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Developing an Inductive–Deductive Learning Model with Cognitive Conflict to Enhance Junior High School Students' Mathematical Problem-Solving Skills and Self-Confidence

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ABSTRACT

Mathematical problem-solving and self-confidence are essential competencies in mathematics education, yet classroom instruction often emphasizes procedural learning rather than flexible reasoning and conceptual understanding. Previous studies have generally examined inductive–deductive reasoning and cognitive conflict independently, leaving limited evidence on their integrated application. This study aimed to develop and evaluate the Thinking in Two Directions learning model, which combines inductive–deductive reasoning with cognitive conflict to improve junior high school students' mathematical problem-solving skills and self-confidence. This study employed Educational Design Research (EDR) based on the Plomp model, including preliminary research, prototype development, and assessment phases. The field trial involved 32 eighth-grade students in Indonesia. Data were collected through mathematical problem-solving tests, self-confidence questionnaires, classroom observations, and student reflections. Quantitative data were analyzed using normalized gain (N-Gain), paired-sample *t*-tests, and Cohen's *d*, while qualitative data were analyzed thematically. The developed model demonstrated satisfactory validity, practicality, and effectiveness. Students' mathematical problem-solving scores improved significantly from 52.10 to 81.90 (N-Gain = 0.62, $p < .05$) with a large effect size ($d = 1.12$). Self-confidence increased by 20.8% ($d = 0.93$). Qualitative findings revealed that cognitive conflict promoted conceptual restructuring, flexible reasoning, and greater confidence in solving mathematical problems. Integrating inductive–deductive reasoning with cognitive conflict provides a theoretically grounded instructional approach that simultaneously strengthens conceptual understanding and self-confidence. The model offers a practical framework for mathematics instruction while contributing to the development of innovative learning models that support higher-order thinking in secondary education.

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1. INTRODUCTION

Mathematics is a discipline that plays an important role in shaping logical, critical, systematic, and creative thinking skills (Achsin, Kartono, & Wibawanto, 2020). However, the reality on the ground shows that students' mathematical problem-solving skills are still relatively low. Students tend to have difficulty understanding contextual problems, are less able to identify important information, and are not used to developing logical solution strategies(Zahrah & Febriani, 2020). In addition, low confidence in facing math problems causes students to be reluctant to try to solve problems independently (Ramadhani, 2018). This indicates the need for learning model innovations that not only foster mathematical thinking skills, but also build students' confidence in facing intellectual challenges (Ningrum & Rejeki, 2023).

One of the learning strategies that is believed to be able to develop these two aspects is the inductive-deductive thinking model based on cognitive conflict (Mahmudin, Sumarmo, & Kustiana, 2020)**.** This model departs from the idea that students need to be directed to think in two directions: inductive**,** by generalizing patterns from concrete examples: Inductive-deductive reasoning refers to a two-way thinking process that connects the formation of general principles from certain cases and the application of those principles to solve certain problems (Hidayat, 2018). This process supports flexible reasoning, allowing students to analyze patterns, formulate generalizations, and use them strategically in a variety of problem situations (Hasratuddin, Fauzi, & Siregar, 2020). From a theoretical perspective, this approach is in line with the constructivist learning theory**,** which sees knowledge as actively built through experience and reasoning. Compared to existing learning models that tend to emphasize inductive exploration or deductive explanation, the integration of the two processes in a structured sequence provides a more balanced pathway for conceptual construction and application

To reinforce conceptual change, the model incorporates cognitive conflict strategies that deliberately present situations that are inconsistent with students' previous understandings. Based on the theory of conceptual change, cognitive conflict creates an intellectual imbalance that encourages learners to reflect, test ideas, and reconstruct their knowledge through logical reasoning and exploration (Qiu, 2025; Saul, 2024). Through this process, students move beyond passive information reception (Akmam et al., 2024) and actively engage in the construction of critical and creative knowledge (Ningsih et al., 2020; Prayogi & Verawati, 2020). However, previous research has generally examined inductive-deductive reasoning and cognitive conflict separately, and limited research has developed and tested an integrated instructional design that systematically combines both approaches within a design-based development framework.

