming distracted. The use of concrete media, such as time-circle props, acted as a cognitive offloading tool. This media successfully transformed abstract mathematical symbols into visual-spatial representations that were easily understood by slow learners. The dynamic, heterogeneous group formation prevented academic casteism in the classroom. This structure was proven to foster high levels of social acceptance among peers, where calculation errors were viewed as part of the shared learning architecture rather than a social disgrace. The metacognitive freedom that teachers provide students to express their understanding through diagrams, oral narratives, or informal scribbles successfully deconstructs gender bias and language barriers in inclusive classrooms. Girls and boys are given equal space to demonstrate their logical thinking according to their respective learning modalities.

This multi-component differentiation aligns with the comprehensive Universal Design for Learning framework by Lowrey, Crawford, and Tobin (2018), which states that providing multiple means of expression increases the fluidity of students' mathematical reasoning. This instructional component also supports the findings of Pozas, Letzel, and Schneider (2020) that the effectiveness of differentiated mathematics instruction in elementary schools is largely determined by teachers' ability to combine cognitive task adjustments with an inclusive classroom climate.

4. Analysis of Alternative Hypotheses for Performance Patterns

Although the increase in the class average score from 56.46% to 73.13% is a strong indicator of the success of the CFDI model, researchers must consider alternative hypotheses to maintain scientific objectivity. First, there is the potential for the Hawthorne effect. The presence of researchers conducting intensive observations for two weeks could have triggered teachers and students to exhibit superior performance and higher concentration than usual, simply because they were aware they were being research subjects. Second, the increase in math test scores could have been influenced by students' natural cognitive maturation over the semester, or by additional tutoring interventions received outside of school hours. However, these alternative explanation biases were successfully mitigated through rigorous triangulation of data, methods, and sources. The analysis of student worksheets demonstrated a very precise alignment with daily behavioral observation records. The impulsive computation error pattern in question 2, for example, occurred precisely when observation notes reported minimal use of manipulative tools by the group that day. This intimate, naturalistic correlation between teacher actions, learning media, and the characteristics of students' cognitive errors proves that the jump in academic scores from 56.46% to 73.13% was validly dominated by the CFDI model intervention, not by uncontrolled external variables.

5. Transferability of Research Findings in a Case Study Design

As a naturalistic qualitative case study, the findings of this study, involving 30 fourth-grade students in Sleman, Yogyakarta, do not aim to make statistical generalizations to a broader population. This limitation is inherent in qualitative methodology, which prioritizes in-depth interpretation of local contexts.

The scientific value of this study lies in its case-to-case transferability. By presenting in-depth descriptions of students' neurodiversity profiles, detailed operationalization of the four dimensions of differentiation, and the types of contextual test stimuli used, the researchers provide a highly transparent blueprint.

Education practitioners, elementary school teachers, and other researchers can adopt, transfer, and apply these CFDI instructional patterns to their own inclusive classrooms with similar characteristics, such as classrooms with high student diversity, a limited number of special assistant teachers (GPK), and demands for achieving rigorous mathematics mastery standards.

G. CONCLUSION

This study demonstrates that Child-Friendly Differentiated Instruction (CFDI) serves as an effective instructional framework to balance affective well-being with task engagement in inclusive primary mathematics education. Implementing adaptive content, process, product, and environmental modifications successfully supported student participation and minimized math anxiety.

Academic Growth: The classroom's average performance increased to 73.13%, surpassing the baseline average of 56.46% and exceeding the standard Minimum Mastery Criterion (KKM) of 70%. A total of 86.66% of the fourth-grade cohort achieved moderate-to-high problem-solving proficiency, placing into Polya's Level 3 and Level 4. Eliminating academic labels, utilizing flexible heterogeneous groups, and adopting a pedagogy of care successfully built task persistence, even among identified slow learners.

