Jurnal MATH-UMB.EDU
Vol 12 (3), 2025

INDEPENDENCE IN MATHEMATICAL THINKING OF GRADE XI STUDENTS OF BENGKULU STATE HIGH SCHOOL IN SOLVING COMBINATION PROBLEMS

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Abstrak

Penelitian ini bertujuan untuk menganalisis secara mendalam kemampuan berpikir mandiri siswa dalam memecahkan masalah kombinasi pada materi kombinatorik. Metode penelitian yang digunakan adalah studi kasus kualitatif, dengan melibatkan 24 siswa SMA kelas XI yang dipilih secara purposif berdasarkan kriteria belum pernah mempelajari konsep kombinasi secara formal dan belum pernah menghadapi soal serupa. Instrumen penelitian terdiri dari soal cerita kombinasi yang dirancang khusus dan pedoman wawancara semi-terstruktur untuk mengeksplorasi proses kognitif siswa. Analisis dilakukan terhadap empat aspek kemampuan, yaitu: (1) kemampuan menyatakan permasalahan dalam bentuk lain, (2) kemampuan membentuk strategi penyelesaian, (3) kemampuan menerapkan strategi untuk penyelesaian, dan (4) kemampuan memverifikasi hasil yang diperoleh. Hasil penelitian menyatakan: (1) menyatakan permasalahan dalam bentuk simbol angka dan diagram, menggunakan kalimat naratif, menggambar lingkaran, membentuk himpunan, dan menggunakan simbol B1 hingga B6; (2) strategi penyelesaian yang digunakan meliputi: mencacah dengan bantuan simbol, mencacah langsung tanpa simbol, mencacah secara selang-seling; (3) menemukan solusi dengan cara menggunakan pendekatan simbol variabel dan himpunan; (4) tidak ada siswa yang melakukan verifikasi terhadap hasil penyelesaian mereka. Temuan ini menegaskan bahwa meskipun mayoritas siswa mampu menampilkan kemandirian berpikir dalam menyatakan masalah dan membentuk strategi, hanya sebagian kecil yang konsisten hingga tahap penerapan strategi dan tidak ada yang melakukan verifikasi hasil. Implikasi penelitian ini dapat menjadi acuan dalam merancang strategi pembelajaran yang lebih efektif untuk mengembangkan kemampuan berpikir mandiri siswa di bidang matematika, khususnya pada materi kombinatorik.

Kata kunci: Berpikir Mandiri, Kombinasi, Pemecahan Masalah

Abstract

This study aimed to analyze in depth the students' independent thinking ability in solving combination problems in combinatorics material. The research method used was a qualitative case study, involving 24 high school students in grade XI who were selected purposively based on the criteria of never having studied the concept of combination formally and never having faced similar problems. The research instrument consisted of specially designed combination story problems and semi-structured interview guidelines to explore students' cognitive processes. Analysis was carried out on four aspects of ability, namely: (1) the ability to state problems in other forms, (2) the ability to form a solution strategy, (3) the ability to apply strategies for solving, and (4) the ability to verify the results obtained. The results of the study stated: (1) problems were stated in the form of number symbols and diagrams, using narrative sentences, drawing circles, forming sets, and using symbols B1 to B6; (2) the solution strategies used included: counting with the help of symbols, counting directly without symbols, and counting alternately; (3) solutions were found by using a variable symbol and set approach; (4) no students verified their solution results. These findings confirmed that although the majority of students demonstrated independent thinking in problem-solving and strategy development, only a small proportion consistently implemented the strategy, and none verified the results. The implications of this research could serve as a reference for designing more effective learning strategies to develop students' independent thinking skills in mathematics, particularly in combinatorics.

***Keywords**: Combination, Independent Thinking, Problem-Solving*

INTRODUCTION

Mathematics is a fundamental discipline consisting of various branches, each of which plays an important role in developing students' cognitive abilities(Maizora & Juandi, 2022). One of the prominent branches is combinatorics, which not only has varied characteristics but also offers wide applications in everyday life (Osaba et al., 2021). Combinatorial concepts often appear in various real-world scenarios, making them an essential component in mathematics learning (Lockwood et al., 2020). Combinatorics material is generally presented in the form of contextual problems that require students to think critically and creatively in finding solutions (Sekaryanti et al., 2023). Solving these problems requires special abilities from students, namely independent thinking (Hoffmann, 2008). Independent thinking is very important because each combinatorics problem can be solved through various approaches, depending on the individual's point of view and creativity. In fact, in some cases, simple combinatorics problems can be solved heuristically, namely based on students' understanding and analytical abilities regarding the problems given. During the completion process, the role of independent thinking becomes more prominent, because students are expected to be able to find solutions independently without having to follow the habits or thought patterns of others. This freedom of thinking arises from a deep understanding of the problems faced and the ability to relate previously mastered mathematical concepts. Thus, mastery of combinatorics material not only enriches students' mathematical insights, but also strengthens the ability to think independently in facing various challenges in the real world.

