Development of mathematics learning tools based on cognitive conflict strategies to improve students' critical thinking skills

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DEVELOPMENT OF MATHEMATICS LEARNING TOOLS BASED ON COGNITIVE CONFLICT STRATEGIES TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS

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ABSTRAK

Perangkat pembelajaran pada materi segitiga dan segiempat sangat penting karena berfungsi sebagai tolok ukur keberhasilan belajar. Rendahnya kemampuan berpikir kritis pada matematika kelas VII menunjukkan bahwa media yang digunakan belum dioptimalkan dan memiliki keterbatasan. Penelitian ini bertujuan untuk mengetahui karakteristik dan aplikasi perangkat pembelajaran matematika yang menggabungkan strategi konflik kognitif pada materi segitiga dan segiempat yang valid, praktis, dan efektif dalam meningkatkan kemampuan berpikir kritis siswa. Penelitian menggunakan desain R&D, dan penelitian dilakukan pada semester musim gugur tahun ajaran 2021/2022 di kelas VII SMP Negeri 2 di Gerokgak. Model pengembangan perangkat *Plomp* diterapkan dalam tiga tahap: penelitian pendahuluan, *prototyping*, dan penilaian. Temuan menunjukkan penggunaan perangkat pembelajaran segitiga dan segiempat dengan strategi konflik kognitif di kelas VII SMP Negeri 2 Gerokgak meningkatkan kemampuan berpikir kritis matematika. Buku siswa mampu menyajikan masalah yang menantang, melakukan diskusi konflik, dan memberikan umpan balik sedangkan buku pegangan guru memberikan tugas-tugas untuk memecahkan skenario permasalahan dan mengevaluasi kepada siswa. Perangkat ini efektif dan praktis, dan dapat menggantikan metode pengajaran tradisional.

Kata kunci: Matematika, perangkat pembelajaran, *cognitive conflict strategy*, *Critical thinking*.

ABSTRACT

Learning tools on triangular and quadrilateral materials are very important because they serve as a benchmark for learning success. The low critical thinking ability in Grade VII mathematics suggests that the media used has not been optimized and has limitations. This study aimed to determine the characteristics and applications of mathematics learning tools that incorporate cognitive conflict strategies on triangular and quadrilateral materials that are valid, practical, and effective in improving students' critical thinking skills. The research used an R&D design, and the study was conducted in the fall semester of the 2021/2022 academic year in grade VII of SMP Negeri 2 in Gerokgak. The Plomp device development model is applied in three stages: preliminary research, prototyping, and assessment. A study found that using triangular and quadrilateral learning tools with cognitive conflict strategies in grade VII SMP Negeri 2 Gerokgak improved math critical thinking skills. The student books presented challenging problems, had conflict discussions, and gave feedback. The teacher manuals included tasks to solve problematic scenarios and evaluate students. These tools are effective and practical, and can replace traditional teaching methods.

Keywords: *Math, Learning tools, cognitive conflict strategy, critical thinking*

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Introduction

Mathematics subjects play an important role and must be taught at the school to university level in Indonesia. It aims to prioritize problem-solving abilities, skills, and agility when dealing with change. According to Siagian (2016), mathematics emphasizes thinking globally and using ratios (reasoning) rather than merely based on experimental or observational results. Mathematics involves ideas, processes, and reasoning about the shape of the human mind (Kaur et al. 2009; Putra et al. 2020). However, data show that mathematics learning methods in Indonesia tend to be mechanistic, rely on the use of practical formulas, and do not involve constructive processes that can reduce students' critical thinking skills (Fadilla et al., 2021). According to the International Student Assessment Report (PISA), Indonesian students' proficiency in mathematics, particularly in applying mathematical concepts, is yet to be enhanced to the level of critical thinking skills (OECD, 2019; Tohir et al., 2021).