In addition to cognitive outcomes, students' mathematical confidence is a major affective factor that affects perseverance, strategy use, and willingness to engage with challenging problems (Rahayuningdewi & Faradillah, 2020). This aspect is closely related to Albert Bandura's theory of self-efficacy, which explains that students with stronger belief in their abilities are more resilient, willing to take risks, and tend to give up when faced with difficulties. Despite its importance, many instructional studies focus primarily on achievement and pay attention to how learning design simultaneously supports the development of confidence

In the global context of mathematics education, the demand for high-level thinking, problem-solving, and learner agency has been emphasized in international frameworks as promoted by the Organization for Economic Co-operation and Development through 21st-century competency standards. Therefore, developing a learning model that integrates inductive-deductive reasoning with cognitive conflict while fostering confidence overcomes the gap is important. Such approaches offer a theoretically grounded and internationally relevant contribution to strengthening students' conceptual understanding, adaptive reasoning, and affective readiness to face complex mathematical challenges applying general principles to solve specific problems(Hidayat, 2018). This two-way thinking process not only strengthens conceptual understanding, but also trains students' thinking flexibility in finding various solutions to a problem (Hasratuddin, Fauzi, & Siregar, 2020).

Meanwhile, cognitive conflict strategies are integrated in this model to trigger intellectual tension when students encounter situations that conflict with their initial understanding (Qiu, 2025). Cognitive conflict encourages students to reflect and reconstruct knowledge through logical proofing and exploration of new solutions (Saul, 2024). Thus, students not only learn to receive information (Akmam et al., 2024), but also actively build knowledge through the process of critical and creative thinking (Ningsih, Sugiman, Merliza, & Ralmugiz, 2020)(Prayogi & Verawati, 2020).

In this context, mathematical self-confidence is an important affective factor that must be developed along with problem-solving skills (Rahayuningdewi & Faradillah, 2020). Students who have high confidence will be more courageous to take risks, try various strategies, and not give up easily when facing challenges. Therefore, the development of a learning model that can combine two-way thinking (inductive and deductive) and foster confidence through cognitive conflict is an urgent need in modern mathematics learning, especially in the era of the Independent Curriculum which emphasizes high-level thinking competence and tough character in dealing with problems (Sugih, Muqopi, & Afriansyah, 2025).

2. METHODS

This study employed Educational Design Research (EDR) following the framework of Tjeerd Plomp (2013), which consists of three phases: preliminary research, prototyping (design and development), and assessment. The design aimed to develop and evaluate the *Thinking in Two Directions* learning model grounded in inductive–deductive reasoning and cognitive conflict. The assessment phase used a one-group pretest–posttest design to examine changes in students' mathematical problem-solving ability and self-confidence after the intervention. This design was considered appropriate because the primary purpose of EDR is to evaluate the effectiveness and practicality of a prototype in authentic classroom settings. However, the study acknowledges its limitations, particularly the absence of a control group, which restricts causal generalization

2.1 Participants and Sampling

The participants were 32 eighth-grade students selected using purposive convenience sampling from a junior secondary school where the teacher agreed to implement the developed model. Inclusion criteria included: (1) enrollment in Grade VIII, (2) participation in the geometry unit on cubes and rectangular prisms, and (3) full attendance during the intervention. Ethical procedures were followed through school approval, teacher collaboration, and informed consent from students and parents. Participation was voluntary, and data confidentiality was maintained.

2.2 Instruments

Two instruments were used: The mathematical problem-solving test (6 open-ended items), assessing understanding, strategy, execution, and verification. Example item: *"A box without a lid is made from a rectangular sheet. Determine the maximum possible volume and explain your reasoning."* The self-confidence questionnaire consists of 20 Likert-scale items measuring belief in one's abilities, persistence, and willingness to employ multiple strategies. Content validity was established through expert review (three mathematics education experts), ensuring alignment with theoretical constructs. Construct validity was examined using factor alignment with predefined indicators. Reliability analysis showed Cronbach's alpha = 0.87 for the problem-solving rubric and α = 0.91 for the self-confidence scale, indicating high internal consistency

2.3 Data Analysis

Quantitative data were analyzed using descriptive statistics, normalized gain (N-Gain) with the Medium category interpretation, paired-sample t-test, and effect size (Cohen's d). Assumption testing included the Shapiro–Wilk test for normality and Levene's test for variance homogeneity prior to inferential analysis.

Qualitative data from classroom observations and student reflections were analyzed using thematic analysis. The coding procedure involved three stages: (1) open coding to identify meaningful units, (2) axial coding to group patterns related to reasoning processes and confidence behaviors, and (3) selective coding to generate themes supporting the quantitative findings.

2.4 Types and Approaches to Research

This study falls under the category of research and development (R&D) aimed at creating and producing a feasible, practical, and effective two-way learning model (Thinking in Two Directions) in improving students' skills in solving mathematical problems and their confidence.

