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# Developing Inductive–Deductive Models with Cognitive Conflict to Enhance Students Problem-Solving and Confidence

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**Abstract:** The ability to solve problems in math and confidence are two crucial skills that need to be built in math learning in the 21st century. However, many students have a challenge in understanding concepts in depth and applying them to solve problems. The purpose of this study is to develop an Inductive–Deductive learning model based on the Cognitive Conflict Strategy, called Thinking in Two Directions, to improve students' mathematical problem-solving skills and confidence. This research follows the Plomp development model which consists of five stages: (1) initial research, (2) design, (3) development, (4) testing, evaluation, and improvement, and (5) implementation. The model is designed with five main steps, namely: Conceptual Identification and Conflict, Inductive Exploration, Deductive Generalization, Reflective Application, and Confirmation and Self-Evaluation. The results of validity, practicality, and effectiveness testing show that this model is valid, practical, and effective for use in mathematics learning. The Thinking in Two Directions model has been shown to be effective in improving students' ability to solve mathematical problems as well as increasing their confidence in dealing with complex mathematical problems.
**Keywords**: inductive–deductive model; cognitive conflict; two direction thinking; mathematical problem-solving; confidence.

## *Mengembangkan Model Induktif-Deduktif dengan Konflik Kognitif untuk Meningkatkan Pemecahan Masalah dan Kepercayaan Diri Siswa*

***Abstrak:*** *Kemampuan untuk memecahkan masalah dalam matematika dan kepercayaan diri adalah dua keterampilan penting yang perlu dibangun dalam pembelajaran matematika di abad ke-21. Namun, banyak siswa yang memiliki tantangan dalam memahami konsep secara mendalam dan menerapkannya untuk memecahkan masalah. Tujuan dari penelitian ini adalah untuk mengembangkan model pembelajaran Induktif-Deduktif berdasarkan Strategi Konflik Kognitif, yang disebut Berpikir Dua Arah, untuk meningkatkan keterampilan dan kepercayaan diri siswa dalam pemecahan masalah matematika. Penelitian ini mengikuti model pengembangan Plomp yang terdiri dari lima tahap: (1) penelitian awal, (2) desain, (3) pengembangan, (4) pengujian, evaluasi, dan perbaikan, dan (5) implementasi. Model ini dirancang dengan lima langkah utama, yaitu: Identifikasi dan Konflik Konseptual, Eksplorasi Induktif, Generalisasi Deduktif, Penerapan Reflektif, dan Konfirmasi dan Evaluasi Diri. Hasil pengujian validitas, kepraktisan, dan efektivitas menunjukkan bahwa model ini valid, praktis, dan efektif untuk digunakan dalam pembelajaran matematika. Model Thinking in Two Directions telah terbukti efektif dalam meningkatkan kemampuan siswa dalam memecahkan masalah matematika serta meningkatkan kepercayaan diri mereka dalam menangani masalah matematika yang kompleks.*
***Kata kunci:*** *model induktif deduktif; konflik kognitif; berpikir dua arah; pemecahan masalah matematis; kepercayaan diri.*

## 1. Introduction

Mathematics is a discipline that plays an important role in shaping logical, critical, systematic, and creative thinking skills (Achsin, Kartono, and 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 and 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

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only foster mathematical thinking skills, but also build students' confidence in facing intellectual challenges (Ningrum and 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, and 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; and deductive, by 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, and 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 et al. 2020)(Prayogi and Verawati 2020).

In this context, mathematical self-confidence is an important affective factor that must be developed along with problem-solving skills (Rahayuningdewi and 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, and Afriansyah 2025).

Based on the explanation above, the questions in this study can be formulated as follows: What are the characteristics of the inductive-deductive learning model based on cognitive conflict that is suitable for the cognitive development of junior high school students? What is the impact of the application of the inductive-deductive model with cognitive conflict on the ability of junior high school students to solve mathematical problems? How does the application of inductive-deductive models involving cognitive conflicts affect junior high school students' confidence when overcoming math problems? In general, this research question can be concluded based on the development method, namely how valid, practical, and effective is the inductive-deductive model based on cognitive conflicts that has been developed?

