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USING QUESTIONS AIMED AT CRITICAL THINKING AND PROBLEM-SOLVING IN SCHOOL MATHEMATICS LESSONS

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Critical thinking, problem-solving, logical questions, numerical reasoning, mathematics education, students.

ANNOTATION

In this article, methods for making school mathematics lessons more useful, easier to understand, and more engaging for students are discussed. For this purpose, the questions and tasks used in school mathematics classes to develop students' critical thinking skills and to form problem-solving abilities for complex problems are classified. Special attention is given to logical numerical questions that require reasoning, analysis, and justification rather than simple calculation. Examples of questions from each group and their solution methods are provided. In addition, the presented types of questions and problems are also categorized according to students' age groups. At the end of the article, techniques for constructing questions aimed at developing critical thinking and problem-solving skills are also demonstrated.

Introduction. Today, ensuring that young people receive quality education and, as a result, increasing the number of specialists who are beneficial to the country in all respects is considered one of the highest priorities of all countries in the world. Achieving this goal begins, first of all, with reforming school education. The attention given to mathematics by our state is reflected primarily in the school education system. In teaching mathematics, research is being conducted on the use of various modern methods during lessons in order to move away from uniformity and to bring students to a level where they can think broadly and apply the concepts they have learned to real life. One such approach is the use of questions aimed at enhancing critical thinking in mathematics lessons.

The term "critical thinking" first emerged in the second half of the twentieth century, and numerous definitions have been proposed. For example, according to Ennis, "critical thinking is the intellectually disciplined process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered or generated through observation, experience, reflection, reasoning, learning, or communication, which guides belief and action." In this context, Ennis also notes that when critical thinking is applied in the educational process, it improves students' cognitive activity and helps them understand and assimilate texts in different ways. According to Halpern, critical thinking primarily includes learning skills such as problem solving, calculation, and the effective use of probabilities.

In contemporary higher education, the development of critical thinking and problem-solving skills is considered a fundamental goal of mathematics instruction. Mathematics is not limited to formulas and procedures; it is a discipline that develops logical reasoning, analytical thinking, and decision-making skills. However, traditional mathematics teaching often emphasizes routine exercises and mechanical calculations. Such an approach may limit students' ability to think independently and solve non-standard problems. One effective way to address this challenge is the use of well-structured questions aimed at critical thinking and problem-solving. Questions that involve numerical logic, reasoning, and justification encourage students to analyze relationships between numbers, identify patterns, and explain their thought processes. Therefore, integrating logical numerical questions into mathematics lessons is essential for improving the quality of student learning.

The purpose of this article is to examine the effectiveness of questions aimed at critical thinking and problem-solving in mathematics lessons for students, with a focus on numerical logic questions.

Literature analysis. In recent years, the development of students' critical thinking and problem-solving skills has been regarded as one of the priority tasks in the education system. In particular, questioning strategies in school mathematics lessons serve as an important didactic tool for forming these competencies. The role of questions aimed at developing higher-order thinking in mathematics education has been extensively covered in scientific literature.

The cognitive taxonomy proposed by Bloom serves as a basis for categorizing questions into levels in the educational process[1]. According to this taxonomy, questions directed toward analysis, synthesis, and evaluation contribute to developing students' critical thinking. Later, Anderson and Krathwohl revised Bloom's taxonomy, adapting it to modern educational needs[2].

One of the main reasons for the negative attitude towards mathematics as a subject—that is, the perception of it as boring, difficult, and merely calculation-focused—is the monotony in school mathematics lessons. We know that in mathematics lessons, the board, chalk, and notebook are often the only three elements used repetitively. For students who are already interested in mathematics and have entered its fascinating world, there might be nothing more engaging than these tools. However, for children who are just beginning to engage with mathematics or who have lower levels of understanding, this repetition becomes extremely dull and monotonous. In such situations, providing interesting math tasks, practical applications, and visually demonstrating how mathematical concepts are used in daily life can be highly beneficial.

In the field of mathematics education, Polya emphasizes the importance of using questions during the problem-solving process. He demonstrates that questions posed by the teacher during the stages of understanding the problem, planning, implementing the solution, and checking the result encourage students' independent thinking[3].