The approach used in this study follows the development model of Plomp (Plomp & Nieveen, 2013), which consists of three main phases, namely:

2.4.1 Preliminary Research
2.4.2 Prototype Development and Validation Phase
2.4.3 Model Effectiveness Assessment Phase

This model was chosen because it is suitable for developing innovative learning (Sugih et al., 2025) tools and methods, which are based on theory and demands in the field.

2.5 Research Subject and Location

The research was conducted at SMP Negeri 3 Percut, Deli Serdang Regency, North Sumatra, Indonesia, which has implemented the Independent Curriculum.

2.5.1 Trial subject: Grade VIII students who study the building material of flat side spaces (cubes and blocks).
2.5.2 Number of students: ± 30 people (experimental group).
2.5.3 Partner teacher: 1 mathematics teacher who acts as a facilitator of model application.

2.6 Research Procedure

2.6.1 Phase 1 – Preliminary Research

Activities:

a. Needs analysis**:** Identify mathematics learning problems faced by students and
b. teachers, especially related to problem-solving skills and confidence for this research topic of building cube and block spaces
c. Theoretical framework analysis**:** Examines the theory of inductive–deductive thinking, cognitive conflict, and *self-efficacy theory* (Gabriel Lopez, 2025)
d. Context analysis**:** Reviewing the curriculum, characteristics of junior high school students, and the availability of technology (GeoGebra).

The result of this stage**:** Initial design of the learning model (Prototype I) with six typical syntaxes:

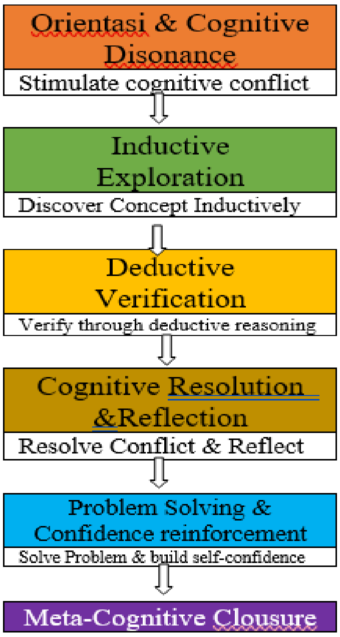

Figure 1. Thinking in Two Directions

2.6.2 Phase 2 – Prototyping Phase

Activities:

a. Design of learning tools**:** lesson plans, GeoGebra-based LKPDs, Student Reflection Sheets, and Teacher Guides.
b. Expert validation**:** Involves 3 validators (math education experts, learning technology experts, and educational psychology experts).
c. Revision of Prototype I to Prototype II based on the results of validation (content, construction, and usability aspects).
d. Small group trial**:** Conducted in small groups (6–10 students) to see the practicality and response of students.
e. Revision and refinement of Prototype II to Prototype III.

Instruments of this level:

a. Model and Device Validation Sheet
b. Teacher Practicality Observation Sheet
c. Student Response Questionnaire

2.6.3 Phase 3 – Assessment Phase

Activities:

a. Field test: Conducted in one class (30 students) to assess the effectiveness of the model in improving problem-solving skills and confidence.
b. Quasi-experimental research design: *One Group Pretest–Posttest Design*

One Group Pretest-Postest Design

O_1	**X**	**O_2**

Source: *(Creswell, 2019)*

Information:

O_1 : Pretest problem-solving skills & confidence

X : Implementation of a two-way thinking learning model
O_2 : Posttest of problem-solving skills & self-confidence

2.7 *Research Instruments*

Table 1. Types of Instruments Used in the Research

Instrument Type	Purpose	Shape	Scale
Mathematical Problem-Solving Test	Measuring the improvement of problem-solving skills	Open-ended description (4 items)	Score 0–4
Student Confidence Questionnaire	Measuring self-perception of math learning beliefs	Likert Scale (20 items)	1–5
Validation Sheet	Assess the validity of the content & construct of the model	Expert sheet	Score 1–5
Observation Sheet	Assess the practicality of implementation	Teacher & student observation	Checklist
Reflective Interviews	Uncovering students' cognitive experiences	Semi-structured	Qualitative

2.8 Data Analysis Techniques

2.8.1 Validity Analysis

a. Validity is calculated using V Aiken to find out the extent to which validators agree (Kania et al., 2024)
b. A model is declared valid if (V > 0.80).

