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JURNAL MANAJEMEN PENDIDIKAN ISLAM

HIGH SCHOOL STUDENTS' CREATIVE THINKING ABILITY IN PROPOSING COLLABORATIVE PROBLEMS ON SEQUENCES AND SERIES

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Abstract

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This study aims to describe the creative thinking ability of high school students in posing collaborative problems on sequences and series, so the type of research used is a case study with a qualitative approach. The subjects in this study were high school students of grade X who were divided into groups of students with high, medium, and heterogeneous mathematical abilities (high, medium, and low). There are four data collection techniques used in this study, namely the mathematics ability test (TKM), the collaborative mathematics problem posing task (TPMKM), observation, and interviews. The instruments in this study are divided into two, namely the main instrument and supporting instruments. The main instrument is the researcher, while the supporting instruments are in the form of the mathematics ability test grid (TKM), the collaborative mathematics problem posing task sheet (TPMKM), observation guidelines, and interview guidelines. The collected data were then analyzed into three stages: data condensation, data presentation, and conclusion drawing. Data validity checking in this study uses method triangulation. There are two methods used in checking the validity of the data, namely researcher observation and FGD. The results of the study found that in homogeneous groups, the high homogeneity group demonstrated creative thinking skills in the form of fluency, flexibility, and novelty when posing collaborative problems, while the medium homogeneity group only demonstrated fluency and flexibility. In heterogeneous groups, the researchers found that student groups only demonstrated fluency. The different creative thinking skills of each group were due to differences in the composition of the mathematical abilities of the group members.

Keywords: ability, creative thinking, problem posing, collaborative, sequences and series.

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INTRODUCTION

The current school learning process in Indonesia uses the independent curriculum concept which focuses on increasing the creativity and independence of each student (Kemendikbudristek, 2021). Creativity is a product resulting from creative thinking. This is in accordance with the opinion of Murdock and Puccio in (McGregor, 2007) which states that creativity and creative thinking are two distinct but conceptually related concepts. Creative thinking is associated with the creative process. In this regard, it is understood that creative thinking activities are important in enhancing student creativity, in line with the objectives of the independent curriculum.

Creative thinking activities in learning can be fostered by honing each student's creative thinking skills. Creative thinking is the mental process an individual uses to discover new ideas or perspectives to solve problems with fluency and flexibility (Siswono & Budayasa, 2006). In the learning process, creative thinking skills are said to be students' efforts to find solutions to problems by developing their own ideas or concepts (Faelasofi, 2017). With these two opinions, it is known that teachers can provide problem-solving activities to hone students' creative thinking skills.

Each student's creative thinking ability is classified into three components as explained by Silver (1997) namely fluency, flexibility, and novelty. Fluency refers to the number of questions a person asks when solving a problem. This indicates that the more questions asked, the higher the creativity. Flexibility refers to a person's ability to change approaches when responding to a command, resulting in more than one approach being taken when responding to the command. Novelty refers to the originality of the ideas a person generates when responding to a command.

Low creative thinking skills can lead to low student learning outcomes. This is explained in research Yusnaeni (2017) which states that creative thinking is related to learning outcomes. The higher a student's creative thinking ability, the higher their learning outcomes, and vice versa. Given the relationship between creative thinking ability and learning outcomes, the role of teachers in independent curriculum-based learning is crucial. Teachers can implement learning that supports students' focused and refined thinking activities to improve creative thinking skills. This aligns with Purwasih (2019) which states that in learning, teachers must involve students' ideas or thoughts in solving problems to improve their creative thinking skills. To improve creative thinking skills, teachers can use learning activities that support this, such as collaborative problem posing (CPP). This statement is based on research Siswono (2005) which states that learning by posing problems can improve three aspects of creative thinking ability (problem information, novelty, and fluency), but flexibility does not increase.

Problem posing is a form of assignment given by teachers to students to formulate questions and solve them using the knowledge they have (Iswara & Sundayana, 2021). Teachers can see the stages of problem submission carried out by students based on their opinions Baumanns & Rott (2022) which consists of the following five stages.

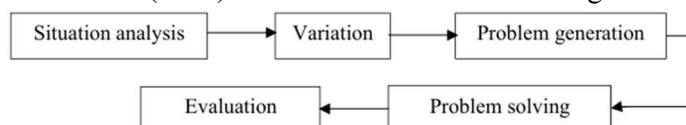


Figure 1. Collaborative Issue Submission Stages

Problem posing is different from problem solving, because in problem solving the focus is only on efforts to determine a solution to the problem given based on the knowledge that is possessed (Shodiqin et al., 2020). Meanwhile, in problem posing, the focus is on students' activities in posing questions based on their own thoughts after solving the given problem.

In the research results Siswono (2023) The results showed that by implementing CPP, students were able to complete several assigned tasks and pose new problems with the problems they had solved. The results of the study showed that students tended to ask questions from sources they had searched for and in accordance with the problems they had just worked on, and that students had also worked collaboratively and responsibly on the tasks given by other friends. Based on the results of the study, it is known that CPP can hone students' creative thinking skills because they collaborated with each other to pose new problems by changing information from previously solved problems.