Hiebert and Carpenter substantiated the significance of open-ended questions in the deep assimilation of mathematical concepts. According to their research, questions that do not have a single correct answer and require explanation develop students' logical thinking and reasoning skills[4]. Furthermore, Stein and Smith proved

[1] Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain.* New York, NY: Longman.
[2] Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman.
[3] Polya, G. (1945). *How to solve it: A new aspect of mathematical method.* Princeton, NJ: Princeton University Press.
[4] Hiebert, J., & Carpenter, T. P. (1992). Learning and teaching with understanding. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 65–97). New York, NY: Macmillan

that questions requiring high cognitive demand enhance the quality of mathematical activity[5].

Recent empirical studies also confirm that questions aimed at critical thinking in mathematics lessons positively affect students' success in problem-solving. Boaler's research notes that teaching through questions based on problematic situations increases students' mathematical thinking and interest in the subject[6].

In conclusion, the analyzed literature shows that the effective use of questions aimed at critical thinking and problem-solving in school mathematics lessons is a significant pedagogical factor in forming students' higher-order thinking competencies. Therefore, this topic holds current scientific and practical importance for modern mathematics education.

Research methodology. Creating an environment for the development of critical thinking is neither a quick nor an easy process. First of all, it is necessary to provide certain conditions for learners. Giving students sufficient time and opportunities to think, being able to accept any ideas they express, ensuring the active participation of every student, fostering self-confidence within the group so that they feel free to voice their opinions, and emphasizing that no idea is inherently wrong—all of these help create a foundation for active engagement and ensure a dynamic critical thinking process.

In this context, students gain the opportunity to participate actively in lessons by expressing their own views, listening to the opinions of others, exchanging ideas, and analyzing through discussion whether those ideas are correct or incorrect.

This study is based on qualitative analysis of student-centered mathematics teaching practices. The following methods were employed: Analysis of pedagogical and methodological literature related to critical thinking; Observation of mathematics lessons that incorporate logical questioning; Examination of numerical logic questions used in classroom activities. The focus was placed on questions that require explanation, justification, comparison, and multiple solution strategies[7].

Examples of Logical Numerical Questions Used in Mathematics Lessons

Example 1. Pattern Recognition

Consider the sequence:

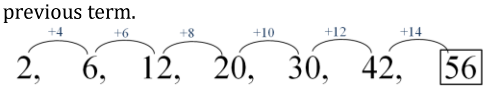
2, 6, 12, 20, 30, 42 ?

What is the next number?

Explain the rule used to generate the sequence.

Educational value: Develops pattern recognition and logical reasoning.

Solution. If we pay attention to the sequence, the first number is 2, and adding 4 results in the second number, which is 6. Adding 6 to the second number results in the third number, 12. Adding 8 to the third number results in 20. Therefore, to find the next term in the sequence, consecutive even numbers starting from 4 are added to the previous term.



From this, it follows that the number coming after 42 is 56.

Problems of the type mentioned above hold significant pedagogical value for students and play an important role in their intellectual development. First and foremost, these problems help develop skills in logical thinking and pattern recognition. While trying to identify the relationship between the given numbers, the student engages not only in calculation but also in processes of analysis, comparison, and generalization.

Furthermore, such problems foster critical thinking. The student tests several possible rules, discards incorrect assumptions, and selects the most logical solution. This process strengthens independent decision-making skills. By continuing the sequence, students begin to grasp elements of abstract thinking, as they transition from specific numbers to a general rule.

In addition, tasks of this kind enhance problem-solving competence. The student learns to solve a problem step by step, to develop a logical plan, and to justify the result. This increases interest in the subject of mathematics and strengthens the student's self-confidence. As a result, such problems not only deepen mathematical knowledge but also elevate students' general intellectual culture.

Results. Based on the analyses above and the results of conducted research, questions that strengthen students' critical thinking in mathematics lessons have been categorized into the following main types:

1. Questions Related to Supporting a Claim and Justification. This type of question develops students' skills in logical justification, proving, and argumentation. The student is required not only to give an answer but also to explain why that specific answer is correct. As a result, they learn to articulate their thoughts clearly, coherently, and logically.