2.8.2 Practicality Analysis

a. Based on the results of observations and questionnaires of responses from teachers.
b. The model is considered practical if the value obtained ≥ 80%.

2.8.3 Effectiveness Analysis

a. Using the Paired Sample t-test (Sugiyono, 2019) to compare pretest and posttest scores, problem-solving skills, and confidence.
b. Supported by N-Gain (Christman, Miller, & Stewart, 2024) to determine the level of improvement.
c. Qualitative data from students' reflections were analyzed by thematic analysis (Hubermen 2014).

2.9 *Model Success Indicators*

A learning model is considered successful if it meets the following criteria (Tajuddin et al., 2025):

a. Valid: Validation score ≥ 0.8
b. Practical: Can be well implemented by teachers and accepted by students (≥ 80%)
c. Effective:
   1) Problem-solving ability increased with a N-Gain of ≥ 0.3 (medium category)
   2) Students' confidence increases ≥ 10% from the initial score

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Quantitative Results

The assessment phase involved 32 eighth-grade students who participated in the implementation of the *Thinking in Two Directions* model. Descriptive analysis showed that the mean pretest score of mathematical problem-solving ability was 52.10 (SD = 8.37), which increased to 81.90 (SD = 7.25) on the posttest. The normalized gain was 0.62, categorized as Medium.

Assumption testing indicated that the data were normally distributed based on the Shapiro–Wilk test ($p > 0.05$). The paired-sample t-test revealed a significant difference between pretest and posttest scores ($p < 0.05$). The calculated effect size (Cohen's $d = 1.12$) indicated a large effect, demonstrating a strong impact of the intervention on students' problem-solving performance.

Students' self-confidence also showed substantial improvement. The average score increased from 63.40% in the pre-intervention phase to 84.20% after implementation, with an increase of 20.8%. The effect size for self-confidence was $d = 0.93$, which falls into the large category.

3.1.2 Qualitative Results

Qualitative data were collected through classroom observations, students' worksheets, reflective journals, and field notes recorded throughout the implementation of the Thinking in Two Directions learning model. The data were analyzed using thematic analysis following open coding, axial coding, and selective coding procedures. Three interrelated themes emerged, providing explanatory evidence for the quantitative improvements in students' mathematical problem-solving ability and self-confidence.

Theme 1. Conceptual restructuring through cognitive conflict

At the beginning of the intervention, many students demonstrated misconceptions regarding the relationships among geometric concepts, particularly when estimating surface area, volume, and spatial dimensions. When confronted with tasks that intentionally contradicted their initial assumptions, students experienced cognitive conflict, characterized by hesitation, uncertainty, and repeated verification of their solutions. Rather than accepting teacher explanations immediately, students actively compared alternative strategies, questioned previous assumptions, and tested competing ideas through discussion and GeoGebra-assisted exploration. Classroom observations indicated that these episodes of cognitive disequilibrium encouraged students to reconstruct their conceptual understanding by integrating new evidence with prior knowledge. As the learning cycles progressed, students produced increasingly coherent explanations supported by logical mathematical reasoning, suggesting that conceptual change occurred through reflective inquiry rather than procedural memorization.

Theme 2. Development of flexible inductive–deductive reasoning

Students' reasoning strategies also evolved substantially during the intervention. In the initial sessions, many participants relied primarily on trial-and-error approaches or memorized procedures without adequately explaining their reasoning. However, subsequent classroom observations and worksheet analyses revealed a gradual transition toward more systematic mathematical reasoning. During the inductive phase, students identified regularities from multiple concrete examples and formulated general mathematical principles. They subsequently employed deductive reasoning to apply these generalizations to unfamiliar problems, justify their solutions, and verify the correctness of their conclusions. Students' written work increasingly demonstrated complete reasoning sequences consisting of problem interpretation, strategy selection, logical justification, and solution verification. These qualitative findings indicate enhanced reasoning flexibility, complementing the medium normalized gain obtained from the quantitative analysis.

Theme 3. Strengthening mathematical self-confidence through mastery experiences

A notable behavioral change was observed in students' confidence throughout the learning process. Initially, many students appeared reluctant to express ideas, answer questions, or defend their reasoning due to fear of making mistakes. As they successfully resolved conceptual conflicts and experienced repeated success during collaborative problem-solving activities, they became progressively more willing to present mathematical arguments, ask questions, challenge alternative solutions, and revise incorrect answers without anxiety. Reflection journals further indicated that students perceived mistakes as opportunities for learning rather than evidence of failure. These behavioral changes suggest that successful engagement with cognitively demanding tasks fostered stronger confidence in their mathematical abilities. This finding aligns with Bandura's self-efficacy theory, which emphasizes mastery experiences as the primary source of confidence development.