Problem-posing tasks are more effective when done collaboratively with several students. Collaboration facilitates the integration of knowledge derived from interactions between two or more students (Brodie et al., 2010). One of the important points in learning

that applies collaborative problem posing is the formation of group members (Moreno et al., 2012). The interaction process between group members and the group's composition significantly determines the effectiveness of group problem-solving. This occurs because group interaction processes, such as perspective-taking (taking on the role of others) and presenting personal perspectives, are used to determine the extent to which the group utilizes available resources to reach a solution. Heterogeneity (different perspectives on a problem) or homogeneity (the same perspective on a problem) within a group can influence problem-solving outcomes (Zuhriyah, 2022).

Specifically, there are two types of grouping methods: homogeneous groups and heterogeneous groups. These groupings take into account three things: estimated student knowledge levels, estimated student communication skills, and estimated student leadership skills (Moreno et al., 2012). Based on the previous explanation, it can be seen that the subjects in this study were divided into two groups, namely homogeneous groups and heterogeneous groups, with reference to the level of students' mathematical abilities. The ideal group division in this study was implemented by applying two principles: inter-homogeneous and intra-heterogeneous. Inter-homogeneous means that diversity between groups must be minimized to ensure that all groups have a similar composition. Composition can be interpreted as the number of concepts that have been accepted or known. Intra-heterogeneous means maximizing diversity within a group (Kirschner et al., 2011).

Collaborative problem-solving can be done based on the results of problem-solving on sequences and series. This statement is based on research results Ardy (2014) namely, problem-posing tasks have a significant influence on the ability to solve problems of arithmetic sequences and series. The quality of questions created in problem-posing tasks has a positive correlation with students' problem-solving abilities, the better the quality of questions created by students, the better their problem-solving abilities. With the correlation between problem-posing tasks and problem-solving abilities, researchers want to know how the correlation of students' collaborative problem-posing tasks is based on the results of problem-solving that has been done previously.

RESEARCH METHOD

This study uses a qualitative approach with a case study as its type of research, so it aims to describe in depth the creative thinking abilities of high school students in homogeneous and heterogeneous mathematical ability groups on collaborative problem-posing tasks of the post-solution posing type on sequences and series. Data collection techniques used in this study are the mathematics ability test (TKM), the collaborative mathematics problem-posing task (TPMKM), observation, and interviews. There are two instruments in this study, namely the main instrument and supporting instruments. The main instrument is the researcher himself, while the supporting instruments are in the form of a mathematics ability test grid, a collaborative mathematics problem-posing task sheet, observation guidelines, and interview guidelines.

The subjects in this study were 10th-grade students from the same class, selected using purposive sampling based on the results of the mathematics ability test in that class. The following is the outline of the mathematics ability test used in this study:

Table 1. Mathematics Ability Test Grid

Indicator	Topic	Question Number	Cognitif Level
Determine the value of the nth term of the number pattern formula formed.	Number patterns	1	C3 (Applying)
Determine the area of the shaded rectangle based on the difference between the outermost rectangle and the unshaded rectangle.	Root forms	2	C4 (Analyzing)
Prove the value of $y = 2x$ based on the given logarithmic equation.	Logarithms	3	C5 (Evaluating)

The following is the form of collaborative problem-posing assignment used in this study to determine the creative thinking abilities of each subject.

Pay attention to each piece of information provided to answer the questions below!

The sum of the first three terms of a geometric sequence is 119. If the first and second terms remain the same, and the third term is reduced by 17, then the three numbers form an arithmetic sequence. Determine the first term of the geometric sequence!

Challenge:

Create more than one new question that is in accordance with the problem topic above and various strategies for solving the new questions proposed!

Figure 2. Collaborative Mathematics Problem-Submission Task (TPMKM)

The researchers used three research subjects: groups of students with homogeneous high, homogeneous medium, and heterogeneous (high, medium, and low) mathematical abilities. Each group consisted of three students. The criteria for grouping students' mathematical abilities used in this study were adopted from the opinion of Ratumanan & Laurens (2011), namely (1) high mathematical ability with a value range of $80 \leq \text{Value} \leq 100$, (2) moderate mathematical ability with a value range of $60 \leq \text{Value} < 80$, and (3) low mathematical ability with a range of $0 \leq \text{Value} < 60$. The three groups of students were then given the task of posing collaborative mathematical problems (TPMKM). There were two tasks that had to be completed by each group. In the next stage, the researcher selected the results of one of the tasks to describe how the creative thinking ability of the student group in posing problems collaboratively.

Analysis of research data obtained by researchers was carried out by applying an interactive model Miles, Huberman, dan Saldana (2014) These are data condensation, data display, and conclusion drawing. Data condensation involves sorting the information obtained from the researcher's observations and focus group discussions (FGDs) and focusing it on the research objectives. The presentation of this research data relates to the presentation of the observation and FGD results for each research subject. Conclusions are drawn from a comparison of the researcher's observations and FGD results, thus obtaining a valid measure of each subject's creative thinking ability.

This study uses a triangulation method to verify the validity of the data obtained. Two methods were used: researcher observations and Focus Group Discussion (FGD). Observations were conducted by the researcher during the problem-posing process undertaken by each research subject, including analyzing the problem situation, discussing creative ideas for developing new questions, and determining various methods for solving the newly developed questions. The FGD was conducted by the researcher after the research subjects completed the TPMKM. The purpose of the FGD was to understand the group's thinking in completing the TPMKM. Therefore, the FGD also validated the observations made by the researcher, allowing the researcher to obtain valid conclusions regarding the creative thinking abilities of each subject.