Such questions strengthen students' critical thinking because they go through the process of evaluating a given claim, selecting evidence, and applying it appropriately. At the same time, students also learn to distinguish between incorrect or insufficient evidence.

In mathematics lessons, proof-based questions help form students' theoretical and abstract thinking. This creates a solid foundation for them to master more complex mathematical concepts later. Additionally, students learn to approach their ideas responsibly and to be able to defend them.

Here is an example of a question related to supporting a claim and justifying an argument:

Problem 1. Scientists advise drivers not to exceed a speed of 70 km/h.

Which of the following strengthens the scientists' argument?

A) The speed of cars should depend on the year they were manufactured.

B) Cars that travel faster than 70 km/h are more expensive than others.

C) Drivers who exceed the speed limit are often fined.

D) Most car accidents involve automobiles traveling at speeds higher than 70 km/h.

Solution of the Problem 1. The problem presents the idea that scientists advise drivers not to exceed a speed of 70 km/h. The question asks which answer choice strengthens this argument, i.e., shows that the scientific recommendation is justified.

Let's analyze the options logically:

A) The speed of cars should depend on the year they were manufactured.
This statement relates to the technical characteristics of cars and does not directly provide evidence for the safety or danger of traveling at 70 km/h. Therefore, it does not strengthen the scientists' argument.

B) Cars that travel faster than 70 km/h are more expensive than others.
There is no logical connection between the price of a car and a speed limit. This point is not relevant to safety or the scientific recommendation.

C) Drivers who exceed the speed limit are often fined. Fines are a legal consequence, but this fact does not scientifically explain why speed is specifically dangerous. Hence, this option is also not sufficient evidence.

D) Most car accidents involve automobiles traveling at speeds higher than 70 km/h. This option directly strengthens the scientists' argument because it shows that when speed increases, road accidents become more frequent. Therefore, staying below 70 km/h helps ensure safety.

Correct answer: Option D.
This answer supports the scientists' recommendation by grounding it in real statistical data, thereby strengthening their argument in a logical and credible way.

2. Problematic Questions Related to Sets. Questions involving sets develop students' analytical thinking and structural reasoning. These questions require mental operations such as identifying relationships between elements and distinguishing common and different characteristics. As a result, the student acquires skills in organizing and systematizing complex information. The topic of sets helps students deeply understand logical operations (union, intersection, difference). This enhances their ability to understand cause-and-effect relationships. Furthermore, such questions develop students' skills in classification and modeling. This type of question also develops formal thinking, which is important not only

[5] Stein, M. K., & Smith, M. S. (1998). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School*, 3(4), 268–275.

[6] Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. San Francisco, CA: Jossey-Bass.

[7] Mirjonov, Y., & Qutimov, J. (2021). *You are a leader* (Educational manual) [*Siz Lidersiz* (O'quv qo'llanma)]. Tashkent: QAMAR MEDIA. [In Uzbek]

for mathematics but also for subjects like computer science and logic. The student learns to define concepts precisely, apply conditions correctly, and draw conclusions. This holds significant importance in their intellectual development.

3. Questions Related to Necessary and Sufficient Conditions. Questions concerning necessary and sufficient conditions develop students' deep logical reasoning. These questions require the student to understand the precise connection between a condition and a conclusion. As a result, they learn to determine which conditions are essential and which are secondary. Such questions develop the skill of analyzing causality. By distinguishing which conditions are necessary and which are sufficient to achieve a certain outcome, the student conducts in-depth analysis. This process helps prevent incorrect generalizations.

Moreover, this type of question assists students in mastering elements of formal logic. This is crucial for understanding proofs, theorems, and the essence of properties. Consequently, students begin to reason in accordance with the requirements of precision and rigor inherent in mathematical thought.

4. Questions Aimed at Identifying Logical Errors. Questions focused on identifying logical errors significantly increase students' ability to critically analyze. While checking a given solution or reasoning, the student actively participates in the process of finding the error, explaining its cause, and proposing the correct solution.

This type of question fosters reflective thinking in students, i.e., the ability to review their own and others' thoughts. As a result, students learn to evaluate any solution rather than accepting it automatically.