Overall, the qualitative findings provide strong explanatory support for the quantitative results by illustrating the mechanisms through which the Thinking in Two Directions learning model promoted learning. The integration of cognitive conflict with inductive–deductive reasoning facilitated conceptual restructuring, strengthened reasoning flexibility, and enhanced students' mathematical self-confidence. These processes collectively explain the significant improvements in mathematical problem-solving performance and the large practical effects observed during the intervention.

3.1.3 Model Validation Results

Validation was carried out by three experts, each assessing aspects of the content, construction, and applicability of the learning model. The results of the recapitulation of the validation score are shown in the following table:

Table 2. Results of Expert Validation of the Developed Learning Model

Aspects Assessed	Average Score	Category
Compatibility with inductive–deductive thinking theory	4.8	Highly Valid
Integration of cognitive conflict in model syntax	4.6	Highly Valid
Integration of model components (objectives, syntax, teacher-student roles)	4.7	Highly Valid
Familiarity in mathematics learning	4.5	Highly Valid
Aiken's Rate V	**0.92**	**Highly Valid**

The learning model is declared to be very valid, which means that it has met the compatibility of theories and concepts for use in mathematics learning. The validator assessed that the uniqueness of this model lies in the two-way thinking mechanism (inductive-deductive) triggered by structured cognitive conflicts

3.1.4 Results of Practicality Test

Practicality is assessed from observation of implementation and questionnaires of teacher and student responses.

a. Model Syntax Execution: 89% (excellent category)
b. Teacher Response: 90% stated that this model is easy to implement and helps develop critical thinking.
c. Student Responses: 88% say that learning becomes more engaging and challenging, especially when using GeoGebra to resolve concept conflicts.

3.1.5 Qualitative Findings

The students showed high enthusiasm when faced with conceptual conflicts regarding diagonals in cube and block spaces. They feel challenged and motivated to seek the truth of the concept through exploration in GeoGebra.

> "*At first I was sure that the diagonal was the same, but after calculating it in GeoGebra, it turned out to be different. So I wonder why that could happen*. "(Student A)

3.1.6 Effectiveness Test Results

Research design: One Pretest–Posttest Group
Sample: 30 students of class VIII
Mathematical Problem-Solving Skills

Table 3. Pretest and Posttest Results of Mathematical Problem-Solving Ability

Statistics	Pretest	Posttest	Gain	Category
Average	55.4	79.8	0.55	Keep

The paired t-test showed t (29) = 9.43, p < 0.05**,** meaning that there was a significant improvement in problem-solving ability after the application of the model.
Analysis:
Students are able to:

a. Identify relevant information from the issue (indicator 1)
b. Develop a settlement strategy based on inductive patterns (indicator 2)
c. Testing the correctness of the solution deductively (indicator 3)
d. Reflecting on the results (indicator 4)

The two-way thinking model encourages students **to reason and reflect twice** —first when building patterns (inductive), and second when proving (deductive).

Student Self Confidence
Instrument: Likert scale questionnaire (1–5)

Table 4. Student Confidence Questionnaire Results

Statistics	Pretest	Posttest	Increase
Average	3.10	3.85	+24,2%

Aspects that experience the highest improvement:

a. Confidence to explore new concepts (26%)
b. Belief in own ability to solve problems (25%)
c. Resilience when facing confusion (23%)

> *"Now I'm not afraid of making mistakes, because I can find out using GeoGebra. If it's wrong, just fix it."* (Student B)

Interpretation:
Cognitive conflict followed by guidance and reflection fosters students' intellectual courage**.** Confidence increases because students experience the process of discovering the truth of concepts through digital exploration and logical proofing.

3.2 Discussion

The findings demonstrate that the Thinking in Two Directions learning model effectively enhanced both students' mathematical problem-solving ability and self-confidence by integrating inductive–deductive reasoning with cognitive conflict within a structured instructional sequence. Quantitative evidence showed significant improvements in mathematical problem-solving, reflected in a medium normalized gain (N-Gain = 0.62), a statistically significant pretest–posttest difference ($p <$ .05), and a large effect size (d = 1.12). Likewise, students' self-confidence increased by 20.8%, with a large practical effect (d = 0.93). These findings indicate that the model not only improved students' cognitive performance but also strengthened their affective readiness to engage with challenging mathematical tasks. The convergence of quantitative and qualitative evidence suggests that learning activities designed to promote conceptual reconstruction through cognitive conflict while systematically connecting inductive exploration with deductive verification create meaningful opportunities for both intellectual and personal growth.

