Enhancing Critical Thinking Skills of Prospective Elementary School Teachers: A Study on Problem-Based Learning Approach

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ARTICLE INFO	ABSTRACT
	Critical thinking is a higher-order thinking skill that must be fostered during learning. This study aims to provide insights into the achievement of critical thinking skills among students through the implementation of the problem-based learning model in the geometry course. The research methodology employed in this study is descriptive in nature. The participants consisted of 40 Primary School Teacher Education students, who were divided into high, medium, and low-ability groups. Data were collected through written tests and observations. Twelve indicators of critical thinking skills were measured, with ten indicators assessed through written tests and two indicators through observations. The data were analyzed using quantitative descriptive analysis techniques. The study's findings indicate that students' critical thinking skills, as assessed through tests and observations, are considered good in the high, medium, and low groups. This is evident from the average percentages of 83.16% for the high group, 76.40% for the medium group, and 72.08% for the low group, respectively. Students in the high-ability group demonstrated a significantly excellent level of critical thinking skills. In conclusion, applying the PBL model significantly enhances students' critical thinking abilities.

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1. INTRODUCTION

The continuous improvement and sustainable development of human resources are of utmost importance, particularly in the era of globalization. The demand for high-quality human resources is vital as they can unlock their potential and effectively address future challenges. As educational entities, higher education institutions play a significant and tangible role in fostering the enhancement of human resource quality, which is evident through the implementation of the *Tridharma* of Higher Education (The university's three main responsibilities of education, research, and community service). Enhancing the quality of human resources poses a formidable challenge for universities. Ideally, higher education should focus on cultivating hard and soft skills among students. However, it is often observed that the emphasis is predominantly placed on hard skills only. Hard skills primarily pertain

to the mastery of academic subjects and theoretical knowledge, while soft skills should complement and reinforce students' hard skills. As Wagner (2008) highlighted, one notable soft skill is critical thinking ability. It encompasses the capacity to identify, analyze, and creatively and logically solve problems, thereby facilitating informed and appropriate decision-making (Tinio, 2003).

Critical thinking is recognised as an essential cognitive capacity that must be developed in educational environments at an advanced level of thinking (Abdullah, 2016). However, one key issue that limits the development of pupils' critical thinking ability is the instructional approach utilised in classrooms. Damanik and Bukit (2013) say that this can be related to the curriculum, which frequently covers a wide range of information, prompting teachers to focus more on finishing the curriculum rather than encouraging critical thinking abilities. Furthermore, teachers may possess a restricted comprehension of efficient teaching techniques. Hence, it is crucial to utilise efficient instructional models in the classroom.

These models are teaching strategies that help teachers plan and implement engaging learning activities to achieve specific learning goals. Based on observations, several noteworthy findings emerge that (1) Instructional methods used in classrooms are often monotonous, relying heavily on traditional approaches like lectures, exercises, and assignments, (2) passive learning experience makes the learning process dull for students, as they listen and take notes on the main points provided by the teacher, (3) Furthermore, student's motivation to learn is often insufficient, which can impact their engagement and overall learning outcomes. In conclusion, teachers must adopt diverse and interactive instructional approaches that promote critical thinking skills among students and foster their active engagement and motivation in the learning process.

According to a study by Nuryanti et al. (2018), it is clear that when learning experiences fail to fully engage students' thinking abilities, it can lead to a lack of critical thinking skills. Furthermore, Karim and Normaya (2015) found that to develop students' critical thinking abilities, the instructional model should facilitate interactive student engagement, with the teacher acting as a facilitator. One instructional model that has been recognized for its ability to enhance critical thinking skills is Problem-Based Learning (PBL). Problem-based learning (PBL) is a learning approach that focuses on real-world problems to help students develop critical thinking and problem-solving skills while acquiring knowledge and concepts. According to Sudarman (2007), PBL involves learners working together to build knowledge by using their existing understanding and information gained through interactions with others. Similarly, Nugraha and Mahmudi (2015) state that PBL effectively develops critical thinking skills as it encourages students to actively construct their knowledge by comprehending learning concepts through problem-solving activities conducted in groups.