Furthermore, by identifying logical errors, students develop attentiveness and precision. This is extremely important in mathematical proofs, problem-solving, and using formulas. Such questions strengthen students' independent thinking and foster a culture of learning from mistakes.

5. Questions Aimed at Determining the Validity (True or False) of Statements. Questions aimed at determining validity (true or false) develop students' skills in evaluation and verification. Before accepting a given statement, the student analyzes its foundations, provides counterexamples, or finds supporting evidence.

This type of question fosters logical caution, as students learn to avoid incorrect generalizations and hasty conclusions. Additionally, they become accustomed to drawing conclusions based on precise definitions of mathematical concepts.

As a result, students' ability for critical evaluation is strengthened. This skill is important not only in mathematics lessons but also in analyzing information and making correct decisions in daily life.

6. Questions Aimed at Finding a Similar Principle. Questions aimed at identifying a similar principle develop students' analogical thinking. The student tries to compare one problem or pattern with another situation to identify the common idea between them.

Such questions develop skills in generalization and transfer, meaning the student learns to apply acquired knowledge in new situations. This leads to the formation of deep and lasting knowledge.

Discussion. The results of this research show that systematically developed question types play a significant role in strengthening students' critical thinking skills in mathematics lessons. Categorizing questions into six main types demonstrates that critical thinking in mathematics is not a single skill, but rather a complex construct composed of reasoning, analysis, evaluation, and argumentation.

Below, we will provide examples of problems belonging to each type, and discuss their solutions and methods of solving them.

Problem 2. In our village, all the farmers who grow wheat also grow rice. But none of those who grow rice grow cabbage.

Which of the following is correct?

A If our neighbor Asad grows wheat, he also grows cabbage.

B If the farmer Sobir grows rice, he definitely grows wheat.

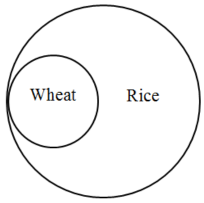
C If Karim grows wheat, he does not grow cabbage.

D If my father grows wheat, he also grows rice and cabbage.

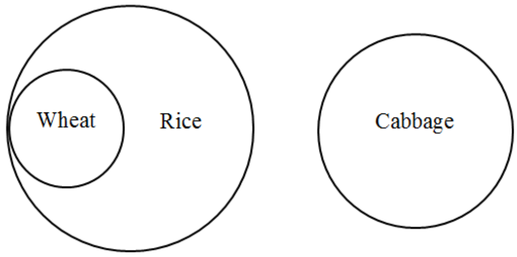
Solution of the Problem 2. Here three sets are given: 1) those who grow wheat; 2) those who grow rice; 3) those who grow cabbage.

Let's separate the given statements:

1) All farmers who grow wheat also grow rice.



2) None of those who grow rice grow cabbage.



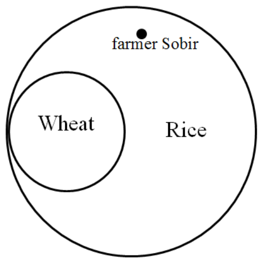
Now let's analyze whether each given answer is correct or incorrect.

A) If our neighbor Asad grows wheat, he also grows cabbage.

This is incorrect. Looking at the sets of those who grow wheat and those who grow cabbage, they do not intersect. This means no farmer who grows wheat grows cabbage.

B) If the farmer Sobir grows rice, he definitely grows wheat.

This is incorrect. The sets of those who grow rice and those who grow wheat intersect. However, we cannot assume that everyone who grows rice also grows wheat. In the diagram, this person could be located only in the area of those who grow rice.



C) If Karim grows wheat, he does not grow cabbage. This is correct. Looking at the set diagrams, the sets of those who grow wheat and those who grow cabbage do not intersect. That is, a person who grows wheat does not grow cabbage.

D) If my father grows wheat, he also grows rice and cabbage. This is incorrect. Looking at the set diagram, all farmers who grow wheat also grow rice. However, none of them grow cabbage, because the sets do not intersect.

Therefore, answer is C.

Problem 3. Tasks must be carried out according to a plan. Only tasks performed based on a thorough plan are executed perfectly.