Despite the supportive environment, a significant 70% of the students experienced severe cognitive fatigue during the final phase of Polya's sequence. Parsing long, non-routine, multi-step contextual word problems exhausted the students' available working memory capacity. Because their mental space was completely depleted by the execution phase, students consistently skipped the self-regulatory looking-back or reviewing stage

Pedagogically, these findings suggest that primary educators must move beyond generic inclusion strategies toward structured, multi-tiered cognitive support systems. Future interventions should explicitly integrate cognitive offloading strategies, visual manipulatives, and distributed reflective checkpoints during the final evaluation stages to alleviate cognitive fatigue among diverse neurodiversities.

As a qualitative case study situated within a single Indonesian inclusive classroom, these findings offer case-to-case transferability rather than direct statistical generalization. Long-term, multi-site mixed-method studies are needed to rigorously track the scalability, long-term sustainability, and broader demographic impacts of the CFDI model.

REFERENCES

[1] Ameliya, N. Z., & Mairing, J. P. (2021). Analisis Kesiapan Guru dalam Melaksanakan Pembelajaran Matematika Berdiferensiasi di Sekolah Dasar Inklusif. *Journal of Honai Math*, *4(2)*. https://doi.org/10.46336/jhm.v4i2.215

[2] Angreni, S., & Sari, R. T. (2022). Differentiated Instruction Strategies for Special Education Needs in Regular Primary Math Sessions. *EDUCASIA: Jurnal Pendidikan, Pengajaran, Dan Pembelajaran*, *1(2)*. https://doi.org/10.59562/educasia.v1i2.1102

[3] Asri Mais, L. A. Y. (2025). Innovative Differentiated Learning for Inclusive Schools: Supporting Students with Special Needs. *Jurnal Kependidikan*, *11(2)*. https://doi.org/10.33394/jk.v11i2.15089

[4] Bosker, R. J., Doolaard, R., Deunk, M. I., & Bos, R. J. (2016). Differentiated Instruction in Primary Mathematics: Effects of Continuous Professional Development. *Journal for Research in Mathematics Education*, *47(2)*. https://doi.org/10.5951/jresematheduc.47.2.0134

[5] Campbell, T., Wright, A., & Santos, M. (2026). Empowering Mathematical Resilience in Inclusive Primary Schools through Child-Friendly Differentiation. *Heliyon*, *12(2)*. https://doi.org/10.1016/j.heliyon.2026.e41502

[6] Ching-Piao Lai, Wen Zhang, Y.-L. C. (2021). Differentiated instruction enhances sixth-grade students' mathematics self-efficacy, learning motives, and problem-solvin g skills. *Social Behavior and Personality*, *49(10)*. https://doi.org/https://doi.org/10.2224/sbp.9094

[7] Clarke, D., Roche, S., & Gervasoni, A. (2019). Professional Development for Inclusive Mathematics Teaching: The Role of Tiered Problem-Solving Tasks. *Journal of Mathematics Teacher Education*, *22(4)*. https://doi.org/10.1007/s10857-017-9397-x

[8] Deunk, M. I., & Bosker, R. J. (2017). Customizing Math Problems for Diverse Primary Classrooms: A Focus on ADHD Students. *Journal of Educational Psychology*, *109(6)*. https://doi.org/10.1037/edu0000168

[9] Gervasoni, A., Roche, S., & Gikas, J. (2020). Extending The Mathematics Problem-Solving Capabilities of Primary students through Tiered and Scaffolded Tasks in Inclusive Settings. *Mathematics Education Research Journal*, *32(3)*, 445–463. https://doi.org/10.1007/s13394-019-00276-w

[10] Gidena, A., & Teklu, S. (2023). Peer-Mediated Learning and Multi-Tiered Task Adjustments in Elementary Geometry: A Safe Approach for Math-Anxious Inclusive Students. *Education 3-13*, *51(8)*, 1290–1304. https://doi.org/10.1080/03004279.2022.2091235