Critical thinking is also one of the components of the Pancasila Student Profile in the Merdeka Belajar Curriculum. As prospective elementary school teachers, the primary teacher education study program students must have critical thinking skills in mathematics, specifically geometry. Their involvement in PBL can contribute to developing their critical thinking abilities. In PBL, students actively engage in the learning process through problem-solving activities and can draw conclusions based on their understanding. According to Hmelo-Silver and Barrow (2006), the problems presented in PBL do not have a single solution, requiring students to explore multiple solution paths. Implementing the PBL model can create a learning environment that goes beyond information transfer and emphasizes the construction of knowledge based on individual and group understanding and experiences. This study aims to analyze the critical thinking abilities of Primary School Teacher Education students as prospective elementary school teachers by implementing PBL in the context of geometry.

PBL is an instructional approach that stimulates higher-order thinking among students in real-world problem-oriented situations, including learning how to learn (Ibrahim & Nur, 2000). According to Rusman (2013), students' understanding of concepts and principles begins with engaging and learning through situations or problems presented via investigation, inquiry, and problem-solving. Students construct concepts or principles by integrating their existing skills and knowledge. It states

that problem-based learning involves students identifying problems, collecting data, and utilizing it for problem-solving (Rusmono, 2012).

PBL is characterised by several key features. First, learning begins with problems as the focal point. These problems are real-world and unstructured, requiring students to consider multiple perspectives. Additionally, the problems in PBL challenge students' existing knowledge, attitudes, and competencies, prompting them to identify their learning needs and explore new areas of learning. Self-directed learning is emphasised, and students are encouraged to utilise diverse sources of knowledge, apply that knowledge, and evaluate information sources. (Rusman, 2013) In addition, the PBL model follows a specific syntax which includes problem orientation, organising students for learning, guiding individuals/groups, developing and presenting the work outcomes, and analysing and evaluating the problem-solving process (Arends, 2013). According to Sanjaya (2011), the PBL model has several advantages. Firstly, problem-solving is an effective technique for better understanding the subject matter. Secondly, it challenges students' abilities and provides satisfaction in discovering new knowledge. Thirdly, it enhances learning activity. Fourthly, it helps students understand real-life problems. Lastly, it assists students in developing new knowledge, taking responsibility for their learning, and encourages self-evaluation of the learning process and outcomes.

Critical thinking is defined by Dewey as "the process by which an individual actively and continuously considers a belief or accepted body of knowledge in light of reasons that support rational conclusions" (Sihotang, 2012). Critical thinking is a procedure for arriving at rational conclusions regarding what to believe and do, according to Ennis (1996). First, you need to be able to clearly state the issue, problem, decision, or activity you're thinking about. Then, you need to state your point of view. Then, you need to propose reasons that are well-founded and supported by trustworthy and relevant information. After that, you need to evaluate assumptions. Then, you need to use clear language. Finally, you need to provide reasoning that is based on convincing evidence. Finally, you need to offer conclusions and think about the implications of those conclusions. According to Johnson (2007), these are the stages that make up Ruggiero's critical thinking process.

The PBL model aims to develop students' critical thinking, analysis, systematic thinking, and logical reasoning abilities to determine alternative problem-solving through empirical data exploration (Suyanti, 2010). The following illustrates the relationship between the syntax of the PBL model and critical thinking skills:

Table 1. The relationship between the syntax of the PBL and critical thinking skills

The syntax of the PBL model		Aspects of Critical Thinking Ability	Indicators of Critical Thinking Ability
1. Problem orientation	-	Giving concise explanation	- Focusing questions
2. Organising students for learning	-	Giving concise explanation	- Focusing questions - Analysing statements - Asking and answering questions - Conforming the information source - Deducing and considering the deduction results
3. Guiding individual and group investigations	- -	Developing basic skills Strategies and tactics	- Considering the credibility of certain sources - Reviewing and considering the observation reports - Defining an action - Interacting with others
4. Developing and presenting students' work	- -	Concluding Making follow-up explanation	- Deducing and considering the deduction results

		-	Strategies and tactics	-	Inducing and considering the induction results
				-	Making and determining judgment values
				-	Defining an action
				-	Interacting with others
5.	Analysing and evaluating the problem-solving process	- -	Concluding Strategies and tactics	- -	Inducing and considering the induction results Defining an action

This study aims to provide information on students' achievement in critical thinking by implementing the Problem-Based Learning (PBL) model in geometry subjects. Therefore, the research question of this study is how students' achievement in critical thinking occurs through the implementation of the Problem-Based Learning (PBL) model in geometry subjects. Theoretically, this research is expected to develop learning models and provide practical benefits in enhancing the effectiveness of teaching and learning processes, specifically in promoting students' critical thinking skills.