What conclusion can be drawn from the above statement?

A) Tasks carried out without planning will have shortcomings.
B) To complete tasks on time, it is necessary to make a plan.
C) All tasks carried out based on a thorough plan are executed perfectly.
D) There are tasks that can be completed in less time than the planned period.

Solution of Problem 3. This question tests the ability to derive a valid logical conclusion from a stated conditional relationship, focusing on necessary and sufficient conditions.

The premise consists of two statements: "Tasks must be carried out according to a plan." (A general recommendation, but not strictly conditional in a logical sense). "Only tasks performed based on a thorough plan are executed perfectly." The second statement is the core logical rule. It can be rephrased as:

If a task is executed perfectly (P), then it must have been performed based on a thorough plan (Q). Formally: $P \rightarrow Q$ (Perfect execution implies a thorough plan). P (Perfect execution) is the sufficient condition. Q (Thorough plan) is the necessary condition. This means that perfect execution guarantees the existence of a thorough plan.

However, having a thorough plan does not guarantee perfect execution (other factors could interfere). The statement says "only" thorough plans can lead to perfect results, not that they always do.

A) Tasks carried out without planning will have shortcomings. This is the contrapositive of the core rule and is logically valid. The rule states: Perfect Execution → Thorough Plan (P → Q). The contrapositive is: No Thorough Plan → No Perfect Execution (not-Q → not-P). If a task lacks a thorough plan ("without planning"), it cannot be executed perfectly, meaning it must have some shortcoming or imperfection. This follows directly and necessarily from the premise. Verdict: Correct.

B) To complete tasks on time, it is necessary to make a plan. The premise is about perfect execution, not about timely completion. "On time" is a new concept not mentioned or implied in the given statements. This conclusion introduces an external element and cannot be logically derived.Verdict: Incorrect.

C) All tasks carried out based on a thorough plan are executed perfectly. This commits the logical fallacy of affirming the consequent or confusing necessity with sufficiency. Our rule is P → Q (Perfect → Thorough Plan). This option states Q → P (Thorough Plan → Perfect). The premise states that a thorough plan is a requirement for perfection, not a guarantee of it. It is a necessary condition, not a sufficient one. Verdict: Incorrect.

D) There are tasks that can be completed in less time than the planned period. This introduces the concept of time efficiency, which is completely unrelated to the premise's focus on perfection of execution based on planning. No information about time vs. planned duration is provided or implied. Verdict: Incorrect.

The correct answer is A. This question reinforces the understanding of conditional logic by requiring the identification of a valid inference—specifically, the contrapositive.

Problem 4. Salima: "Students who study at Presidential Schools are very skilled at critical thinking. Therefore, a student's critical thinking ability must develop very well at Presidential Schools."

Which of the following indicates the flaw in Salima's reasoning?

A) At Presidential Schools, foreign teachers teach.

B) At Presidential Schools, low-achieving students learn from high-achieving students.

C) Students with strong critical thinking abilities are admitted to Presidential Schools.

D) At Presidential Schools, special subjects aimed at developing critical thinking are taught.

Solution of Problem 4. Salima thinks that studying at a Presidential School develops students' critical thinking ability. However, in reality, what if students with strong critical thinking abilities are admitted to Presidential Schools? That is, studying at this school may not be the cause of developing the student's ability; on the contrary, the student's strong critical thinking ability may be the reason for their admission to this school. Answer C precisely indicates this logical error.

There may be several conditions necessary to reach a conclusion in an argument, but any one of them alone may not be sufficient for the entire event to occur. When an author makes a logical error, they often mistakenly consider one condition necessary for an event as sufficient for the entire event to happen.

The following argument illustrates such an issue:

“If a baby is hungry, it starts crying. The baby is crying. Therefore, it is hungry.”

This reasoning is flawed. Being hungry is one of the reasons a baby cries. However, the baby crying is not fully sufficient to conclude that it is hungry. This is because the baby might be crying for other reasons. For example, a baby also cries if it is in pain somewhere or if it is cold.

Problem 5. Donyor waters the flowers deliberately every day. However, the plant does not require much water and grows better in drier soil, so frequent watering destroys the plant. Therefore, Donyor destroyed the plant intentionally.