## 2. Materials and Methods

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 and Nieveen 2013), which consists of three main phases, namely: The first Preliminary Research, the second Prototype Development and Validation Phase. The third Model Effectiveness Assessment Phase. This model was chosen because it is suitable for developing innovative learnin (Sugih et al. 2025) tools and methods, which are based on theory and demands in the field.

The research was carried out in one of the SMP Negeri 3 Percut Kec. Percut Sei Tuan Kab. Deli Serdang North Sumatera, Indonesia that has implemented the Independent Curriculum. The first Trial subject: Grade VIII students who study the building material of flat side spaces (cubes and blocks). The second Number of students: ± 30 people (experimental group). The third Partner teacher: 1 mathematics teacher who acts as a facilitator of model application.

The research procedures carried out consist of three phases, namely: Preliminary Research, Prototyping Phase and Assessment Phase.

Phase 1 – Preliminary Research. The activities carried out in this phase are: the first needs analysis**:** identify mathematics learning problems faced by students, and the second teachers, especially related to problem-solving skills and confidence for this research topic of building cube and block spaces. The third theoretical framework analysis**:** examines the theory of inductive–deductive thinking, cognitive conflict, and *self-efficacy theory* (Gabriel Lopez 2025). The fourth 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 syntax:

 

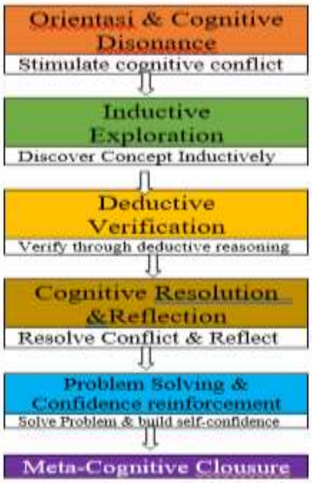

Figure 1. Thinking in Two Directions

Based on figure 1 above, it can be explained that the inductive-deductive thinking learning model with cognitive conflict strategies is designed to develop two-way thinking skills (inductive and deductive) through the creation, resolution, and reflection of cognitive conflicts experienced by students during the learning process. The syntax of this model consists of six main stages as shown in the following Figure.

The first stage cognitive orientation and dissonance (cognitive conflict stimulation). This initial stage aims to trigger cognitive conflict by presenting a difficult problem or situation that contradicts the student's initial understanding. The teacher facilitates students to be aware of the incompatibility between the concepts they have and the observed phenomena. This condition is a trigger for students to actively seek new understanding. The second stage inductive exploration after the emergence of cognitive conflicts, students are directed to explore and discover concepts through inductive reasoning. They observe, identify patterns, and draw general conclusions from a variety of concrete examples. This process develops generalization skills and at the same time builds a strong conceptual understanding.

The third stage deductive verification. In this stage, students verify and test the correctness of concepts obtained through deductive reasoning. Principles or generalizations that have been found before are applied to specific cases to ensure their consistency and validity. This step trains logical, systematic, and argumentative thinking skills. The fourth stage Cognitive resolution and reflection. This stage focuses on resolving the cognitive conflicts experienced by students. They reconstruct the understanding based on the results of exploration and deductive verification, as well as reflect on the thought process that has been carried out. This reflection helps students understand the conceptual changes that occur and reinforces new cognitive structures.

The fifth stage problem solving and strengthening self-confidence. Students then apply the concepts they have understood to solve more complex math problems. Success in solving problems not only strengthens the understanding of concepts, but also increases students' confidence in their thinking and reasoning abilities. The sixth stage meta-cognitive closure. The final stage is meta-cognitive closing, in which students evaluate the thought processes they have undergone. They assess the effectiveness of the strategies used, realize the strengths and weaknesses of inductive-deductive thinking, and draw general conclusions about the meaning of the learning obtained.

Phase 2 – Prototyping Phase. The activities carried out in this phase are: The first design of learning tools: lesson plans, GeoGebra-based LKPDs, student reflection sheets, and teacher guides. The second Expert validation: Involves 3 validators (math education experts, learning technology experts, and educational psychology experts).

The third revision of prototype I to prototype II based on the results of validation (content, construction, and usability aspects).