Previous research has indicated that the level of critical thinking skills in mathematics is crucial for the advancement of other sciences (Adnyana & Sudaryati, 2022; Hidayah et al., 2017; Triyanti et al., 2021). Ismail et al. (2018) stated that the critical thinking skills of public junior high school students are not optimal. This is because of students' lack of practice in dealing with mathematical problems that demand critical thinking skills (Ahdhianto et al., 2020; Darmawati & Mustadi, 2023; Rahayu et al., 2022). This is also supported by data obtained when conducting preliminary studies at SMP Negeri 2 Gerokgak, which showed that grade VII fall semester students in the 2021/2022 academic year have many errors in solving flat building problems, especially triangular and quadrilateral materials, as shown in figure 1.

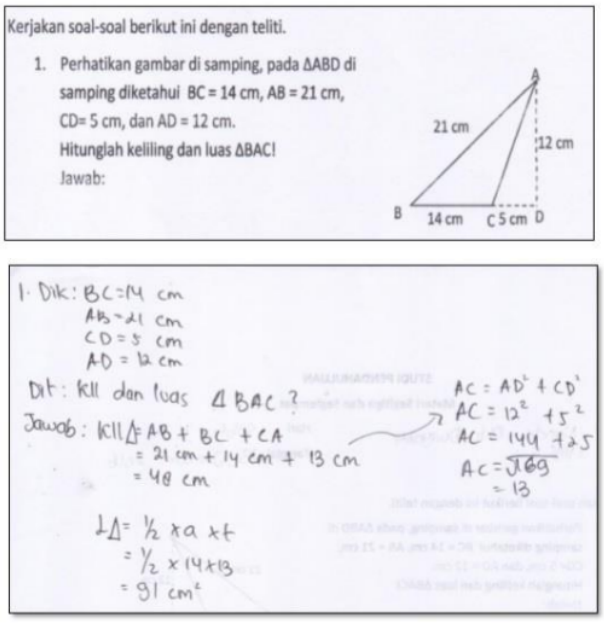

Figure 1. Examples of student errors in solving flat wake problems

In the preliminary study and the example in figure 1, the students faced several challenges when understanding the problem. They managed to find the circumference and area of the ΔBAC field well because they were able to recognize the AC side as an apothema ΔACD and used the Pythagorean Postulate that had been studied since grade VI. However, the students had difficulty answering subsequent questions. Most students understand ΔBAC and can use formulas to precisely find the area of a triangle; however, they lack critiquing the elements of a triangle presented in the problem. Consequently, they misplaced the side of the air conditioner with high ΔBAC, as shown in the figure.

Evendi et al. (2022) revealed that this could be due to three factors: weak basic teacher concepts or inappropriate models, strategies, or learning methods used; weak students' basic concepts; and an unsupportive learning environment. The same problem expressed by Firmanti (2022) asserts that students are discouraged from fostering critical thinking abilities during their educational experience. Learning that tends to have problems with one-way orientation results in information being conveyed from the teacher to the student but not as expected. Students spent more time sitting and listening to the teacher explanations. Consequently, the learning process in the classroom is geared toward memorizing information, which impairs the growth of students' critical thinking abilities (Darling-Hammond et al., 2020; Juwita & Fauzan, 2020; Suryawan, Nitiasih, et al., 2023). The negative impact of this situation often causes students to experience errors in their understanding of mathematical concepts. Errors in one concept can affect overall learning achievement and understanding of other mathematical concepts (Makhrus & Hidayatullah, 2021; Mufit et al., 2022).

The future demands the enhancement of students' critical thinking abilities, which involves systematic examination, comparison, and appraisal of all elements of a situation or problem, including testing, to confirm conclusions (Adnyana & Sudaryati, 2022). Karyadi Hidayat et al. (2023) and Suryawan et al. (2023) stated that every child needs critical thinking skills to live with future challenges. These competencies should enable students to compete in the future. Efforts can be made to improve learning strategies by using cognitive conflict strategies. Learning with cognitive conflict strategies is based on assumptions regarding cognitive conflicts in the learning process. Cognitive conflict is a condition in which an individual experiences imbalance in consciousness. This imbalance arises because of the presence of information that contradicts knowledge stored in the cognitive structure of the individual. Learning with cognitive conflict strategies involves learning the real context by providing several problems, statements, and examples to improve students' ability to criticize situations related to mathematical material (Pratiwi et al., 2022; Yolanda, 2019). Sayce (2009) Cognitive conflict is beneficial for students, as it encourages them to think more objectively and stimulates their mathematical critical thinking skills while providing motivation.