The improvement in mathematical problem-solving can be interpreted from the perspective of constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction with meaningful experiences rather than passively received from teachers. Throughout the learning process, students first explored concrete examples to identify mathematical patterns inductively before testing and validating these emerging generalizations deductively in unfamiliar situations. This reciprocal reasoning process required learners to formulate hypotheses, evaluate evidence, justify arguments, and verify solutions, all of which represent essential dimensions of mathematical problem-solving (Facione, 2020). Unlike traditional mathematics instruction that often separates concept discovery from procedural application, the Thinking in Two Directions model intentionally integrated these reasoning processes into a coherent learning cycle. Consequently, students developed greater flexibility in transferring conceptual understanding across different problem contexts, supporting previous findings that combining inductive and deductive reasoning enhances mathematical understanding and adaptive problem-solving (Hasratuddin et al., 2020; Mahmudin et al., 2020).

An important contribution of this study lies in demonstrating the pedagogical function of cognitive conflict as a catalyst for conceptual change rather than merely as a source of classroom difficulty. Students frequently entered learning activities with misconceptions regarding geometric relationships, particularly when predicting relationships between surface area, volume, and spatial dimensions. Instead of immediately correcting these misconceptions, the instructional model deliberately presented contradictory situations that challenged students' existing beliefs. According to conceptual change theory, cognitive conflict creates intellectual disequilibrium that motivates learners to evaluate competing explanations and reconstruct inaccurate mental models through reflective reasoning (Qiu, 2025; Saul, 2024). Classroom observations revealed that students actively compared alternative solutions, questioned their initial assumptions, and justified revised conclusions through discussion and exploration. This process suggests that cognitive conflict encouraged deeper conceptual restructuring rather than superficial procedural correction, thereby explaining the substantial improvement in mathematical performance observed after the intervention.

The qualitative findings further illustrate how the integration of inductive and deductive reasoning supported students' cognitive flexibility. Initially, many participants relied heavily on trial-and-error strategies or memorized formulas without fully understanding underlying mathematical principles. As the intervention progressed, students increasingly demonstrated the ability to identify patterns from specific examples, formulate general mathematical rules, and subsequently apply those rules to solve more complex problems. This transition reflects the development of bidirectional reasoning, where students moved dynamically between inductive generalization and deductive application rather than depending exclusively on one form of reasoning. Such flexibility is particularly important in mathematics because effective problem solving requires both discovering relationships and evaluating whether those relationships remain valid under different conditions. These findings extend previous studies by suggesting that structured integration of inductive and deductive reasoning provides a more comprehensive pathway for developing mathematical reasoning than approaches emphasizing either process independently (Hidayat, 2018; Hasratuddin et al., 2020).

Another notable finding concerns the significant improvement in students' self-confidence. From the perspective of Bandura's self-efficacy theory, mastery experiences represent the strongest source of efficacy beliefs because successfully overcoming challenging tasks strengthens learners' confidence in their capabilities (Bandura, 1997). Throughout the intervention, students repeatedly encountered cognitively demanding problems that initially produced uncertainty but ultimately resulted in successful conceptual understanding through guided exploration and collaborative discussion. These repeated mastery experiences encouraged students to participate more actively, propose alternative strategies, ask questions, and defend mathematical arguments without fear of making mistakes. Reflection notes indicated that students gradually viewed errors not as indicators of failure but as opportunities for learning and conceptual refinement. This finding suggests that confidence was not developed through external encouragement alone but emerged naturally from students' successful engagement with increasingly complex mathematical challenges. Similar relationships between mastery experiences, self-efficacy, and mathematical achievement have been reported in previous mathematics education research (Ningrum & Rejeki, 2023; Rahayuningdewi & Faradillah, 2020).