The fourth small group trial: Conducted in small groups (6–10 students) to see the practicality and response of students. The fifth 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.

Phase 3 – Assessment Phase. The activities carried out in this phase are: the first stage field test: conducted in one class (30 students) to assess the effectiveness of the model in improving problem-solving skills and confidence. The second stage Quasi-experimental research design: *One Group Pretest–Posttest Design*. The third stage One Group Pretest-Postest Design

| $O_1$ | X | $O_2$ |
|---|---|---|

Sumber : (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-confidenc

The research instruments used in this study are shown in table 1 below.

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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 implementatio n | Teacher & student observation | Checklist |
| Reflective Interviews | Uncovering students' cognitive experiences | Semi-structured | Qualitative |

This table 1 outlines the various research tools used to collect data quantitatively and qualitatively in the development of an inductive-deductive thinking learning model with a cognitive conflict approach. Tools applied include:

The first mathematical problem-solving test, consisting of four open-ended questions with a score of 0–4, which aims to assess the improvement of students' ability to solve mathematical problems after the application of the model. The second student confidence questionnaire, using a Likert scale of 1–5 which has 20 questions, serves to assess students' perception and confidence in learning mathematics. The third validation sheet, which is an expert assessment document, aims to assess the authenticity of the content and construction of the learning model with a score between 1–5.

The fourth observation sheet, consisting of observation sheets for teachers and students, is used to assess the practice of learning implementation based on implementation indicators and participants' responses. The fifth reflective interviews, conducted in a semi-structured manner, aim to explore students' cognitive experiences and reflections during the learning process, so as to deepen existing quantitative data.

Overall, the five tools complement each other to collect comprehensive data on the effectiveness, authenticity, and practice of the developed learning models.

The data analysis technique in this study uses several stages. In the validity analysis process, several stages are carried out. The First Validity is calculated using V Aiken to find out the extent to which validators agree (Kania et al. 2024). The Second A model is declared valid if ($V > 0.80$). In the practicality analysis process it is carried out in two steps. The first based on the results of observations and questionnaires of responses from teachers. The second A model is considered practical if the value obtained ≥ 80%.

There are three stages in the analysis of effectiveness in this study. The first using the Paired Sample t-test (Sugiyono 2019) to compare pretest and posttest scores, problem-solving skills, and confidence. The Second supported by N-Gain (Christman, Miller, and Stewart 2024) to determine the level of improvement. The third qualitative data from students' reflections were analyzed by thematic analysis (Hubermen 2014).

The success indicators of the model applied in this study are outlined below. A learning model is considered successful if it meets the following criteria (Tajuddin et al. 2025): The first valid if validation score ≥ 0.8. The second practical if can be well implemented by teachers and accepted by students (≥ 80%). The third effective if problem-solving ability increased with a N-Gain of ≥ 0.3 (medium category) and Students' confidence increases ≥ 10% from the initial score.

## 3. Result and Discussion

### Preliminary Research (Phase 1): Preliminary Findings from the Field

The initial research stage was carried out to get a real picture of the mathematics learning process at the junior high school level, as a basis for developing an inductive-deductive learning model based on cognitive conflict. Data from this stage was obtained through classroom observations, interviews with mathematics teachers, and analysis of learning documents such as lesson plans and teaching materials.

The results of the observation show that in mathematics learning, the method used is still dominated by explanations from teachers and practice questions that tend to be procedural. Generally, teachers explain concepts through formulas and examples, then students are given tasks to work on similar problems. Inductive thinking processes, such as identifying patterns from examples, as well as reflective deductive thinking, have not been applied in a balanced manner. This affects the low ability of students to solve problems, especially when they are faced with problems that are not routine or contextual.

Findings from interviews with teachers also support these results. The teachers said that most students could only solve problems similar to the examples that had been given. When the

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questions undergo modifications, students tend to be confused and give up easily. In addition, teachers observed that students' confidence in learning mathematics was relatively low, as seen from their lack of asking questions, fear of mistakes, and high dependence on instructions from teachers.

Analysis of the learning documents shows that the objectives of the lesson plan are in accordance with the demands of the curriculum in developing high-level thinking and problem-solving skills. However, the designed learning activities have not fully supported the achievement of these goals. Cognitive conflict strategies have not been clearly and systematically designed in the learning process.