Looking at this information, mathematics learning problems that do not emphasize students' critical thinking skills are challenges that must be developed, especially in the SMP Negerai 2 Gerokgak. The inadequate problem-solving skills of students require the implementation of this research, which aims to develop more effective, practical, and participatory learning tools. This study aimed to determine the attributes and application of cognitive conflict-based mathematics learning tools for valid, practical, and effective triangular and quadrilateral materials to enhance critical thinking skills among students of the SMP

Negerai 2 Gerokgak. We hope that the findings of this research will help students and teachers improve their learning and critical thinking abilities in mathematics.

Method

This study uses an R&D research design (Darwin et al., 2021). The resulting product was a triangular and quadrilateral learning device with cognitive conflict strategies in the form of student books and teacher manuals. This study was conducted at SMP 2 in Gerokgak, considering affordability and feasibility. The research for this study will be conducted during the fall semester of the 2021/2022 academic year. The study involved Class VII students and teachers as participants. Students will help gather data on the practicality and effectiveness of learning devices, specifically in the form of student books, whereas teachers will focus on gathering data on the overall practicality of these devices.

This study used the Plomp device development model (Mufit et al., 2022), including preliminary research (carried out a review of a number of data related to the needs of students, teachers, and supporting facilities, accompanied by interviews about obstacles in mathematics learning and studies of content standards and textbooks for grade VII students), prototyping (carried out by carrying out the design of student books, teacher books, and research instruments, carrying out expert tests (validation) prototype I with two experts in the field of mathematics education, carrying out one-to-one tests with one teacher and three students with low, medium, and high abilities, and conducting limited trials and field trials), and assessment (by carrying out summative evaluations on trials with shifting techniques). The effectiveness of learning devices is evaluated by measuring their ability to achieve learning objectives and enhance students' critical mathematical thinking skills, as well as ensuring that their use does not exceed the allocated learning time.

This study focused on creating triangular and quadrilateral learning tools using cognitive conflict strategies. The validity of these tools was tested at various stages, including content and construct validity. To be considered practical for use in the classroom, the learning devices must score at least $2.50 \leq Sr \leq 3.50$ on the validity scale. The practicality of the tools was further evaluated based on the teacher's ability to apply them in the classroom and the teachers' and students' responses to their use. A score of at least 2.50 on the practicality scale was needed for the tools to be considered practical. Finally, the effectiveness of the developed learning tools was determined by assessing their ability to achieve research objectives. They were considered effective if the average score on students' critical thinking skills improved by more than 67%. All data related to this study are descriptively presented (Adnyana, 2021).

Results and Discussion

A. Result

1. Preliminary Research

At this stage, an analysis of the learning conditions, situations, and problems that arise when the learning process takes place at SMP Negeri 2 Gerokgak is conducted. This analysis was conducted through observations of the learning process carried out in class, assessment of learning tools, and interviews with Grade VII mathematics teachers. Only smart students dominate the learning process, resulting in less interest for other students to follow the learning

process. Students lack the opportunity to discuss both individually and in groups, resulting in their thinking processes in learning still lacking, and most students are embarrassed to ask questions when they find difficulties at the time learning takes place. This is because students are not accustomed to asking questions or providing ideas or opinions.

Interviews conducted with Grade VII mathematics teachers of SMP Negeri 2 Gerokgak were conducted by teachers who have tried to teach student strategies that have been used by teachers, but most students still do not express their opinions or ideas. In addition, teachers prioritize the delivery of materials without providing opportunities for students to explore the material and mathematical problems faced. The learning tools used by students provide alternative solutions to the math problems presented on the learning devices, so students seem to only read these alternatives without trying them alone or in groups to solve the given math problems. During the learning process, teachers ask students questions more often at school and at home. Teachers rarely provide opportunities for students to ask questions, argue, or express the results obtained by answering the given questions. Teachers do not have their own manuals for conducting the learning process. The book used by the teacher was only a student book; therefore, the learning process was fixed from what was written in the student book. Another problem is that teachers do not understand future needs, one of which is critical thinking; therefore, the learning process carried out by teachers is still in the form of delivering information. The teacher did not provide provoking questions that encouraged students to think.