The observations conducted by the researchers and the FGDs were based on

creativity indicators and stages of collaborative problem-posing. The following are the creativity indicators used in this study.

Table 2. Components of Creativity in Problem Filing

No.	Creativity Components	Creativity Component Indicators	Code
1.	Fluency	Students can produce more than one varied question.	KF
2.	Flexibility	Students can submit questions that have more than one solution.	FL
3.	Novelty	Students can ask questions that have different content and context from the given problem.	KB

Fluency in generating more than one varied problem in research can be in the form of mathematical problem posing and contextual problems. Flexibility in this research means that students can submit problems using more than one solution method, so that the proposed problems have various solution methods. The novelty component in the form of content in this research is like changing the flow of information on the problem given, while the novelty of the context is like changing the type of mathematical problem text into a contextual problem. Novelty can be fulfilled when the problem proposals compiled by students have novelty in content and context, so that if only showing one of them is considered the student does not have novelty in the proposed problem. The indicators of the collaborative problem posing stages used by the researcher can be described as follows.

Table 3. Stages of Collaborative Problem Submission

No.	Collaborative Issue Submission Stages
1.	Situation Analysis - Students identify problem information based on the views of each group member. - Students determine a strategy for solving the given problem by accommodating the various perspectives of group members. - Students apply strategies that have been agreed upon by group members to achieve solutions to the problems given.
2.	Variations Students change problem information by removing or adding new information based on the agreement of the group discussion results.
3.	Problem Generations - Students combine the ideas of each group member regarding adding or changing information from the problem given. - Students formulate new problems based on ideas that have been formed from the results of group discussions.
4.	Problem Solving - Students determine a strategy for solving the problems created by the group. - Students apply the problem-solving strategies that group members have created.
5.	Evaluation Students assess the problems that group members have created, by looking at whether the problems can be solved, are well defined, are appropriate, or are interesting to solve.

RESEARCH RESULTS AND DISCUSSION

A. High Creative Thinking Ability of Homogeneous Groups

Highly homogeneous groups can demonstrate creative thinking skills in the components of fluency, flexibility, and novelty in solving problem-posing tasks. This is the same as research D. Wahyuni & Sutiarto (2024) which also states that students with mathematical creative thinking skills at level 4 (very creative) can demonstrate fluency, flexibility, and novelty. Other research by Widyastuti & Harun (2021) also



found that students with high thinking skills at level 4 (very creative) met the indicators of fluency, originality, flexibility, and elaboration in problem posing learning with an open-ended approach based on story problems.

Fluency is seen in the differences in the variations of the two problems proposed by the highly homogeneous group. These differences in variation include geometric and arithmetic sequences, the flow of problem information, the type of problem text, and the questions asked. Each member of the highly homogeneous group expressed creative ideas in proposing these varied new problems. This is seen during the discussion carried out by the highly homogeneous group collaboratively and evenly, so it can be said that the group did not rely on just one member in finding and realizing creative ideas in compiling new problems. Fluency in the highly homogeneous group can be seen in the submission of the following two new problems.

KF

Rani mengumpulkan cangkang kerang untuk membuat karya seni. Setiap minggu, jumlah cangkang kerang yang ia kumpulkan membentuk barisan geometri. Dalam tiga minggu pertama, ia mengumpulkan total 56 cangkang. Namun pada minggu ketiga, ia hanya mengumpulkan 8 cangkang lebih sedikit dari rencana awal karena kehilangan beberapa cangkang, sehingga sekarang jumlah cangkangnya membentuk barisan aritmatika. Mulai minggu keempat, ia kembali mengumpulkan cangkang kerang mengikuti pola barisan geometri di awal. Berapa lama Rani mengumpulkan cangkang kerang sampai totalnya mencapai 248 cangkang?

Information:

- Changing the value of a geometric three-term series
- Additional information
- Changing the form of geometric and arithmetic sequences
- Changes to the questions asked

Figure 3. First Question Submission for Highly Homogeneous Group

Nita adalah seorang kolektor buku yang menyimpan koleksinya dalam 3 rak buku. Jumlah buku pada setiap rak tersusun membentuk barisan aritmatika dengan selisih jumlah buku antar rak adalah 9. Suatu hari, Nita membeli buku lagi dan membuat perubahan pada jumlah buku di rak ketiga yaitu di tambahkan sejumlah buku di rak pertama. Setelah perubahan tersebut, jumlah ketiga buku di ketiga rak ternyata membentuk barisan geometri. Berapa perkiraan jumlah buku yang dibeli Nita?

Information:

- Changing the value of a geometric three-term series
- Additional information
- Changing the form of geometric and arithmetic sequences
- Changes to the questions asked

Figure 4. Submission of Questions for the Two Highly Homogeneous Groups

Flexibility can be demonstrated by the high homogeneity group during the FGD by explaining methods other than those written in the solution of the first and second question submissions. The explanation of the method cannot be proven to be accurate in answering the questions asked in each question submission. This is because the high homogeneity group only explains it verbally without demonstrating the application of the method in writing to answer the questions asked. The flexibility explained by the

high homogeneity group is related to two different methods for determining the value of the quadratic equation, namely the factoring method and the abc formula. The high homogeneity group also uses different methods in the elaboration of a series of three geometric terms, namely in algebraic form and using the formula for the nth term of a geometric sequence. The flexibility demonstrated by the high homogeneity group can be seen in the following interview transcript.