From a technological point of view, the school already has basic equipment such as projectors and internet access, but its use is still limited for presentations. Technology has not been utilized optimally to support concept exploration and problem-solving. These findings confirm the need to develop an inductive-deductive learning model based on cognitive conflicts that is in accordance with the characteristics of students in junior high school and the real situation in classroom learning. The activities of teachers and students in the preliminary phase are presented in table 2 below,

Table 2. Student and Teacher Activities

| **Activity** | **Implementation and Output Brief** |
|---|---|
| Study literature | Reviewing journals, books, and curriculum documents related to inductive-deductive learning, cognitive conflict, problem-solving, and junior high school students' confidence. External: theoretical foundations and research gaps. |
| Learning observation | Observe the mathematics learning process in the classroom to identify learning patterns, student involvement, and inductive-deductive thinking processes. Output: an overview of the real conditions of learning. |
| Teacher interviews | Semi-structured interviews to explore students' difficulties, learning strategies, teacher constraints, and learning model needs. Outputs: data on learning needs and problems. |
| Document analysis | Analyze lesson plans, teaching materials, and assessment instruments to assess suitability with curriculum demands. Output: identification of planning and implementation gaps. |
| Technology analysis | Identify the availability and utilization of mathematics learning technology in schools. External: a map of potential technology integration. |
| Synthesis of findings | Integrate all findings to formulate learning problems and initial specifications of cognitive conflict-based inductive–deductive models. External: the direction of model development. |

Table 2 describes the activities of the *preliminary research stage* which includes literature studies, classroom observations, teacher interviews, document and technology analysis, and synthesis of initial findings. All activities aimed to identify learning problems and the need for the development of inductive–deductive models based on cognitive conflict in junior high schools

Model validation was conducted by three experts, 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 3. 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 Rate V** | **0,92** | **Highly Valid** |

From the table above it can be interpreted that 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.

The results of the practical test in this study showed that practicality is assessed from observation of implementation and questionnaires of teacher and student responses. The first model syntax execution: 89% (excellent category), the second teacher Response: 90% stated that this model is easy to implement and helps develop critical thinking. The third student responses: 88% say that learning becomes more

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engaging and challenging, especially when using GeoGebra to resolve concept conflicts.

The results of the study from qualitative data show that, 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)

The results of the data effectiveness of this research design for One Pretest–Posttest Group, Sample: 30 students of class VIII Mathematical Problem-Solving Skills presented in Table 4 as follows,

Table 4. Pretest and Postes 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. The analysis obtained from the data can be described as follows**, s**tudents are able to:

The first identify relevant information from the issue (indicator 1), the second develop a settlement strategy based on inductive patterns (indicator 2), the third testing the correctness of the solution deductively (indicator 3). The fourth reflecting on the results (indicator 4). The conclusion obtained is that the two-way thinking model encourages students to reason and reflect twice —first when building patterns (inductive), and second when proving (deductive).

Student confidence data is obtained using instruments in the form of Likert scale questionnaire (1–5)

Table 5. Student Confidence Questionnaire Results

| Statistics | Pretest | Posttest | Increase |
|---|---|---|---|
| Average | 3,10 | 3,85 | +24,2% |

Aspects that experience the highest improvement:

The First Confidence to explore new concepts (26%). The second belief in own ability to solve problems (25%). The third 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)

Based on the results, both qualitative and quantitative, it can be interpreted as 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.

Based on the things that have been explained in the findings of this research, research or discussion can be carried out on things such as the Effectiveness of Models in Developing Two-Way Thinking. The results of the study show that students are not only able to remember concepts, but are also able to develop and test these concepts through a two-way way of thinking. This process is in line with the principles of constructivism, where knowledge is formed through conflict and cognitive rearrangement.

This model encourages students to think more flexibly, allowing them to switch between inductive patterns (identifying patterns from examples) and deductive patterns (constructing logical arguments to prove them).

The Role of Cognitive Conflict as a Driver of Learning In this model, cognitive conflict has two functions: The First Activity Functions as a as a curiosity booster,

The Second Activity Functions as a change in the direction of thinking.