After reviewing the Grade VII mathematics book of the 2013 curriculum revised edition of 2014, several things were found to need improvement, including that most of the mathematics problems presented in the student book already included alternative solutions, so students tended to read these alternatives without wanting to try to do the math problems presented, and there are some problems in the student book that should not be given first. This was because the students did not obtain mathematical concepts in accordance with these mathematical problems. Reviewing the situations and conditions found, as well as the results of interviews with mathematics teachers at SMP Negeri 2 Gerokgak, as well as the results of reviewing books used by students, a mathematics learning tool is needed that can help teachers and students improve critical thinking skills and provide a conducive learning atmosphere through group discussions by applying cognitive conflict strategies in the form of student books and teacher manuals.

2. Prototyping

At this stage, two experts assessed the validity and revision of the student books. The assessment carried out by the experts included the rationale, purpose, material, presentation method, and physical form of student books. In revising student books, the researchers referred to the results of the discussions and suggestions provided by the validators. Furthermore, an analysis of Prototype I's validity was conducted using student books and teacher manuals. In the assessment obtained, prototype I student books with Sr = 3.43 in the range of $2.5 \leq Sr < 3.5$ *are* valid categories. Furthermore, based on the results of the validity and revision of the teacher manual, which contains the content and systematics of the presentation of the teacher manual by experts, prototype I in the form of a teacher manual with Sr = 3.28 is in the range of

2.5≤Sr<3.5 in the valid category. The results regarding the validity of student and teacher books are presented in Table 1.

Table 1. Validity of student books and teacher manuals

No	Validation Aspect	Average Validator Score		Sum	Average	Sum	*Sr*
		I	II				
Student Book Validity							
1.	Content Validation	3,54	3,38	6,92	3,46	**6,85**	**3,43**
2.	Construct Validation	3,33	3,44	6,77	3,39		
Validity of teacher manuals							
1.	Content Validation	3,20	3,40	6,60	3,30	**6,55**	**3,28**
2.	Construct Validation	3,25	3,25	6,50	3,25		

Information: Sr = average student and teacher book validity score.

The teacher manuals that were deemed valid underwent revisions before being used. Once all validity assessments and revisions were completed, we tested the validity of the learning equipment practicality instruments, including observation sheets, on the implementation of the learning devices, student response questionnaires, and teacher response questionnaires. These instruments were first validated by experts, and the results were as follows: The learning device practicality instrument in the form of a learning device implementation observation sheet was determined to be very valid with a score of Sr = 3.64 (range 3.5≤Sr≤4.0). Additionally, the student response questionnaire was found to be very valid, with a score of Sr = 4.0 (range 3.5≤Sr≤4.0), and the teacher response questionnaire was categorized as valid, with a score of Sr = 3.53 (range 3.5≤Sr≤4.0), as presented in Table 2.

Table 2. Instrument validity practicality of learning devices

No.	Validation Aspect	Average Validator Score		Sum	*Sr*
		I	II		
Expert Assessment					
1.	Learning tools implementation observation sheet	3,73	3,55	7,28	3,64
Assessment by students					
1.	Student Response Questionnaire	4	4	8	4
Assessment by teachers					
1.	Teacher Response Questionnaire	3,72	3,33	7,05	3,53

Information: Sr = average instrument validity practicality of learning devices.

The validity of the mathematical learning device is evaluated to determine its effectiveness. Evaluation was conducted by measuring the critical thinking skills of students who used the tool during the trial period. The instrument was tested for validity by two experts prior to its use and was found to be valid based on the criteria for learning device validity. The student achievement test was categorized as having a value of Sr = 3.63 (range 3.5 ≤ Sr ≤ 4.0), as presented in Table 3.

Table 3. Instrument validity of learning device effectiveness

No.	Validation Aspect	Average Validator Score		Sum	*Sr*
		I	II		
1.	Test students' math critical thinking skills	3.5	3.75	7.25	3,63

Information: Sr = average instrument validity of learning device effectiveness.