2.   METHODS

This study employs a descriptive analysis method to describe or depict natural or human-engineered phenomena (Sukmadinata, 2011). The analysis used in this study is quantitative descriptive analysis, which provides a representation using measures, numbers, or frequencies to obtain research findings that can be recommended to improve the quality of the learning process. In this study, the aspect to be examined is critical thinking skills. The research subjects consist of 40 students from the Primary School Teacher Education Program, specifically in geometry and social arithmetic. The students are grouped into three categories: high, medium, and low, based on the standard deviation derived from the students' test results. The data collection process in this study involved several steps. In the preparation phase, the researchers analyzed the subject matter and developed research instruments, i.e., tests and observation sheets. The students were divided into groups during the implementation phase, which consisted of multiple sessions. The student's critical thinking skills were tested and observed to assess their capacity. In the completion phase, the researchers processed and analysed the collected data, discussed the research findings, drew conclusions, and potentially made recommendations based on the results. The data were analyzed using quantitative descriptive analysis techniques.

3.   FINDINGS AND DISCUSSION

The objective of this study is to measure students' critical thinking skills through the implementation of the Problem-Based Learning (PBL) model in the subject of geometry. The research findings were obtained from the data collected through critical thinking skills tests and additional data gathered through observation and interviews to capture certain indicators that cannot be measured solely through tests. The learning process through the PBL model consists of five stages: problem orientation, organizing students for learning, guiding individual or group investigations, developing and presenting work outcomes, and analyzing and evaluating the problem-solving process. The PBL model is effective in assessing students' critical thinking skills. Critical thinking skills have five aspects: elementary clarification, basic support, inference, advanced clarification, and strategies and tactics. These aspects encompass the ability to provide simple explanations, build foundational skills, draw conclusions, provide further explanations, and employ strategic and tactical thinking in problem-solving situations.

There are twelve indicators of critical thinking skills examined in this study, namely: focusing questions, analysing questions, asking and answering questions, considering source credibility,

observing and considering observational reports, deducing and considering deductive results, inducing and considering inductive results, making and determining value judgments, defining terms and definitions, identifying assumptions, determining courses of action, and interacting with others.

The data in this study were obtained from various sources. Firstly, critical thinking skills were assessed using essay-type tests, which measured indicators such as focusing questions, analyzing statements, asking and answering questions, considering source credibility, deducing and considering deductive results, inducing and considering inductive results, making and determining value judgments, defining terms and definitions, identifying assumptions, and determining courses of action. Secondly, direct observations conducted by observers provided data on two additional indicators that cannot be measured through tests: observing and considering observational reports, and interacting with others. Lastly, interviews were conducted with students representing the groups to gather data on their responses to learning with the PBL model. These interview data, test, and observation data were used to strengthen the analysis of students' critical thinking skills through the PBL learning model.

3.1 Students' critical thinking skills based on critical thinking tests results

A test was conducted to measure students' critical thinking skills after the learning process using the PBL model. The test was open-ended questions consisting of 12 items representing ten critical thinking skills indicators. The overall results of the critical thinking skills achievement for 40 students across the ten indicators are presented in Table 2.

Table 2. Students' Critical Thinking Skills Based on Test Results

No	Indicators of critical thinking skills	Mean	Categories
1	Focusing questions	77.77	Good
2	Analysing statements	76.39	Good
3	Asking and answering questions	51.83	Moderate
4	Conforming the information source	81.79	Very good
5	Deducing and considering the deduction results	84.58	Very good
6	Inducing and considering the induction results	81.30	Very good
7	Making and determining judgment values	84.09	Very good
8	Defining terms and definitions of consideration	86.03	Very good
9	Identifying assumptions	54.46	Moderate
10	Defining an action	81.79	Very good

The table above shows that of the ten indicators, there are six indicators in the very good category, two indicators in the good category, and two in the moderate category. The indicators in the very good category consist of conforming the information sources by reviewing whether the source can be trusted or not (81.79%), deducing and considering deduction results (84.58%), inducing and considering the induction results (81.30%), making and determining judgment values (84.09%), defining terms and definitions of considerations (86.03%), and defining actions (81.79%). The indicators with the moderate category fall in the indicator of asking and answering questions (51.83%), and identifying assumptions (54.46%).