This is in contrast to the traditional model that often avoids conflict and directly conveys concepts to students. The conflicts that arise through digital experiments in GeoGebra help students find errors in thinking, verify existing ideas, and improve their understanding.

The contribution of students in terms of confidence in this study was found to be when students successfully resolve conceptual conflicts, they gain a mastery experience that plays an important role in increasing *self-efficacy*. This challenge-based learning fosters a positive mindset towards mistakes, that mistakes are part of the learning process. Students who were previously passive become more confident to try, discuss, and prove their opinions. The same thing with research (Andra Meisantry Assari 2025).

The integration of the independent curriculum and the technology applied in this study are this model supports the implementation of the Independent Curriculum, especially in the dimensions *of critical*, *independent*, and *reflective thinking*. GeoGebra'**s** integration makes the model responsive to the needs of the digital age — not just a visual aid, but a conceptual thinking tool.

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The results of the field research show that the teaching methods used are in accordance with the implementation of the Independent Curriculum, especially in strengthening students' critical, independent, and reflective thinking skills. During the learning process, students are encouraged to analyze problems, explore alternative solutions, and rethink strategies that have been implemented without relying entirely on the teacher's guidance. The use of GeoGebra in learning not only serves as a visual aid, but also as a medium for conceptual thinking that supports students in exploring the interconnectedness between concepts, verifying hypotheses, and building meaningful understanding. These findings show that the proposed method is sensitive to the needs of mathematics education in the digital era and supports the development of student profiles in accordance with existing curriculum policies.

## 4. Conclusion

This research produced a learning model called Thinking in Two Directions which combines inductive and deductive processes using cognitive conflict strategies and supported by GeoGebra digital tools. This model is aimed at addressing the problem of students' low ability to solve mathematical problems as well as their confidence in mathematics studies at the Junior High School (SMP) level.

The model that has been developed emphasizes that mathematical thinking does not just move in one direction—from example to concept (inductive) or from concept to application (deductive)—but must be mutually reinforcing reciprocal. Cognitive conflict serves as an intellectual trigger that encourages students to review, refine, and reconnect the knowledge they have. Through engaging interactions with GeoGebra, students gain visual and conceptual experiences that help them move from confusion to better understanding.

The results of the application of this model show progress in two main aspects:

Mathematical Problem-Solving Ability, which can be seen from students' increased skills in analyzing problems, planning solution strategies, and providing logical reasons at each step of the solution.

Student Confidence, which is formed through successful experiences in resolving conceptual conflicts, reflective support from teachers, as well as visual feedback provided through GeoGebra.

Overall, the Thinking in Two Directions model makes a contribution both theoretically and practically to modern mathematics learning that demands the integration of critical thinking skills, cognitive flexibility, and digital literacy. This model is an innovative alternative to implement learning based on the Independent Curriculum, which focuses on strengthening the profile of Pancasila students — especially in the aspects of critical, creative, and independent thinking skills.

The suggestions for mathematics teachers that researchers can convey from the results of this study are: teachers are advised to gradually apply inductive and deductive thinking methods based on cognitive conflicts in mathematics teaching. They need to tap into relevant and contextual conceptual conflicts, as well as use GeoGebra to support visual exploration and logical verification by students. In addition, educators must prepare challenging trigger questions so that students can stay focused on thinking both through inductive and deductive routes.

Suggestions that schools can implement include: schools can make this approach an innovation in 21st-century learning that encourages collaboration, reflective thinking, and the application of technology in math lessons. All of this requires the support of facilities such as computers or laptops, a stable internet connection, and training in the use of GeoGebra for teachers.

For future researchers are advised to test how effective these models are in other math topics such as spatial geometry, functions, or algebra. Develop interactive digital worksheets for learners that are based on cognitive conflict so that students can learn independently. Combine this model with a metacognitive approach to improve students' self-reflection and self-evaluation skills.

Suggestions that can be given to Curriculum Developers and Policy Makers: this model can be used as a reference in the preparation of teaching materials that combine problem-solving, confidence, and digital literacy at the same time. Curriculum developers are advised to pay attention to this two-way thinking strategy as part of efforts to strengthen the character and numeracy skills in the Independent Curriculum.

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