After validating the instruments, learning aids, and responses of the students and grade VII teachers of SMP Negeri 2 Gerokgak, a trial was conducted to test these learning aids. The purpose of this trial was to enhance the quality of learning aids, including student books and teacher manuals, and determine the practicality and effectiveness of the learning aids used. The results of the limited trials conducted on the learning devices are as follows. In the first stage, one-to-one trials were individual evaluation trials, and the implementation of individual trials was important because it could identify deficiencies and provide feedback on the product being developed. The subjects involved in this individual trial were a teacher as an educator and three students with low, medium, and high abilities. In the second stage, a limited trial was conducted, involving as many as eight meetings according to the material in the student book. This trial included 39 VIIB3 classes. The purpose of this limited trial was to obtain an overview of the learning characteristics and determine the implementation of learning using the learning aids that were prepared. The practicality of these devices can be observed in the implementation of learning by using the developed learning aids. To determine its practicality, an instrument in the form of an observation sheet was developed to implement mathematics learning aids. The results of the analysis of the data obtained during the observations of the implementation of the learning aids developed in limited trials are presented in Table 4.

Table 4. Limited testing of learning tools

Analysis	Meeting to-							
	1	2	3	4	5	6	7	8
Number of Observer Scores per Meeting	29	33	34	35	37	38	41	42
Average Observer Score for Each Meeting	2,64	3,0	3,10	3,18	3,36	3,45	3,73	3,82
Average score (*Sr*)	3,29							

Information: Sr = average student book validity score.

The findings in Table 4 show an increase in the average observation score for the implementation of learning devices from 2.64 to 3.82. In the trial, Sr = 3.29 was obtained during the implementation of learning using learning tools that had been prepared; therefore, based on practicality criteria, it could be stated that triangular and quadrilateral learning devices with cognitive conflict strategies were in the practical category, which was in the range of $2.5 \leq Sr < 3.5$. Although practically used, during the implementation of limited trials, there were several things that became obstacles to learning using the mathematics learning tools that had been compiled, including during the discussion process, and most students still exhibited a rigid attitude. This is because the students were not used in a group-learning atmosphere.

Most students are still embarrassed to express opinions or ask questions if there are things they do not understand; therefore, teachers need to take an approach to the students concerned and the activities of most students while learning using these learning tools. In addition to the

obstacles mentioned above, there have been improvements in learning tools, including student books and teacher manuals. The improvement lies in instructions for working on mathematical problems, explanations of diagrams or drawings, writing sentences in mathematical problems, and presenting examples that need to be added. After revising Prototype II based on the findings obtained during the limited trials, Prototype III was obtained, which was subsequently conducted during field trials.

The implementation of field trials aimed at determining the quality of Prototype III. This field trial involved two classes VII, namely, classes VII-C1 and VII-C2, each of which consisted of 33 students for a total of 66. The material discussed in the field trials was in accordance with that discussed in limited trials. Focus on conducting field trials to improve the quality of mathematics learning tools. The results showed an increase in the average implementation score of mathematics learning tools from the beginning of the meeting by 3.00 to the last by 3.90. The average score obtained during the field trials on the implementation of the mathematics learning tools was 3.43. In accordance with the practicality criteria, the triangular and quadrilateral learning tools with cognitive conflict strategies used in learning were in the practical category (range $2.5 \leq Sr < 3.5$) and are presented in Table 5.

Table 5. Results of the implementation of mathematics learning tools in field trials

Analysis	Meeting to-							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of Observer Scores per Meeting	33	34	35	37	38	40	42	43
Average Observer Score for Each Meeting	3,00	3,10	3,18	3,36	3,45	3,64	3,82	3,90
Sr	3,43							

Information: Sr = average of the implementation of mathematics learning tools in field trials.

After the test, we evaluated students' feedback on their learning resources. The outcomes revealed that the overall student response score, calculated through the student response questionnaire, was 3.67 in the "very practical" category. The average score of student responses across all categories was between 3.5 and 4.0. A summary of student feedback on learning resources is presented in Table 6.