A distinguishing feature of combinatorics education lies in its emphasis on problem solving, which requires students to demonstrate specific cognitive abilities. One of the most important skills in this domain is independent thinking, which allows students to approach problems from multiple perspectives and devise their own solutions without resorting to imitative thinking procedures (Welsh & Dehler, 2013). Although combinatorial problems are inherently complex, not all require a complex mathematical approach. Certain problems can be effectively solved using heuristic methods, which allow students to draw on intuition and prior experience in constructing feasible solutions. This heuristic approach fosters flexibility and adaptability, essential traits in mathematical reasoning (Lehmann, 2025; Morales et al., 2025; Selter, 2009; Vogel et al., 2022).

A key aspect of combinatorics learning is the development of students' independence in problem solving (Savenkov et al., 2021). This independence refers to the ability to tackle mathematical challenges without resorting to imitative thinking or fixed procedural habits. Ideally, combinatorics instruction should be designed to encourage students to develop a variety of solution strategies and strengthen (Khamidovna et al., 2021) ample opportunities for exploration and creativity, plays a critical role in achieving this goal. In addition, integrating real-world contexts into combinatorics education enhances students' ability to recognize practical applications of mathematical concepts.

Ultimately, independence of thought in combinatorial problem solving is influenced by students' understanding of mathematical principles and their ability to make connections between different concepts. These abilities serve as important indicators of the quality of mathematics learning, especially in domains such as combinatorics that demand creativity and flexibility in reasoning.

There has been much research on problem-solving skills, but the extent of independent thinking, particularly in combinatorics, has not been explored. Therefore, the research question is how students' independent thinking skills improve when solving combinatorics problems. The novelty of this research is its discussion of high school students' independent thinking in combinatorics.

METHOD

This study is a qualitative study with a case study method that aims to comprehensively analyze students' independent thinking skills in solving combination problems(Creswell et al., 2007).

The case study approach was chosen to gain a comprehensive understanding of the cognitive processes and problem-solving strategies used by students (Maizora & Juandi, 2022; Maizora & Rosjanuardi, 2021) The test participants consisted of 24 grade XI students of SMAN 1 Bengkulu Tengah who provided answers, which were selected intentionally based on the criteria that they had never studied the combination concept formally and had never faced questions similar to the story questions given, either textually or contextually. The story problems given have been confirmed to all students that it is true that students have never faced this problem.

The research instruments used were: a combination of story questions and semi-structured interview guidelines. The story question given was “Dani will cross a pond through an arrangement of six stones lined up to cross the pond. Dani was asked to only step on four stones with the note that the two stones that were not stepped on must not be adjacent. How many ways can Dani choose stones?”. This question has a scenario that requires the selection of 4 stones from 6 available stones, which is carefully designed to ensure novelty for the participants. This question aims to access various student abilities in the independent thinking process. Independent thinking can occur in various aspects such as restating a problem, solution strategies, implementing solution strategies, and how to guarantee the correctness of the solution (Xamzayeva & Rahimova, 2021; Xaydarov, 2021; Xudaybergenova, 2021). The abilities seen are 1) the ability to state problems in another form, 2) the ability to form a solution strategy, 3) the ability to apply strategies for solving, and 4) the ability to verify the results obtained.

Semi-structured interviews were conducted to investigate students' cognitive processes, explore the strategies and reasons behind their chosen solution methods, and identify factors that influence students' independent thinking (Dursun & Aykan, 2025). Data collection was conducted by giving 24 students combination story problems individually, observing their problem-solving process, and conducting in-depth interviews after analyzing students' answers to explore their thinking processes, strategies used, and underlying causal factors. Qualitative data analysis was conducted through the stages of data reduction, organizing and simplifying test and interview data; data presentation, which involved narrative descriptions and categorization of response patterns; and drawing conclusions, which aimed to identify characteristics of students' independent thinking based on the answers given. To ensure the validity of the findings, data triangulation was applied by combining written test results with interview data, complemented by member checks to verify the accuracy of the researcher's interpretation of students' responses and explanations.