The integration of GeoGebra further strengthened the effectiveness of the learning model by functioning as a conceptual visualization tool rather than merely a technological supplement. Dynamic visualization enabled students to observe geometric relationships, test conjectures, and immediately verify mathematical predictions generated during inductive reasoning. When students encountered discrepancies between their predictions and visual simulations, GeoGebra reinforced cognitive conflict by providing concrete evidence that encouraged further reflection and conceptual revision. Consequently, technology supported both conceptual understanding and confidence because students were able to explore mathematical relationships independently while receiving immediate visual feedback. This finding aligns with recent research emphasizing that digital technology contributes meaningfully to mathematical learning when integrated into pedagogically purposeful inquiry rather than serving as a presentation medium alone (Akmam et al., 2024; Prayogi & Verawati, 2020).

Despite these promising findings, several limitations should be acknowledged. First, the study involved a relatively small sample from a single junior secondary school and employed a one-group pretest–posttest design without a comparison group, limiting the generalizability of the findings and restricting causal interpretation. Second, the intervention focused exclusively on geometry topics involving cubes and rectangular prisms, making it uncertain whether similar effects would be observed across other mathematical domains. Third, although qualitative findings complemented quantitative results, longer-term follow-up was not conducted to determine whether improvements in reasoning and self-confidence were sustained over time. Future research should therefore employ quasi-experimental or randomized controlled designs involving larger and more diverse samples, investigate implementation across different mathematical topics, and examine the long-term development of students' reasoning and self-efficacy. Further studies may also explore teachers' professional development in implementing cognitive conflict and inductive–deductive learning strategies to support broader adoption of the Thinking in Two Directions model in secondary mathematics education.

4. CONCLUSION

This study developed and evaluated the Thinking in Two Directions learning model, which integrates inductive–deductive reasoning with cognitive conflict to enhance junior high school students' mathematical problem-solving skills and self-confidence. The findings demonstrate that the model is valid, practical, and effective in improving both cognitive and affective learning outcomes, as evidenced by significant gains in mathematical problem-solving performance, medium normalized gain, large effect sizes, and qualitative evidence of conceptual restructuring, flexible reasoning, and increased confidence. These results suggest that combining cognitive conflict with reciprocal inductive–deductive reasoning provides a meaningful instructional pathway for promoting deeper conceptual understanding while strengthening students' willingness to engage with challenging mathematical tasks. Nevertheless, this study is limited by its relatively small sample size, implementation within a single school and mathematical topic, and the use of a one-group pretest–posttest design without a control group, which limits the generalizability of the findings and the strength of causal inferences. Future research should involve larger and more diverse samples, employ quasi-experimental or randomized controlled designs, investigate the long-term sustainability of students' cognitive and affective development, and examine the applicability of the

Thinking in Two Directions model across different mathematical topics, educational contexts, and technology-supported learning environments to further validate its effectiveness and scalability.

REFERENCES

Achsin, M., Kartono, & Wibawanto, H. (2020). Analysis of Problem Solving Capabilities in Problem Based Learning Contextual Approaches Based on Metacognitive Awareness. *Unnes Journal of Mathematics Education Research*, *9*(2), 147–155. Retrieved from https://journal.unnes.ac.id/sju/index.php/ujmer/article/view/32979

Akmam, A., Afrizon, R., Koto, I., Setiawan, D., Hidayat, R., & Novitra, F. (2024). Integration of cognitive conflict in generative learning modelto enhancing students' creative thinking skills. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(9). https://doi.org/10.29333/ejmste/15026

Andra Meisantry Assari, N. A. (2025). *Development of Inquiry-Based E-Modules Integrated with STEM in Stoichiometry Material to Improve Creative Thinking Skills and Learning Motivation*. *11*(3), 1130–1142.

Christman, E., Miller, P., & Stewart, J. (2024). Beyond normalized gain: Improved comparison of physics educational outcomes. *Physical Review Physics Education Research*, *20*(1), 10123. https://doi.org/10.1103/PhysRevPhysEducRes.20.010123

Creswell, J. W. (2019). *Research design pendekatan kualitatif, kuantitatif, dan mixed / penulis, John W. Creswell ; penyunting, Saifuddin Zuhri Qudsy*. Jakarta : Yayasan Mitra Netra, 2019.

Gabriel Lopez, G. (2025). Self-Efficacy: Bandura's Theory Of Motivation In Psychology. *Https://Www.Simplypsychology.Org/Self-Efficacy.Html*, (i), 1–26.

Hasratuddin, K., Fauzi, M. A., & Siregar, N. (2020). Geometry Learning Based on Cognitive Conflict in the Department of Mathematics. *… Journal of Mathematics*, *3*(10), 1–9. Retrieved from http://www.ijojournals.com/index.php/m/article/view/362

Hidayat, A. a. (2018). *DEVELOP STUDENTS ' MATHEMATICAL PROBLEM*. *1*(1), 24–33.