Label	Interview Transcript	Code
PHT1FL79	In the results of the first assignment, is there another way you can solve the problem?	FL
SHT1FL80	Yes, we can describe a three-term geometric sequence by adding the form of the first term to the third term. We can also use the factoring method to determine the value of the first term in a quadratic equation.	
PHT2FL83	In the second assignment, are there any other ways you can use to solve the problem?	
SHT2FL84	We believe there's no other way to solve the second problem. Using the factoring method to determine the first term, we can convert it to the root method. This is our reason for saying there's no other way to solve the second problem, as it doesn't alter the majority of the solutions already implemented.	

The fluency and flexibility demonstrated by homogeneous groups were high in collaborative problem posing according to research Puspitasari et al. (2021) which says that high homogeneity groups can be creative and innovative in creating problems and solving them.

The novelty of content and context (KB code) can be demonstrated by the highly homogeneous group only in the second question submission. In the second question submission, the novelty of content is seen from the difference in the flow of information between the problem and the given question. The flow of information in the given question relates to the value of the series of the first three terms of a geometric sequence, which is then used to construct the first three terms of an arithmetic sequence. In the second question submission, the highly homogeneous group uses the flow of information related to the value of the series of the first three terms of an arithmetic sequence, which is then used to construct the first three terms of a geometric sequence. The novelty of context is seen in the transformation of the mathematical problem into a contextual problem, namely related to the number of books on the shelf. In the first question submission, the highly homogeneous group only shows context novelty, like the second question submission. The problem context used in the first question submission is based on the experience of one member of the highly homogeneous group in school activities. The flow of information used in the first question submission is the same as the given question, so the novelty of content cannot be demonstrated by the highly homogeneous group. The creative thinking ability in the form of novelty carried out by the highly homogeneous group in the second question submission is the same as the research results Widyastuti & Harun (2021) which says that groups of high-ability students can create new problems that have never been exemplified.

The description of the collaborative problem-posing stages carried out by the highly homogeneous group in both question submissions based on the researcher's observations and FGD interviews can help researchers describe the group's creative thinking abilities. All stages of collaborative problem-posing can be demonstrated by the highly homogeneous group. The situation analysis stage is carried out well by the

highly homogeneous group in analyzing all important information and determining the appropriate solution strategy in answering the questions in the given problem. The variation, problem generation, problem solving, and evaluation stages can also be demonstrated by the highly homogeneous group in both question submissions that have been prepared.

In both problem posings, the variations made by the highly homogeneous group were based on different thought processes. This is indicated by the differences in ideas for changing the problem information in the two problem posings. The ideas for changing the problem information given in the first problem posing were related to geometric and arithmetic number sequences, the type of problem text, and the questions posed, while the second problem posing used ideas for changes in the problem information flow, geometric and arithmetic number sequences, the type of problem text, and the questions posed. The explanation of the problem generation stage can show how the highly homogeneous group got creative ideas for variations in the two new problems and how collaboration was carried out in posing the new problems. These creative ideas came from all group members without relying on just one member. The activeness of each member of the highly homogeneous group is in accordance with research Hery (2016) which states that high-mathematics groups tend to actively discuss, clarify ideas with each other, and collaborate in developing problem-posing strategies. The problem-solving stage describes how the high-homogeneous group determines and implements the correct problem-solving strategy in answering the questions posed in the two new problems. Another aspect demonstrated in the problem-solving stage is that the high-homogeneous group solves the problems sequentially and systematically. The results of the evaluation stage show how the high-homogeneous group assesses the problems posed, as well as the steps taken by the high-homogeneous group in examining the accuracy of the answers in each problem. The high-homogeneous group's assessment of the second problem was better than the first. This is because the high-homogeneous group used a different flow of problem information, type of problem text, and questions than the given problem. The accuracy of the answers produced by the high-homogeneous group was based on the arrangement of the arithmetic sequence before posing the second problem.

Highly homogeneous groups can collaboratively propose both questions to determine ideas for change. These ideas for change are based on the thoughts of each member of the highly homogeneous group. Each member of the highly homogeneous group can respond to and add to the ideas expressed by other members, thus creating new questions with more variety and novelty. This collaboration in highly homogeneous groups is consistent with research Nisa' et al. (2023) who stated that collaborative problem-posing works well in groups of students with high mathematical abilities. The differences in mathematical understanding between these groups are not too great, allowing them to share ideas without relying on one another.

B. Creative Thinking Ability of Homogeneous Groups

The homogeneous group demonstrated creative thinking skills only in the fluency and flexibility components. This is similar to research conducted by I. Wahyuni & Ratu (2018) which says that students with average abilities can only achieve fluency and flexibility. Another study by Isna et al. (2018) also stated that students with average abilities can meet the creative thinking indicators of fluency and flexibility. Students with average abilities cannot achieve novelty because it is difficult to find innovative changes that have never been encountered before. (Yayuk et al., 2020).