RESULTS AND DISCUSSION

The research results are presented in accordance with the research objectives, namely to describe the results and causal factors of: 1) the ability to state problems in another form, 2) the ability to form a solution strategy, 3) the ability to apply strategies for resolution, and 4) the ability to verify the results obtained.

The Ability to State Problems in Another Form

Stating a problem in another form of a story problem is the initial part of solving a problem with independent thinking skills (Ida et al., 2021). There is no special formula for stating another form of a problem in a story problem (Hayes, 2013). The other form that is formed is the result of students' interpretations based on their own understanding of the problem and involves students' connection skills in connecting a problem with mathematical concepts. The representation displayed by students is the result of independent thinking because there are no similar problems that have ever existed in students' thinking experiences (Hadiastuti & Soedjoko, 2019). As a result, the results obtained in this study are unique, due to the problems that are not imitations of problems that students have ever encountered and there are no formal procedures that students have in solving this problem.

Stating the problem in another form is the same as the term restating the concept in the problem-solving steps proposed by Polya (Juliarti et al., 2024). Based on the results of the analysis of student answers, there are five different groups in stating the problem in another form.

The first group, as many as 19 students stated the problem in the form of a diagram by writing the numbers 1, 2, 3, 4, 5, 6 as a substitute for the six stones in the pool. The number symbols are written sequentially as in Figure 1.

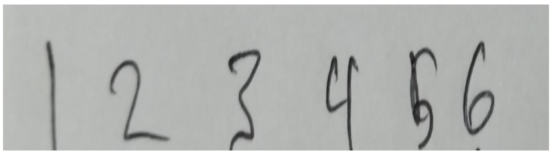

Figure 1. Six Number Symbol For Six Stones

Students tend to state six stones with the first six digits in the natural number. This is done to make it easier for students to mention the stones in question. This can be understood together because students need the names of the stones to distinguish between the six stones. The easiest name to mention according to students is to state it in numbers. In the interview results, all students stated that the numbers used did not state a certain size of the stone that was given a name, but were names that represented the order of arrangement in the pool.

Seven of the 19 students who stated the stones in numbers provided an illustration of a circle as a manifestation of the stones in question. Figure 2 is an example of one of the student's answers who wrote a circle with a name in the form of a number.

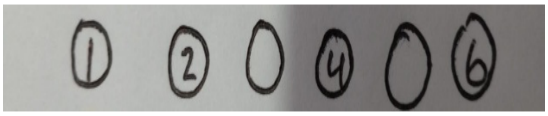

Figure 2. Numbers in Circles

The appearance of the circle is influenced by the appearance of several stones that students often see in the surrounding pond. At least, the pond in their school. Writing numbers in the circle has no strong reason. Two students out of seven, wrote numbers under the circle. The numbers written indicate the name of the circle above the number.

The appearance of the stone other than in the form of a circle, is the appearance of a square as in Figure 3. Naming the numbers is still used by writing the numbers in the square. The appearance of a square with numbers in it was written by a student. The appearance of a square is given because the question states that the stone will be used as a foothold to cross the pond. Students think that the appearance of the stone that can be stepped on to cross should be square so that Dani does not fall when crossing.

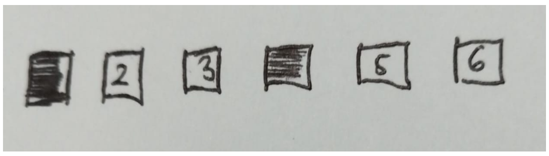

Figure 3. Square as the Embodiment of Stone

The second group, states the problem in the form of a sentence. The name of the stone is distinguished by the name of the first stone, the second stone and so on. The name of the stone is directly as the order of the position of the stone in the pond. This group was written by two students in almost the same way. Other students called it stone one, stone two, and so on. There was no strong reason given by the two students for naming the stone. Writing in sentences is done because of the habit of students writing something clearly without using symbols to shorten it.

The third group, stated six stones in the pond in the form of a lined-up circle without the need to give a name for each stone. Figure 4 is a picture made by this group of three. There is only one student in this group. The student drew a complete picture with the symbol Dani and the edge of the pond. In explaining the solution, students still mention the first stone, the second stone and so on with sentences, without symbolizing them in the form of numbers.

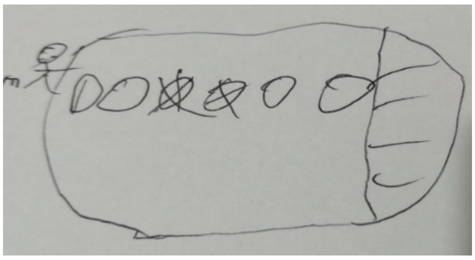

Figure 4. Stones depicted in a circle without any names

The stone is made in a circular shape only because it is quicker to draw a circle than any other shape.