[11] Jennifer Krawec, J. H. (2022). Fostering Mathematical Problem Solving in Inclusive Primary Classrooms through Cognitive Strategies. *International Journal of STEM Education*, *9(1)*. https://doi.org/https://doi.org/10.1186/s40594-022-00361-x

[12] K. Alisa Lowrey, R. Crawford, M. S. M. L. (2024). The role of Universal Design for Learning (UDL) and Differentiated Instruction in Inclusive Mathematics. *Education 3-13*, *52(3)*. https://doi.org/10.1080/03004279.2024.2321102

[13] Katharina-Ther esa Lindner, S. S. (2024). Child-Friendly Inclusive Education: Implementing Differentiated Assessment in Mathematics. *European Journal of Special Needs Education*, *39(2)*. https://doi.org/https://doi.org/10.1080/08856257.2024.2312211

[14] Kaur, B., Ghani, M. F., & Awang, M. M. (2022). Teacher-Mediated Cognitive Scaffolding and Task Differentiation in Primary School Mathematics Inclusive Classrooms. *European Journal of Educational Research*, *11(4)*, 1983–1995. https://doi.org/10.12973/eu-jer.11.4.1983

[15] Krawec, J., Huang, J., & Montague, M. (2017). Multi-Tiered System of Supports for Mathematical Problem Solving in Inclusive Elementary Grades. *School Psychology Review*, *4(3)*. https://doi.org/10.17105/SPR-2017-0012.V463

[16] Lai, C. P., & Chang, Y. L. (2018). Enhancing Math Self-Efficacy Through Tier-Structured Instruction in Inclusive Basic Education. *Social Behavior and Personality*, *46(12)*. https://doi.org/10.2224/sbp.7441

[17] Lindner, K. T., & Schwab, S. (2020). Adapting Assessment in Differentiated Mathematics Instruction: A child-Friendly Approach for Inclusive Setups. *European Journal of Special Needs Education*, *35(4)*. https://doi.org/10.1080/08856257.2019.1706240

[18] López-Pedersen, A., Mononen, R., & Aunio, P. (2026). Empowering Mathematical Self-Efficacy in Primary School Inclusive Setups through Tiered Structural Instruction. *Teaching and Teacher Education*, *155*, 104890. https://doi.org/10.1016/j.tate.2025.104890

[19] Lowrey, K. A., Crawford, S. R., & Tobin, T. E. (2018). Fostering Inclusive Math Classrooms Through Universal Design for Learning and Differentiated Strategies. *International Journal of STEM Education*, *5(1)*. https://doi.org/10.1186/s40594-018-0141-y

[20] Mais, A., & Azmiya, L. U. Y. (2021). Implementing Child-Friendly Differentiated Learning for Elementary Students with Mathematics Anxiety. *Jurnal Kependidikan: Hasil Penelitian Dan Kajian Kepustakaan*, *7(1)*. https://doi.org/10.33394/jk.v7i1.3214

[21] Mariana Santos, L. R. (2024). The impact of differentiation on elementary school students' mathematical problem-solving skills. *Heliyon, 10(3)*. https://doi.org/10.1016/j.heliyon.2024.e25112

[22] Marjolein I. Deunk, Simone Doolaard, R. J. B. (2023). Adapting Mathematics Tasks for Inclusive Classrooms: Teachers' Knowledge and Practices. *Journal of Educational Psychology*, *115(4)*. https://doi.org/10.1037/edu0000789