Fluency was demonstrated by the moderately homogeneous group by proposing two new, varied problems. This variation was seen in the differences in geometric sequences, arithmetic sequences, the questions asked, and the types of problem texts. Each member of the homogeneous group was expressing creative ideas for changes that could be made to the two new problems, but only one member was able to realize the idea in compiling the new problem. This was shown in the results of the researcher's observations when observing the discussion carried out by the highly homogeneous group. In the discussion, it was seen that the moderately homogeneous group trusted only one member to realize the idea that had been agreed upon together to compile the new problem, but still agreed on the results of the realization of the idea together. Fluency in the moderately homogeneous group was the same as the research conducted by Puspitasari et al. (2021) which states that student groups can be innovative in creating new questions. The fluency of the homogeneous group can be seen in the submission of the following two new questions.

KF

Jumlah dua suku pertama Suatu barisan geometri adalah 15. Jika suku pertama tetap dan suku kedua dikurangi 3, maka kedua bilangan tersebut membentuk barisan aritmetika dengan selisih 5. Tentukan Suku pertama barisan geometri tersebut.

Information:

 → Changing the many terms used

 → Changing the form of geometric and arithmetic sequences

Figure 5. First Question Submission for the Medium Homogeneous Group

Silvia memiliki waktu dua minggu untuk mempersiapkan olimpiade matematika, setiap minggu, ia mengerjakan soal selama tiga hari berturut-turut. Pada minggu pertama, jumlah soal yang ia kerjakan membentuk barisan geometri dan jumlahnya adalah 70. Pada minggu kedua, jumlah soal per-hari membentuk barisan aritmetika dengan pola hampir sama dengan minggu pertama. Soal hari ke-1 dan ke-2 sama, namun hari ke-3 berjumlah 10 soal. Berapa perlakuan total seluruh soal yang dikerjakan Silvia?

Information

 → Changing the pattern of the third term of an arithmetic sequence

 → Changing the form of geometric and arithmetic sequences

 → Changes to the questions asked

Figure 6. Submission of Questions for the Two Medium Homogeneous Groups

The moderate homogeneous group demonstrated flexibility in solving the second problem by producing two different solution methods. These different solution methods were demonstrated by the moderate homogeneous group during the FGD interview. The moderate homogeneous group explained two methods that can be used to determine the roots of a quadratic equation: the factoring method and the abc formula. On the TPMKM results sheet, the moderate homogeneous group only wrote the abc formula method, while the factoring method was written in the FGD interview. The following is evidence of the flexibility demonstrated by the moderate homogeneous group during the FGD.

FL ←

$$\begin{aligned}
 &2r^2 - 5r + 2 = 0 \quad \rightarrow p, q = 1 \\
 &\frac{1}{2}(2r-4)(2r-1) = 0 \quad p+q = -5 \\
 &\frac{1}{2}(r-2)(2r-1) = 0 \\
 &1(r-2)(2r-1) = 0 \\
 &(r-2)(2r-1) = 0 \\
 &r-2 = 0 \quad 2r-1 = 0 \\
 &r = 2 \quad 2r = 1 \\
 &\quad \quad r = \frac{1}{2}
 \end{aligned}$$

Figure 7. Flexibility of Medium Homogeneous Groups in the Second Question Submission

The accuracy of both methods in answering the questions posed in the second questionnaire can be determined, as evidence is provided. The flexibility demonstrated by the moderately homogeneous group is similar to the research findings Fadhlurrahma et al. (2023) that students with average abilities include students who can produce various alternative answers correctly

In the first problem, the moderately homogeneous group could only explain and write one solution method, namely the factoring method. This is because the moderately homogeneous group used the same solution steps as the problem given. Observations show that the moderately homogeneous group only stuck to the problem's solution steps, so they were unable to produce different steps. The variety of solution methods that the moderately homogeneous group could not produce in the first problem showed a lack of flexibility. The flexibility demonstrated by the moderately homogeneous group can be seen in the following interview transcript.

Label	Interview Transcript	Code
PHS1FL71	In the results of the first assignment, is there another way you can solve the problem?	
SHS1FL72	We believe there's no other solution to the second problem. This is because many of the terms used in the second problem are different from those in the first problem, and therefore the solution steps are also different. The quadratic equation involving ratios is also not generated in the second problem, so there's no alternative method as in the first problem.	
PHS2FL75	In the second assignment, are there any other ways you can use to solve the problem?	FL
SHS2FL76	In determining the ratio value in the form of a quadratic equation, we can use another method in the form of the factoring method.	

The novelty of content and context could not be demonstrated by the moderately homogeneous group in both questions that had been prepared. Both questions did not show novelty of content. This is because both questions use the same information flow as the given problem, namely the known geometric sequence series and used to construct an arithmetic sequence. Context novelty can only be demonstrated by the moderately homogeneous group in the second question proposal by changing the mathematical problem into a contextual problem, while the first question proposal uses the same context as the given problem, so there is no context novelty in the first question proposal. The creative thinking component in the form of novelty that is not demonstrated by the moderately homogeneous group has the same results in the research findings Hery (2016) which says that the group is able to discuss and

determine strategies in presenting problems, but cannot develop these ideas or strategies in an original way.