3.2 Students' critical thinking skills based on observation

The observed results of critical thinking skills during the PBL-based learning process are presented using the discussion method to solve problems through student worksheets and geometry material presentations. The assessment of the learning process observation was conducted using an observation sheet. The observed indicators in this observation sheet included observing and considering the results

of observation reports and interacting with others. The observations on this sheet were carried out by two observers, who were provided with guidance to assess these two indicators during the learning process. The observations were conducted on a total of 40 students divided into 8 groups, with each group comprising 5 students. The average data reflecting the achievement of critical thinking skills based on the observations are presented in Table 3.

Table 3. Students' critical thinking skills based on observation results

No	critical thinking skills	Mean	Categories
1	Reviewing and considering the observation reports	82.94	Very Good
2	Interacting with others	77.98	Good
	Mean	82.64	Very Good

Table 3 shows that the mean results of critical thinking skills based on the observations results of indicators can be categorized as very good and good. The indicator in the very good category is reviewing and considering the observation reports (82.94%), while interacting with others (77.98%) is in the good category.

The results of critical thinking skills for all indicators based on students' groups is presented in Table 4. Table 4 indicates the overall average achievement of critical thinking skills indicators based on the students' positions in different groups. The average achievement of critical thinking skills in the high group is 83.16%, categorized as very good. The average achievement in the moderate group is 76.40%, categorized as good. Meanwhile, the average achievement in the low group is 72.08%, as good category.

Table 4. Critical thinking skills for all indicators based on students' groups

No	Indicators of critical thinking skills	High		Medium		Low	
		Score (%)	Category	Score (%)	Category	Score (%)	Category
1	Focusing questions	86.54	Very Good	74.27	Good	72.50	Good
2	Analysing statements	82.69	Very Good	76.47	Good	70.00	Good
3	Asking and answering questions	63.46	Good	47.05	Moderate	45.00	Moderate
4	Conforming the information source	86.54	Very Good	83.82	Very Good	75.00	Good
5	Deducing and considering the deduction results	88.46	Very Good	82.29	Very Good	80.00	Good
6	Inducing and considering the induction results	86.54	Very Good	82.35	Very Good	75.00	Good

7	Making and determining judgment values	88.46	Very Good	83.82	Very Good	80.00	Good
8	Defining terms and definitions of consideration	90.30	Very Good	85.29	Very Good	82.50	Very Good
9	Identifying assumptions	63.38	Good	50.00	Moderate	50.00	Moderate
10	Defining an action	86.54	Very Good	83.82	Very Good	75.00	Good
11	Reviewing and considering the observation reports	86.54	Very Good	82.29	Very Good	80.00	Good
12	Interacting with others	88.46	Very Good	85.29	Very Good	80.00	Good
	Mean	83.16	Very Good	Very Good	Good	72.08	Good

Discussion

Based on the data analysis of the indicators based on the test results, the achievement of critical thinking skills in the first indicator, which focuses on questions, is as follows: for the high group, it is 86.54% categorized as very good, for the medium group, it is 74.27% categorized as good, and for the low group, it is 72.50% categorized as moderate, respectively. There are variations in the scores among the different groups, with the low group having the lowest percentage compared to the high and medium groups. In the test analysis, students were able to identify questions or problems present in the questions. According to Schafersman, critical thinkers can ask appropriate questions, gather relevant information, act efficiently and creatively based on the information, and draw reliable conclusions (Sadia, 2008). Based on this statement, students who think critically are those who can identify a problem and formulate a question based on the given problem. It can be concluded that all students can focus on questions with at least a good category. For the second indicator of analyzing questions, the high group, 82.69%, was categorized as very good. The medium group is 76.47% categorized as good, and 70.00% of the low group is also categorized as good. This means that students are able to analyze statements effectively.