The fourth group, stated the stones in numbers but not in a diagram but by writing a set as in figure 5. The stones are represented by numbers 1 to 6. Only one student did this. The student counted all possible unstepped stones that were not a solution. This set is said to be not part of the solution because the two stones are adjacent.

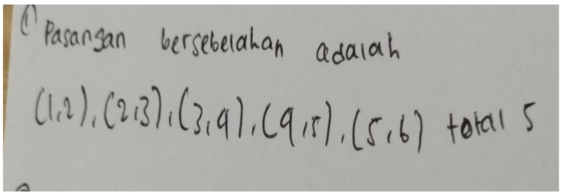

Figure 5. Stating the problem in the context of a set

Students feel that by using the context of sets, problems in story problems are easier to solve. It is predicted that students are quite familiar with the set material that has been studied in grade VII. With the concept of sets they have, these students feel that the problems are clearly visible.

The fifth group states the names of the stones with the symbols B1, B2, B3, B4, B5, and B6. The symbol B is an abbreviation for stone. B1 means the first stone in the sequence in the pool. Likewise, with B2 and so on sequentially according to the order of the stones as in Figure 6. There is only one student who states this.

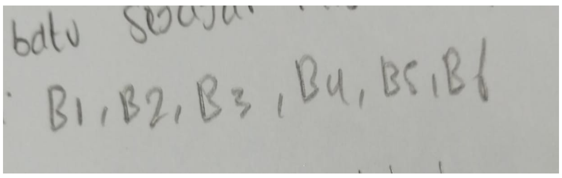

Figure 6. The Six Stones are symbolized by B1, B2, and so on in sequence

From the interview results, it was found that this student imitated the variable symbols even though the naming of the stones did not fulfill the rules for naming variables properly.

Ability to Form Resolution Strategies

Forming a solution strategy is an important step in problem solving. An effective solution strategy will produce the right and fast solution. The solution strategies given by students can be divided into four groups. The first group used a counting strategy with the help of symbols as many as 12 students, the second group used a counting strategy directly without going through symbols as many as 7 students, the third group used an alternating counting strategy as many as 3 students, and the fourth group used a strategy that was not relevant to solving the problem as many as 2 students.

The first group, counted many ways using a counting strategy with the help of symbols as shown in Figure 7. Students did the counting using symbols because students felt helped in thinking by directly writing down all the possibilities on the symbols used. In Figure 7, students wrote down the possible ways to cross the pool by writing numbers on the circles. The stones that were stepped on would have their numbers written on them, while the ones that were passed would not have their numbers written on them. Students rewrote the symbols and numbers for different ways. There was no simple pattern in how to determine the choice of four stones for the possibility of finding the next way.

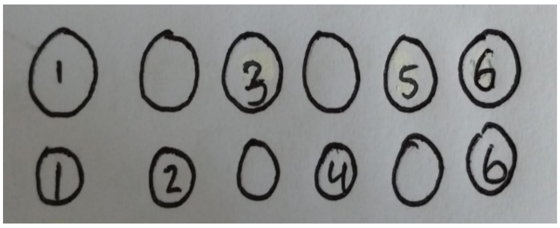

Figure 7. Counting with the Help of Symbols

Of the 12 students, there was one student who used enumeration with symbols in calculating the number of ways but only wrote two symbols in the form of writing a set as in Figure 5. The student counted the number of ways to write two stones out of the six available stones, then also determined the number of ways to write two adjacent stones.

The second group, calculated the number of ways using the enumeration strategy directly without using symbols. In Figure 8, it can be seen that students use direct sentences to convey the possible ways that are the solution. There is no strong reason to use the enumeration strategy directly without using symbols.

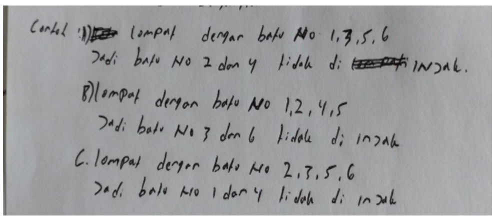

Figure 8. Strategy for Direct Enumeration Without Using Symbols

There is no simple pattern that can be followed to determine the next possible way that students will find.

The third group, counts the number of ways by using an alternating counting strategy as shown in Figure 9. The alternating is only meant if there are still two groups for both groups, namely the group of stones that are stepped on as many as four stones and two stones that are not stepped on. From the interview it is known that what is done alternately is the stone that is not stepped on. This means that two stones that are not stepped on will never be close together. It turns out that this alternating is the meaning of two stones that are not stepped on are not close together. It can be seen that students make strategies by making other representations of the question request.