The creative thinking abilities of the moderately homogeneous group can be seen in detail in the description of the collaborative problem-posing stages in each question submission. All stages of collaborative problem-posing can be demonstrated by the moderately homogeneous group. The situation analysis stage is carried out well by the highly homogeneous group in analyzing all important information and determining a solution strategy for the given problem. The variation, problem generation, problem solving, and evaluation stages can be demonstrated by the moderately homogeneous group in both question submissions that have been prepared.

The explanation of the variation stage can reveal the differences in the ideas for change in the two problem proposals prepared by the moderately homogeneous group. The first problem proposal produced by the moderately homogeneous group used ideas for change related to geometric and arithmetic number sequences, as well as the addition of the difference values of arithmetic sequences, while the second problem proposal related to geometric and arithmetic number sequences, the type of problem text, and the questions asked. The problem generation stage can show how the process of getting ideas for change from each group member and how to realize them into new problems. Another thing that can be shown in the problem generation stage is the form of idea realization that can only be done by one member, but in producing decisions on ideas for change in both problem proposals is still done together. The dependence on one member of the moderately homogeneous group that is seen in the realization of ideas for change is the same as the results of the study Rahmadhani & Rosyidi (2025) that is, a medium group discussion is only based on the thoughts of two members of the 4 members of the group.

The problem-solving stage describes how the homogeneous group determines and implements appropriate problem-solving strategies in answering the questions in the two new problems. The solutions produced by the moderately homogeneous group tend to be monotonous in both problem-posing questions. This monotonous solution is based on the similarity of the problem information flow used in both new problem-posing questions. The evaluation stage reveals how the homogeneous group assesses the problem-posing questions and the steps taken to determine the accuracy of the two problem-posing problem-posing steps. The moderately homogeneous group assesses the second problem-posing question as better than the first. This is because the second problem-posing question uses the same number of geometric sequence terms as the given problem, as well as the use of contextual problem text related to the number of mathematical problems. The similarity in the number of geometric sequence terms is considered the reason for assessing the second problem-posing question because the moderately homogeneous group already has a good understanding of the information pattern of the first three-term series in the given problem. The accuracy of the problem-posing questions is carried out by the moderately homogeneous group by checking the previously agreed-upon geometric and arithmetic sequences.

The medium homogeneous group collaboratively determined the change ideas for both question proposals. This was evident from the active participation of each member of the medium homogeneous group in explaining the change ideas and experimenting with the ideas they proposed. Only one member of the medium homogeneous group successfully experimented with the ideas, so the trial of the change ideas for both question proposals was entrusted to that one member. The decision to use the tested ideas in developing new questions was still based on the opinion of each member of the medium homogeneous group. The medium homogeneous group was able to capitalize on the strengths of each group member

without compromising their confidence in their own abilities, thus avoiding relying on a single member to make all the decisions needed to complete the task.

C. Creative Thinking Ability of Heterogeneous Groups

The heterogeneous group only demonstrated creative thinking skills in the fluency component. This is inconsistent with the research Setiyani (2020) which states that heterogeneous groups can demonstrate fluency, flexibility, and novelty in the problem-posing approach. The reason that only fluency alone fulfills creative thinking skills in heterogeneous groups can also be based on research results Khumaidi & Budiarto (2013) which says that students with high and medium abilities can demonstrate fluency, while students with low abilities cannot but demonstrate all indicators of creative thinking, so that the collaboration of the three students with different initial abilities is less than optimal in demonstrating all indicators of creative thinking.

Fluency can be demonstrated by heterogeneous groups by submitting two varied problems. These variations include differences in geometric sequences, arithmetic sequences, the third term pattern of arithmetic sequences, and the type of problem text. Each member of the heterogeneous group was seen actively contributing ideas and experimenting with those ideas, but only one member succeeded in experimenting with the idea. The success of the experiment carried out by one member was then used in both problem submissions. During the discussion, it was apparent that the heterogeneous group only relied on the thinking of one member because the other members felt incapable of realizing the idea. Fluency in the heterogeneous group can be seen in the submission of the following two new problems.

KF

Jumlah Tiga suku pertama barisan geometri adalah 175. Jika suku pertama dan suku kedua tetap, namun suku ketiga hasil penjumlahan suku pertama dan ketiga. Maka, ketiga bilangan tersebut membentuk Barisan Aritmetika. Tentukan jumlah suku Barisan Aritmetika tersebut.

Information:

- Changing the pattern of the third term of an arithmetic sequence
- Changing the form of geometric and arithmetic sequences
- Changes to the questions asked

Figure 8. Submission of the First Question for the Heterogeneous Group

Doni dan Rafi menabung selama tiga minggu untuk membeli sepeda lipatan mereka. Jumlah tabungan Doni setiap minggu membentuk barisan geometri. Sedangkan tabungan Rafi adalah Rp. 260.000. Tabungan Rafi setiap minggu membentuk barisan Aritmetika. Pola tabungan Rafi dibuat berdasarkan tabungan Doni, dengan aturan sebagai berikut:

- Tabungan minggu pertama Rafi sama seperti tabungan minggu pertama Doni.
- Tabungan minggu kedua Rafi adalah tabungan minggu kedua Doni dikurangi tabungan minggu pertama Doni.
- Tabungan minggu ketiga Rafi sama seperti tabungan minggu kedua Rafi.