Which of the following is based on a reasoning principle similar to the flawed reasoning method presented in the argument above?

A) Bek stole 1000 soums from Kumush and bet on one team in a football match. In this football match, Bek won 10,000 soums. Therefore, Bek stole 10,000 soums from Kumush.

B) Sayyora knows that coffee is grown in the mountains of Peru and that Peru is in South America. Therefore, Sayyora must know that coffee is grown in South America.

C) The restaurant owner decided to remove a certain dish from the restaurant's menu. This decision upset Jasmina because that dish was her favorite. Therefore, the restaurant owner intended to upset Jasmina.

D) Heavy rain caused the dam to break, and the bursting of the dam resulted in the fields being flooded. Therefore, the heavy rain caused the fields to be flooded.

Solution of Problem 5. Flowers require little water and grow well in drier soil. Donyor deliberately destroyed the flowers by watering them frequently, it is claimed. But did Donyor know in advance that frequent watering is harmful? Why are we concluding that he did it intentionally? After all, we have no basis for this. This is precisely the flawed reasoning in the argument.

A very similar line of reasoning is found in answer choice C. The restaurant owner removed a dish from the menu. Jasmina was upset by this. But did the restaurant owner know that removing the dish would upset Jasmina? There is no way to know that. So why are we saying the owner intentionally upset Jasmina? Intentionally = doing something deliberately. Therefore, this reasoning is flawed and similar to the reasoning in the question.

Moreover, finding similar principles activates students' creative thinking. They begin to see connections between different mathematical topics, which helps them understand the subject as an integrated system. As a result, mathematics becomes a logically interconnected system of knowledge for the student, rather than just a collection of separate formulas.

Conclusion. The article underscores the value of structuring mathematics instruction to actively involve learners and strengthen their higher-order cognitive capacities. Analysis indicates that the impact of different question types on nurturing critical thinking and problem-solving proficiency varies significantly; thus, deliberate task selection and classification are crucial. Grouping questions into distinct categories—such as logical sequence tasks, set-based reasoning, necessity and sufficiency conditions, logical error detection, verification of statements, and identification of analogous reasoning patterns—enables educators to systematically develop specific dimensions of students’ analytical processes.

Questions involving logical sequences, for example, prompt learners to move beyond mechanical computation and instead examine underlying patterns, articulate justifications for their solutions, and provide clear explanations. These activities cultivate abstract reasoning, analytical precision, and the capacity to build well-structured arguments. Likewise, tasks rooted in set theory and formal logic encourage methodical thought, helping students grasp connections, operations, and foundational mathematical structures. Problems that focus on necessary and sufficient conditions, along with exercises in spotting logical inconsistencies and verifying truth claims, sharpen evaluative judgment, allowing students to identify reasoning gaps, test assumptions, and draw valid conclusions. Activities that require recognizing similar principles across different contexts stimulate analogical and creative thought, equipping learners to apply knowledge flexibly and integrate mathematical ideas.

The discussion further notes the need to tailor questions to the developmental stage and cognitive readiness of students. Offering tasks calibrated to an appropriate level of challenge maintains engagement while progressively advancing higher-level thinking abilities. Illustrative examples and guided solution pathways demonstrate how educators can formulate questions that are pedagogically effective and cognitively accessible.

Taken together, the observations in the article propose that a deliberate and organized framework for question design can meaningfully enhance students’ analytical and problem-solving skills in mathematics. Incorporating these strategies into regular classroom routines fosters a more participatory and intellectually enriching educational atmosphere. This approach not only deepens mathematical comprehension but also equips learners to address intricate challenges in academic and everyday settings, thereby nurturing enduring habits of analytical and logical reasoning.

The findings of this study confirm that questions aimed at critical thinking and problem-solving play a crucial role in mathematics lessons for students. Logical numerical questions, in particular, help develop independent thinking, analytical reasoning, and problem-solving skills. Integrating such questions into regular teaching practice enhances the effectiveness of mathematics education and prepares students for real-life problem-solving.

Therefore, educators are encouraged to systematically incorporate logical and problem-based questions into mathematics instruction.

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