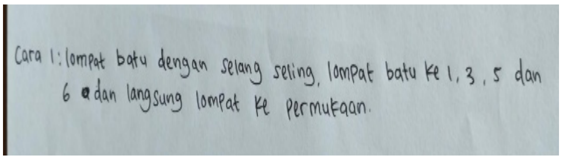

Figure 9. Alternate Enumeration Strategy

There is no simple pattern of how to determine the next possibility that can be understood from the students' answers.

The fourth group, calculates many ways using strategies that are not relevant to solving the problem. The answers given include crossing the pool by swimming and other students provide a way to cross the pool by jumping directly from the edge to the opposite edge of the pool if they are able. These students do not want to be bound by the request for questions that only use four of the six available stones to cross, on the grounds that there are always other ways besides the method given in solving the problem. The students' thinking process is very unexpected which is the result of independent thinking without being bound by the requested requirements.

Ability to Apply Strategy for Solution

Applying the solution from the planned strategy is very important in the solution. Student consistency in continuing the planned strategy is needed to obtain the solution results. Of the 24 students, only two students obtained the solution results. Both students used different strategies. The first student continued the enumeration strategy using the symbols B1, B2, B3, B4, B5, and B6 as in Figure 6. The student changed the keyword stepping on four stones out of six stones with the keyword choosing four stones out of six. Furthermore, the student simply used the word choosing four of six with the condition that the two stones that were not selected were not adjacent. In the enumeration, the student wrote down the symbol of the selected stone with the conditions that had been determined by the question. This student gave an answer of 10 ways to step on four stones out of six stones to cross the pond. Not all the ways that the student meant were written on the answer sheet. However, the results of the student's interview only chose two of six with the condition that the two chosen were not adjacent. This method in combination is justified because the result of the calculation of the number of ways to choose four stones out of six stones is the same as the number of ways to choose two stones out of six stones.

Another student who applied the strategy until finding a solution used the enumeration strategy using set symbols as shown in Figure 5. This student gave the answer 10 ways to step on four stones out of six stones to cross the pond. This result was obtained from finding 15 ways to write two stones out of six stones and finding 5 ways to write two adjacent stones in those 15 ways.

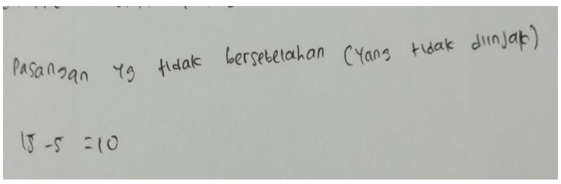

Figure 10. Student completion results

As a result, the solution result is the subtraction of the first result from the second result because the second result is not included in the desired solution result as in Figure 10.

Ability to Verify Results Obtained

The results obtained from the application of the strategy need to be verified as a solution. There are many ways to verify the answers obtained, depending on the information available (Maizora et al., 2025; Nugroho et al., 2025; Richardo et al., 2025). The convincing process is carried out after obtaining the estimated results in solving the problem. Of the two students who applied the strategy for solving, none of the students verified. This happens because students are not used to verifying the results after solving math problems (Israilova & Sheraliyeva, 2021; Semadeni, 2008; Xamzayeva & Rahimova, 2021).

These four indicators are an essential component of problem-solving. These indicators will help students learn how to solve problems, enabling them to recall previously implemented strategies when facing similar challenges. These four indicators of independence will also help students improve their problem-solving thinking skills.

CONCLUSION

This study revealed that students' independent thinking skills in solving combination problems still vary greatly. Most students are able to state problems in other forms, such as using number symbols, diagrams, or narratives, which indicate creativity in understanding the problem. However, only some students are able to form effective solution strategies, either through symbolic, direct, or alternating enumeration. Of all the participants, only two students succeeded in implementing the strategy to obtain the correct solution. None of the students verified the results of their solutions, indicating a lack of reflection habits in the process of solving mathematical problems. These findings indicate that although students can think independently at the initial stage, consistency until the final stage of problem solving is still low. The main factor influencing this is the lack of experience and habituation in dealing with combinatoric problems that require non-imitative reasoning. Therefore, a learning approach is needed that emphasizes more on exploration, creativity, and verification of results. Student-centered combinatoric learning can improve independent thinking skills and flexibility of thinking. The implications of this study are expected to be a reference in designing more effective and innovative mathematics learning strategies.

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