Tentukan jumlah seluruh tabungan Rafi!

Information:

- Changing the pattern of the second term of an arithmetic sequence
- Changing the pattern of the third term of an arithmetic sequence
- Changing the form of geometric and arithmetic sequences
- Changes to the questions asked

Figure 9. Submission of Questions by the Two Heterogeneous Groups

The heterogeneous group failed to demonstrate flexibility in both of the questions they had prepared. This was because the problem information flow used in both questions was the same, so the heterogeneous group used the same steps in both questions. The similarity of the steps in both questions increased the heterogeneous group's confidence that there was no other appropriate method to use to answer the questions posed other than the method they had written. The heterogeneous group's explanation regarding the lack of flexibility in the TPMKM can be seen in the following interview transcript.

Label	Interview Transcript
PHE1FL67	In the results of the first problem-solving assignment, are there any other ways you can solve the problem?
SHE1FL68	We don't think there is one, because the solution we've written is the only way to solve the first problem. A different solution, in our opinion, would involve first converting the three-term arithmetic sequence into a series before substituting the first term and the ratio to answer the question.
PHE2FL69	In the second problem-posing task, are there any other ways you can use to solve the problem?
SHE2FL70	In our opinion, there is none, because in the second problem statement, the arithmetic sequence arrangement pattern is only changed, so the stages of solution are the same as the problem given and the first problem statement.

The heterogeneous group could not demonstrate novelty in content and context in both problem proposals. The information flow used in both problem proposals was the same as the given problem, namely knowing the geometric sequence and using it to construct an arithmetic sequence. The similarity in the information flow indicates the absence of novelty in content in both problem proposals. Context novelty could only be demonstrated by the heterogeneous group in the second problem proposal by changing the mathematical problem into a contextual problem. In the first problem proposal, the heterogeneous group used the same type of problem as the given problem, namely a mathematical problem, thus not demonstrating any context novelty.

The creative thinking abilities of heterogeneous groups can be seen in detail in the description of the stages of collaborative problem-posing in each question. All stages of collaborative problem-posing can be demonstrated by the moderately homogeneous group. The situation analysis stage is carried out well by the highly homogeneous group in analyzing all important information and determining a solution strategy for the given problem. The stages of variation, problem generation, problem solving, and evaluation can be demonstrated by the moderately homogeneous group in both question-posing proposals that have been prepared.

The variation stage reveals the differences in ideas for change in both problem proposals, demonstrating the fluency of the heterogeneous group. The problem generation stage demonstrates how the heterogeneous group derived its ideas for change from both problem proposals. It also demonstrates whether the heterogeneous group's collaboration is progressing well. One example of information obtained from the problem generation stage is that the heterogeneous group appears to rely solely on the thinking of one member, resulting in poor collaboration. The problem solving stage demonstrates the process of determining and implementing the heterogeneous group's problem-solving strategy for both problem proposals. Information obtained from the problem solving stage demonstrates that both problem proposals have the same solution stages. In the evaluation stage, the heterogeneous group demonstrates its assessment of the two problem proposals and the steps taken to examine the accuracy

of the problem-solving strategies used in both problem proposals.

Heterogeneous groups demonstrated both good and poor collaboration when completing problem-posing tasks. Good collaboration was demonstrated by heterogeneous groups when each member attempted to construct new arithmetic and geometric sequences, as well as formulating a second problem based on the agreed-upon change idea into a contextual problem related to saving activities. Poor collaboration was seen when heterogeneous groups realized ideas and made decisions based on the opinion of only one member, namely a student with high mathematical ability. This was caused by a decrease in the self-confidence of students with medium and low mathematical ability when they were unable to realize ideas into the formulation of new problems. This decreased self-confidence became the beginning of all decisions depending on only one student, namely the student with high mathematical ability. This heterogeneous group collaboration is similar to the results of research from Khusnah & Rosyidi (2024) which states that active collaboration is only carried out by students with high and medium abilities, while students with low abilities are less visible in the process.

CONCLUSION

Based on the research results and discussions that have been described in the previous chapters, the following conclusions can be drawn regarding the creative thinking abilities of high school students in posing collaborative problems on sequences and series.

A. Creative Thinking Ability of Homogeneous Groups in Collaborative Problem-Submitting Tasks

Highly homogeneous groups demonstrated greater creative thinking skills than moderately homogeneous groups. This was evident in the collaborative problem-posing task results. Highly homogeneous groups demonstrated fluency, flexibility, and novelty, while moderately homogeneous groups only demonstrated fluency and flexibility. This difference in creative thinking skills suggests that the composition of group members influences the resulting product, which in this study was a novel problem.

The number of new questions submitted by the high and medium homogeneity groups was the same, namely two new questions. The number of new questions produced by both groups is a sign that they can demonstrate fluency. Fluency is also seen from the variety of new questions produced by the high and medium homogeneity groups. The variety of questions made by the high homogeneity group appears to be more creative than the medium homogeneity group. This statement is based on the idea of changing the flow of problem information in the second question submission made by the high homogeneity group, while the medium homogeneity group uses the same flow of problem information as the questions given in the two question submissions that have been made. Creative ideas are also seen from the use of text types by the high homogeneity group in the two new questions. The high homogeneity group uses contextual problems in both new questions with different problem contexts, while the medium homogeneity group can only compose one contextual problem.