63.46% of the third indication for asking and answering questions in the high category is classified as good. The medium group represents 47.05% and falls into the moderate category, while the low group accounts for 45.00% and is classified as fair. Students typically fall into the average group when it comes to asking and answering questions. During the test analysis, pupils seemed to have difficulty with formulating and responding to questions in the provided prompts. The pupils' comments did not effectively explain the purpose of a certain question. According to the interview findings, pupils appeared perplexed when attempting to define a question. Only a small number of students from the high-achieving group accurately articulated the purpose of the query. Only a small number of pupils were actively participating in the learning process by asking and answering questions presented by the teacher. While some students possessed ideas or viewpoints, they lacked the assurance to articulate them verbally.

The fourth indicator is confirming the information sources by determining whether a source can be trusted. In the problem-based learning process, lecturers perform the role of a facilitator, guiding and directing the discussion process undertaken by students. Students must collect information and evaluate the reliability of pertinent hypotheses in order to address a problem. The professor guides and supports students in the learning process, while students actively gain knowledge and critically assess

the reliability of theories. This method promotes the enhancement of students' problem-solving abilities and stimulates the utilisation of critical thinking in their educational progress. The high and medium groups show great average accomplishment in evaluating the credibility of sources, with percentages of 86.54% and 83.82%, respectively. The low group attained a favourable outcome of 75.00%. On average, students demonstrated effective understanding of source credibility based on the test analysis results.

For the fifth indicator of deducing and considering the results of deductions, the high and medium groups achieved very good results with percentages of 88.46% and 82.29%, respectively, while the low group gained a good result of 80.00%. Based on the data from the test analysis, students in all groups performed at least at a good level in interpreting statements or drawing conclusions from general to specific (deduction). According to existing theories, drawing conclusions is humans' mental activity based on their understanding (truth), which can lead to new understanding/knowledge. The human thought process can take two approaches: deduction and induction (Depdiknas, 2009). Based on the interview results, all groups of students did not encounter difficulties in concluding given statements. During the learning process, students were also trained to discuss and summarize the results of their discussions.

In the sixth indicator of inducing and considering the induction results, the high and medium groups achieved very good results, with percentages of 86.54% and 82.35%, respectively, while the low group attained a good result of 75%. Based on the data from the test analysis, with the problem-based learning model accompanied by the discussion and presentation methods, students were able to draw conclusions from the material effectively. Critical thinking theory involves active, continuous, and careful consideration of beliefs or accepted forms of knowledge, including supporting reasons and rational conclusions (Sihotang, 2012). This statement suggests that critical-thinking students can draw rational conclusions from given problems by providing supporting reasons. Based on the interview results, all groups of students did not encounter difficulties in concluding the material. This indicates that the PBL learning model can develop students' critical thinking.

The seventh indicator of making judgments and determining the value of considerations refers to the ability to summarize conclusions from one or multiple premises. The process involves testing the relationship between several statements or data (Depdiknas, 2009). The skill of making judgments and determining the value of considerations for students in the high and medium groups obtained percentages of 88.46% and 83.82%, respectively, while the low group achieved a good result of 80%. In the test analysis, all students were able to make judgments and determine the value of considerations. This is consistent with the interview results, where several students did not find it difficult to determine considerations.

The eighth indicator of defining terms and the definition of considerations among the high, medium, and low groups achieved very good results, with percentages of 90.30%, 85.29%, and 82.50%, respectively. Based on the data from the test analysis, on average, students were able to define terms and provide definitions of considerations. This is also supported by the interview results, which showed that, on average, students did not have difficulties in defining terms and explaining the material. The students engage in the PBL process while testing their thinking, questioning, critiquing their ideas, and exploring new things (Taufiq, 2010).

The ninth indicator of identifying assumptions for the high group is moderate, with 63.38%, while the medium and low groups are moderate with 50.00% for each. The test data shows that some students cannot identify assumptions effectively. This is in line with the interview results, which indicate that, students are struggling in identifying assumptions. Each student's reasoning ability differs, resulting in different thought outcomes. Reasoning is a thinking process that produces a conclusion. During the thinking process, individuals can be influenced by subjective and objective factors. This is why different understandings of the phenomenon can lead to different conclusions (Taufiq, 2010). This aligns with the theory that PBL is an approach to learning that uses real-world problems as the context for students to learn problem-solving skills (Khoiri, 2013).