Table 6. Assessment of student responses to learning devices

Valuation	Student Response Statement Item									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
SS	48	44	50	46	48	49	45	41	44	43
S	18	22	14	20	15	17	21	25	20	23
TS	0	0	2	0	3	0	0	0	2	0
STS	0	0	0	0	0	0	0	0	0	0
Valuation	**Student Response Statement Item**									
	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	-
SS	43	35	30	38	52	52	48	50	49	
S	23	31	33	28	10	14	18	16	17	
TS	0	0	3	0	4	0	0	0	0	
STS	0	0	0	0	0	0	0	0	0	
Average score	**242,26**									
Average total score (*Sr*)	**3,67**									

Testing teacher responses to learning devices obtained an average score from teacher responses to learning devices arranged at 3.61 in the very practical category, which is in the range of 3.5≤Sr<4.0, as shown in Table 7.

Table 7. Assessment of teacher responses to learning tools

Valuation	Teacher Response Statement Item								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SS	1	1	1	1	0	0	1	0	1
S	0	0	0	0	1	1	0	1	0
TS	0	0	0	0	0	0	0	0	0
STS	0	0	0	0	0	0	0	0	0
Valuation	**Teacher Response Statement Item**								
	10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
SS	1	1	1	1	0	1	0	0	0
S	0	0	0	0	1	0	1	1	1
TS	0	0	0	0	0	0	0	0	0
STS	0	0	0	0	0	0	0	0	0
Total Score	**65**								
Average score (*Sr*)	**3,61**								

3. Evaluation

During the assessment phase, activities were conducted to collect data on the students' critical mathematical thinking skills. These data were gathered through a test that evaluated the students' critical mathematical thinking abilities using a quadrilateral triangle and four essay items. The results of the test were analyzed, and the average score obtained was 74.73. According to the effectiveness criteria for critical mathematical thinking skills, a score above 67 was considered effective. As the average test score was above 67, it can be concluded that mathematics learning tools with cognitive conflict strategies using triangular and quadrilateral materials were effective in enhancing students' critical mathematical thinking skills. The results of students' mathematical critical thinking testing in the field trials are presented in Table 8.

Table 8. Testing students' mathematical critical thinking on field trials

Student Code	Score	Student Code	Score	Student Code	Score
C01	72	C23	76	C45	72
C02	72	C24	64	C46	44
C03	76	C25	72	C47	96
C04	64	C26	68	C48	84
C05	80	C27	48	C49	76
C06	60	C28	72	C50	96
C07	76	C29	76	C51	60
C08	84	C30	72	C52	72
C09	88	C31	80	C53	64
C10	72	C32	72	C54	84
C11	72	C33	52	C55	80
C12	76	C34	84	C56	92
C13	60	C35	80	C57	72
C14	84	C36	96	C58	56
C15	96	C37	80	C59	76
C16	76	C38	84	C60	68
C17	52	C39	72	C61	84

Student Code	Score	Student Code	Score	Student Code	Score
C18	72	C40	56	C62	96
C19	84	C41	92	C63	76
C20	64	C42	80	C64	72
C21	68	C43	76	C65	76
C22	80	C44	84	C66	72
Total Score	**4932**				
Average Score ($\bar{P}$)	**74,73**				

B. Discussion

A cognitive conflict strategy is a learning approach based on a constructivist perspective (Adnyani, 2020; Dickens et al., 2020; Mufit et al., 2022; Putra et al., 2020). Students are given a new element or surprise that can be a counterexample or statement that causes uncertainty in their initial knowledge. Several forms of learning utilize cognitive conflict strategies. The first is to provide examples of challenging contextual problems (Andayani 2020; Syadzili et al. 2018). In this context, students face challenges in the form of problems relevant to their situation as a tool to encourage their motivation to critique the problem. In addition, contextual problems, statements, questions, or examples can be inserted to help students avoid mistakes in finding solutions to these problems (Shahbari, 2021).