The flexibility demonstrated by the high and medium homogeneity groups in the TPMKM results has similarities and differences. The similarities can be seen in the acquisition of different solution methods from the solutions on the TPMKM sheet. Both groups were seen to only write one solution on the TPMKM worksheet, but during the interview both groups were able to produce other solution methods for the questions they had created. The difference is seen in the ability of the high and medium

homogeneity groups to produce more than one solution for each question. The high homogeneity group can show flexibility in both question submissions, while the medium homogeneity group only shows flexibility in the second question submission. The accuracy of the different methods produced by the high homogeneity group during the interview cannot be known, because they did not provide written solutions, while the medium homogeneity group can show the accuracy of different methods in the second question submission because it is proven through writing.

In the problem proposals made by each homogeneous group, it is seen that the high homogeneity group can demonstrate novelty, while the medium homogeneity group cannot demonstrate such novelty. The high homogeneity group can demonstrate novelty of content and process in the second problem proposal, while in the first problem proposal only shows novelty of context. The novelty of content is seen from the idea of changing the flow of problem information, and the novelty of context is seen from changing the type of problem text, namely changing the mathematical problem into a contextual problem. The first problem proposal made by the medium homogeneity group does not have novelty of content and context, while in the second problem proposal it appears only to have novelty of context. Fulfillment of novelty of context alone in the second problem proposal by the medium homogeneity group still does not show novelty in this study.

The collaboration of each member of the highly homogeneous group appears to be better than that of the moderately homogeneous group. This is based on the results of observations and FGD interviews which indicate that the highly homogeneous group does not solely rely on one member in generating, making decisions, and realizing ideas for change. In the moderately homogeneous group, there is a student who is dominant in realizing ideas for change generated by each group member. Each member of the moderately homogeneous group is seen actively contributing ideas, but only limited to initial ideas and not to the realization of the idea. The realization of ideas that only depend on one member of the moderately homogeneous group indicates poor collaboration.

B. Creative Thinking Ability of Heterogeneous Groups in Collaborative Problem-Submitting Tasks

Heterogeneous groups can demonstrate creative thinking skills in the form of fluency alone. Fluency is seen when heterogeneous groups can produce two new, varied problems. The variations referred to relate to differences in ideas for change in the two problem proposals, such as differences in information in the form of geometric sequences, arithmetic sequences, the arrangement pattern of the second and third terms of arithmetic sequences, and the type of problem text. The proposal of two questions that are said to be new relates to ideas for change that are different from the questions given. These ideas relate to changes in information regarding geometric sequences, arithmetic sequences, the arrangement pattern of the second and third terms of arithmetic sequences, the type of problem text, and the questions asked.

The heterogeneous group failed to demonstrate flexibility in solving the two problems. Interview excerpts show the heterogeneous group was unable to determine a different method for the two problems. This is because the heterogeneous group used the same problem information flow as the problem presented in both problems, so they felt confident that there was only one correct solution method. This belief was also based on the heterogeneous group's verification of the results of the solution stages in both problems using geometric number sequences arranged before posing the two problems.

Novelty was also not demonstrated by the heterogeneous group in both of the

questions they submitted. Both questions submitted by the heterogeneous group used the same problem information flow as the given question, so there was no apparent novelty in the content of the two questions. Contextual novelty was only evident in the second question submission by changing the mathematical problem into a contextual problem, while the first question submission used the same type of text as the given question, namely a mathematical problem. The heterogeneous group was only able to demonstrate one component of novelty in the second question submission. This does not align with the creativity indicators in the study, so it can be said that the heterogeneous group was unable to demonstrate novelty in the second question.

The collaboration carried out by heterogeneous groups appears to be less than optimal, because it only relies on one member to decide on the change idea to be used and realize the idea in compiling new problems. Each member of the heterogeneous group appears to be actively contributing ideas, but students with medium and low mathematical abilities are more confident in the ideas produced by students with high mathematical abilities. This indicates poor collaboration from heterogeneous groups, because decisions and realization of ideas are only based on the thoughts of each group member. The impact of this less than optimal collaboration causes a lack of variety of ideas in compiling new problems and different problem-solving methods, so that heterogeneous groups cannot demonstrate flexibility and innovation.

SUGGESTIONS/RECOMMENDATIONS

Based on the conclusions of the research results, the suggestions that researchers can put forward are as follows.

1. This study found that highly homogeneous groups demonstrated greater **creative thinking skills in** the form of **fluency, flexibility, and novelty** compared to moderately homogeneous and heterogeneous groups. These findings can be considered by teachers in implementing group-based learning models to enhance the creativity of each student, thus creating a creative product that demonstrates fluency, flexibility, and novelty for the entire group.
2. Researchers interested in conducting similar research are advised to consider group composition to achieve their desired research objectives. Further research could consider heterogeneous groups, beyond those comprising high-, medium-, and low-ability students, to provide a deeper understanding of the creative thinking abilities of heterogeneous groups when posing problems collaboratively.

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