In the tenth indicator of determining a course of action, the high and medium groups are very good, with 86.54% and 83.82%, respectively, while the low group achieved a good result of 75.00%. Based on the data from the test analysis, on average, students were able to determine a course of action to seek solutions to a problem effectively. Learning from real-life problems enables students to think critically. Students who are trained in PBL learning will find it easier to find solutions to problems. This aligns with the theory that PBL is an approach to learning that uses real-world problems as the context for students to learn problem-solving skills (Khoiri, 2013). Based on the interview data, students seems to be able to determine a course of action with at least a good category.

The eleventh indicator for evaluating and analysing observation outcomes across all student groups is excellent. The high group achieved 86.54%, the medium group achieved 82.29%, and the poor group achieved 80.00%. Based on direct observation data, all student groups, including the high, middle, and low groups, actively engaged in group discussions to solve geometry issues. It supports the idea that problem-based learning is beneficial for students in developing critical thinking, problem-solving, and intellectual abilities (Kusumaningtias, 2013). Nuryanti et al. (2018) demonstrated that learning experiences failing to optimise students' cognitive abilities could lead to restricted development of critical thinking skills. Furthermore, Karim and Normaya (2015) showed that to build students' critical thinking abilities, the instructional paradigm should encourage interactive student interaction, with the teacher acting as a facilitator. One educational model that has been recognized for its capacity to promote critical thinking skills.

The twelfth indicator of the skill of interacting with others for the high and medium groups is categorized as very good, with 88.46% and 85.29%, respectively, while the low group achieved a good result of 80.00%. Based on the test analysis, on average, students were able to engage in discussions effectively, although only a few were actively asking and answering questions posed by the teacher. Active participation of students in the learning process can eliminate feelings of boredom and cultivate a sense of enjoyment in learning, ultimately leading to increased motivation (Susilo, 2012). The high and medium groups were very active in interacting with their peers. Meanwhile, the low group was able to interact with their peers effectively, which is consistent with the interview results of several students.

The PBL learning process supported by the discussion and presentation methods has been successful. The advantage of the discussion method is that it trains students to think critically and systematically, be open-minded, and learn to respect the opinions of others (Zulfiani, 2009). In the first stage of the learning process, problem orientation, students actively solve the given geometry problems by engaging in group discussions to find solutions in their worksheets. Most students actively ask and answer questions from the teacher, while others who are less active in asking questions may lack confidence to ask directly to the teacher. Additionally, some students find it difficult to express their opinions to their group members. In the second stage, organising students for learning, students work together with their groupmates to gather information about theories related to the given problem.

Most students search for information regarding the geometry problem, including looking for information online. In the third stage, guiding individual and group investigations, students collaborate to solve the geometry problems. In the fourth stage, developing and presenting their work, students are required to present the results of their group discussions, with each group creating a report on their discussion outcomes. In the fifth stage, analysing and evaluating the problem-solving process, students engage in discussions to answer questions in their worksheets and summarize the outcomes of their discussions. Based on the average achievement data of all critical thinking skills indicators through the PBL model, the overall score is 77.21%, categorized as good. Two indicators scored moderate: the indicator of asking and answering questions and identifying assumptions. The factors contributing to both indicators are that students have not fully utilised their abilities and interactions during the discussions to optimize problem-solving. However, overall, the PBL learning model creates an active atmosphere and fosters the development of student's critical thinking skills.

4. CONCLUSION

Based on the research findings, it can be concluded that overall, students' critical thinking skills, as assessed through tests and observations, are considered good in the high, medium, and low groups. This is evident from the average percentages of 83.16% for the high group, 76.40% for the medium group, and 72.08% for the low group, respectively. This can be attributed to the active role of students in the problem-based learning approach. Two indicators scored moderately in the high, medium, and low groups, i.e., asking and answering questions and identifying assumptions. This may be due to students lacking confidence in dealing with challenging geometry concepts. These results strongly recommend that teachers develop or integrate the PBL model in their learning process to enhance students' higher-order thinking skills, such as critical thinking, creativity, and scientific reasoning abilities. By incorporating problem-based learning, students can gain more confidence in tackling complex geometry concepts and improve their overall performance in these areas. Additionally, providing opportunities for students to practice asking and answering questions and identifying assumptions can further enhance their skills in these areas.

Conflicts of Interest: the authors declare no conflict of interest.

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