Through this contextual problem solving, students can analogize the results of their solutions into mathematical concepts to obtain general conclusions used in mathematics. This is an example of the application of math learning tools with cognitive conflict strategies, developed in both student books and teacher manuals. In this developed mathematics learning tool, students can produce various models and contexts of problems and write relevant information based on the obtained contextual problems (Dong et al., 2023; Dwi Rohmawati & Fathoni, 2022; Harizah et al., 2020). Teachers are also given alternative possibilities from student answers in teacher manuals to facilitate the students' production of various models and contexts of problems. Furthermore, as Damon and Killen explain, cognitive conflicts can arise when there are differences in opinions or thoughts between individuals. Therefore, when learning mathematics using cognitive conflict strategies, it is important to conduct discussions among the students. This discussion aims to create conflicts (Hendrajah et al., 2023; Makhrus & Hidayatullah, 2021; Putra et al., 2020).

Kaur et al. (2009) emphasized that the questions asked students to teach them to appreciate the need to communicate and provide arguments as supporting evidence, as well as spark discussion among students about how they interpret the context of a given question. This is an important part of student books, as learning tools have been developed. Students are encouraged to formulate questions that provide directions for solving various possible answers, compile various answer concepts, formulate reasonable arguments, and show differences and similarities (Agus & Purnama, 2022; Mania et al., 2021; Ratnaningtyas, 2016).

Students will also deduce logically, provide logical assumptions, make propositions and hypotheses, conduct investigations/collect data, generate data, create tables and graphs, and interpret statements. This will train students in critical thinking skills, especially problem solving (Hidayati et al., 2023; Ismail et al., 2018; Rahayu & Fauzan, 2020). Teachers, as facilitators in learning, also play an important role in being able to make provoking questions to encourage students to engage in discussion conflicts. This is an important part of the teacher

manual that gives the teacher a shadow over questions that can lead to discussion conflicts (Sayce, 2009; Tohir et al., 2021). Through a teacher manual, teachers can insert questions or keywords that encourage students to reconsider their thinking, and students can recognize mistakes or deficiencies in their understanding during the learning process (Mufit et al. 2022). Here, students will reflect on and reinterpret the results and problem-solving processes that have been carried out, look once again more deeply, and find possible ideas and perspectives of alternative solutions that have been made.

In addition to cognitive conflict strategies, students' interactions with the environment are also important during learning. Piaget found that children's cognitive development depends largely on their interactions with their environment (Dickens et al., 2020; Evendi et al., 2022; Mufit et al., 2022). In the classroom context, a learning approach that encourages students to discover their knowledge through interactions with the environment has been applied. The tools or media used to support learning are not limited; they can be observed or other tools that make learning activities fun while still encouraging students to think critically. Learning with contextual cognitive conflict requires students to explore the concepts of triangles and quadrilaterals and find relationships between the learning materials and real-world conditions. This is reflected in the math learning tools that have developed cognitive conflict strategies. Through the activities in this student book and teacher manual, students can improve their critical thinking skills by conducting an in-depth analysis of triangular and quadrilateral materials.

C. Research Limitations

The material presented in this study was triangular and quadrilateral, even in semesters for grade VII students, so the material tested was limited to triangular and quadrilateral materials. In addition, this study focused only on SMP Negeri 2 Gerokgak; therefore, the data obtained did not vary from one school to another.

Conclusion

Triangular and quadrilateral learning tools incorporating cognitive conflict strategies were found to be valid, practical, and effective in enhancing the critical thinking skills of mathematics students in SMP Negeri 2 Gerokgak grade VII. These tools, presented in the form of student books, feature challenging contextual problems, create opportunities for conflict discussions, provide space for reflective thinking, encourage logical reasoning, improve analytical skills, offer feedback, and facilitate problem solving. Teacher manuals with similar characteristics, such as examples of tasks and problems with cognitive conflict strategies, teaching scenarios with cognitive conflict strategies, critical thinking questions, problem-solving strategies, evaluations, and feedback, were also identified as effective. As a result, triangular and quadrilateral learning tools with cognitive conflict strategies can be used as alternatives to traditional classroom teaching methods to improve students' critical thinking skills. However, further research is needed to explore the components that lead to critical thinking in real-world contexts and to update the material and its applications in other educational units at the same level.

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Daftar Pustaka

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