Kania, N., Kusumah, Y. S., Dahlan, J. A., Nurlaelah, E., Gürbüz, F., & Bonyah, E. (2024). Constructing and providing content validity evidence through the Aiken's V index based on the experts' judgments of the instrument to measure mathematical problem-solving skills. *REID (Research and Evaluation in Education)*, *10*(1), 64–79. https://doi.org/10.21831/reid.v10i1.71032

Mahmudin, C., Sumarmo, U., & Kustiana, A. (2020). The Effect of Inductive- Deductive Approach on Studentsâ€™ Mathematical Creative Thinking Ability and Self-Efficacy. *(Jiml) Journal of Innovative Mathematics Learning*, *3*(4), 215–226. https://doi.org/10.22460/jiml.v3i4.p215-226

Ningrum, S. A. U., & Rejeki, S. (2023). Improving Students' Self-Confidence and Problem-Solving Ability Through RME Approach with TTW Type Cooperative Learning Model Setting. *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, *7*(1), 145–156. https://doi.org/10.25217/numerical.v7i1.3093

Ningsih, S. W., Sugiman, S., Merliza, P., & Ralmugiz, U. (2020). Keefektifan model pembelajaran CORE dengan strategi konflik kognitif ditinjau dari prestasi belajar, berpikir kritis, dan self-efficacy. *Pythagoras: Jurnal Pendidikan Matematika*, *15*(1), 73–86. https://doi.org/10.21831/pg.v15i1.34614

Plomp, T., & Nieveen, N. (2013). Educational Design Research Educational Design Research. *Netherlands Institute for Curriculum Development: SLO*, 1–206. Retrieved from http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ815766

Prayogi, S., & Verawati, N. N. S. P. (2020). The effect of conflict cognitive strategy in inquiry-based learning on preservice teachers' critical thinking ability; [L'effetto della strategia cognitiva del conflitto sull'apprendimento centrato sull'abilità di pensiero critico degli insegnanti in form. *Journal of Educational, Cultural and Psychological Studies*, *2020*(21), 27–41. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-85086245651&doi=10.7358%2Fecps-2020-021-pray&partnerID=40&md5=96684d82ef306285190ae814285f0204

Qiu, Y. (2025). Using Cognitive Conflict to Develop Critical Thinking in Reading Teaching. *Journal of*

Education and Educational Research, *12*(2), 166–170. https://doi.org/10.54097/pxcnv861

Rahayuningdewi, P. D., & Faradillah, A. (2020). How Does Problem-solving Method Affect Students' Self-confidence and Mathematical Understanding? *Indonesian Journal of Science and Mathematics Education*, *3*(2), 165–177. https://doi.org/10.24042/ijsme.v3i2.6640

Ramadhani, R. (2018). The enhancement of mathematical problem solving ability and self-confidence of students through problem based learning. *Jurnal Riset Pendidikan Matematika*, *5*(1), 127–134. https://doi.org/10.21831/jrpm.v5i1.13269

Saul, M. (2024). Piaget ' s Theory and Stages of Cognitive Development. *Simply Psychology*, 1–34. Retrieved from https://www.simplypsychology.org/wp-content/uploads/simplypsychology.org-Piagets-Theory-and-Stages-of-Cognitive-Development.pdf

Sugih, S., Muqopi, A., & Afriansyah, E. A. (2025). *Self-Confidence in Mathematics : Voices of Indonesian Junior High Students*. *5*(July), 349–364.

Sugiyono. (2019). *Metode Penelitian Pendidikan (Kuantitatif, Kualitatif, Kombinasi, R&D dan Penelitian Pendidikan*. Alfabeta.

Tajuddin, N. I. I., Abas, U. H., Aziz, K. A., Nor, R. N. H., Izni, N. A., Sudin, M. N., … Noor, N. M. (2025). Content Validity Assessment Using Aiken's V: Knowledge Integration Model for Blockchain in Higher Learning Institutions. *International Journal of Advanced Computer Science and Applications*, *16*(6), 601–608. https://doi.org/10.14569/IJACSA.2025.0160659

Zahrah, R. F., & Febriani, W. D. (2020). a Contextual Problem Based of Local Wisdom Improve the Ability To Solving a Word Problem Mathematics Students of Elementary School. *PrimaryEdu - Journal of Primary Education*, *4*(1), 55. https://doi.org/10.22460/pej.v4i1.1492