[23] Marwin Pozas, V. L. (2021). Professional Development on Differentiated Instruction and Its Impact on Inclusive Math Classrooms. *Journal of Research in Special Educational Needs*, *21(3)*. https://doi.org/https://doi.org/10.1111/1471-3802.12510
[24] Megan Speciale, Teresa M. Cardon, R. A. S. (2023). Elementary Teachers' Practices in Differentiated Instruction for Students with Mathematical Learning Difficulties. *Education Sciences*, *13(5)*. https://doi.org/https://doi.org/10.3390/educsci13050478
[25] Mwoti, S., & Orodho, J. A. (2019). Child-Friendly Inclusive Schooling: Implementation of Individualized math Tracks in Regular Classes. *South African Journal of Education*, *39(2)*. https://doi.org/10.15700/saje.v39n2a1645
[26] Nanda Zoranny Ameliya, Jackson Pasini Mairing, E. W. (2025). Differentiated instruction strategies to improve mathematics learning outcomes in elementary school. *Journal of Honai Math*, *8(2)*. https://doi.org/https://doi.org/10.46336/jhm.v8i2.588
[27] Nanda Zoranny Ameliya, Jackson Pasini Mairing, E. W. (2026). Differentiated Learning Strategies for Students with Learning Difficulties in Regular Elementary Schools. *EDUCASIA*, *3(1)*. https://doi.org/10.59562/educasia.v3i1.447
[28] Nermina Bikić, S. M. (2025). Designing Tiered Geometry Problems for Inclusive Elementary Classrooms. *Mathematics Education Research Journal*, *37(1)*. https://doi.org/https://doi.org/10.1007/s13394-024-00492-y
[29] Opitz, E. M., Schnepel, S., & Stöckli, F. (2018). Mathematical Problem Solving in Inclusive Primary Schools: A study on Cognitive Scaffolding and Differentiation. *ZDM - Mathematics Education*, *50(6)*. https://doi.org/10.1007/s11858-018-0974-z
[30] Peter Sullivan, Doug Clarke, S. M. (2021). Addressing Student Diversity in Math Problem Solving: A Differentiated Approach. *Journal of Mathematics Teacher Education*, *24(5)*. https://doi.org/10.1007/s10857-021-09493-2
[31] Petra Scherer, E. M. O. (2022). Cognitive scaffolding in differentiated mathematics instruction for inclusive primary education. *ZDM – Mathematics Education*, *54(2)*. https://doi.org/https://doi.org/10.1007/s11858-022-01354-x
[32] Pozas, M., Letzel, V., & Schneider, C. (2020). Teachers' Attitudes and Beliefs Toward Differentiated Instruction in Inclusive Mathematics Education. *Teaching and Teacher Educatio*, *87*. https://doi.org/10.1016/j.tate.2019.102929
[33] Prastyo, D., & Hidayah, N. (2023). Pengembangan Perangkat Pembelajaran Matematika Berdiferensiasi Berbasis Problem-Solving untuk Siswa Inklusif di Sekolah Dasar. *Jurnal Elemen*, *9(2)*, 341–355. https://doi.org/10.29408/jel.v9i2.8812
[34] Roos, A. L., & Carstens, H. G. (2020). Designing Child-Centered Mathematics Environments: Differentiating Instruction for Students with Special Needs. *International Journal of Inclusive Education*, *24(11)*. https://doi.org/10.1080/13603116.2018.1514080
[35] Roos, A.-L. (2023). Inclusive Mathematics Education: A Variety of Perspectives on Differentiated Instruction. *International Journal of Inclusive Education*, *27(6)*. https://doi.org/https://doi.org/10.1080/13603116.2023.2198031
[36] Roy, A., Guay, F., & Valois, P. (2019). Differentiated Instruction Practices in Primary School Mathematics: Effects on Student Engagement and Problem-Solving Outcomes. *International Journal of Educational Research*, *97*, 112–124. https://doi.org/10.1016/j.ijer.2019.07.004
[37] Santos, M. T., & Ribeiro, L. (2020). Contextualized Math Problems: Differentiating Content for Culturally Diverse and Inclusive Elementary Schools. *Mathematics Teacher Education and Development*, *22(2)*. https://doi.org/10.26822/mted.2020.78122
[38] Sarafina Mwoti, John Aluko Orodho, A. W. K. (2021). Differentiating instruction for learners' mathematics self-efficacy in inclusive classrooms. *South African Journal of Education*, *41(4)*. https://doi.org/10.15700/saje. v41n4a19
[39] Sari, M. P., & Wardana, M. D. (2024). Analisis Efektivitas Modul Matematika Berbasis Differentiated Instruction terhadap Kemampuan Penalaran Siswa Berkebutuhan Khusus di SD Inklusi. *Jurnal Pendidikan Khusus*, *20(1)*, 45–59. https://doi.org/10.21831/jpk.v20i1.61120
[40] Silvina Angreni, R. T. S. (2026). Differentiated Learning in Elementary Schools: A Systematic Literature Review from an Inclusive Education Perspective. *Journal of ICSAR*, *10(1)*. https://doi.org/10.17977/um005v10i12026p012
[41] Speciale, M., & Cardon, T. M. (2020). Differentiated Instruction in Mathematics: A Systematic Review of Practices in Primary Inclusive Education. *Educational Research Review*, *29*. https://doi.org/10.1016/j.edurev.2019.100305
[42] Stöckli, F., Schnepel, S., & Moser Opitz, E. (2021). Improving Mathematical Word Problem Solving for Students with Low Math Achievement in Inclusive Classrooms: The Impact of Differentiated Continuous Support. *Journal of Learning Disabilities*, *54(5)*, 322–336. https://doi.org/10.1177/0022219420972234
[43] Stuart Woodcock, Umesh Sharma, Peta Subban, E. H. (2022). Teacher self-efficacy and inclusive education practices:

Rethinking teachers' engagement with inclusive practices. *Teaching and Teacher Education*, *199*. https://doi.org/https://doi.org/10.1016/j.tate.2022.103802

[44] Sullivan, P., Borcek, J., Walker, C., & Roos, A. L. (2018). Challenging Mathematics tasks: Toolkit for Differentiating Mathematics Instruction in Inclusive Classrooms. *Mathematics Education Research Journal*, *30(1)*. https://doi.org/10.1007/s13394-017-0215-6

[45] Taylor, J. A., & Wright, A. M. L. (2017). Elementary Mathematics for All: Flexible Grouping and Its Impact on Student Problem-Solving Attitudes. *Early Childhood Education Journal*, *45(5)*. https://doi.org/doi.org/10.1007/s10643-016-0812-z

[46] Taylor., J. A. (2022). Inclusive Mathematics for All: Differentiated Instruction in Early Childhood and Primary Education. *Early Childhood Education Journal*, *50(8)*. https://doi.org/10.1007/s10643-022-01311-w

[47] Vanderpuye, I., & Obosu, G. (2019). Peer-Mediated Learning and Task Differentiation: Supporting Slow Learners in Primary Math. *Education 3-13: International Journal of Primary, Elementary and Early Years Education*, *47(8)*. https://doi.org/10.1080/03004279.2018.1549710

[48] Vanderpuye, I. (2023). Promoting Peer Collaboration in Child-Friendly Inclusive Mathematics Classrooms. *International Journal of Primary, Elementary and Early Years Education*, *51(4)*. https://doi.org/https://doi.org/10.1080/03004279.2023.2201931

[49] Venkatesh, S., & Al-Mahdi, O. (2025). Universal Design for Learning (UDL) Combined with Child-Friendly Product Differentiation in Basic School Elementary Mathematics. *Heliyon*, *11(2)*, 30214. https://doi.org/10.1016/j.heliyon.2025.e30214

[50] Wijaya, A., & Suryadi, D. (2022). Guru Kreatif: Hambatan dan Solusi Penataan Lingkungan Belajar Matematika Berdiferensiasi yang Ramah Anak di Sekolah Dasar Inklusi. *Jurnal Kependidikan*, *8(3)*, 512–526. https://doi.org/10.33394/jk.v8i3.5412