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COLLABORATIVE PROBLEM-SOLVING PROCESS IN JUNIOR HIGH SCHOOL STUDENT ASSOCIATION MATERIALS BASED ON HETEROGENEITY OF MATHEMATICAL ABILITY

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Abstract
Students' mathematical problem-solving skills currently demonstrate a low proficiency, thus necessitating a collaborative approach that effectively integrates cognitive and social abilities in problem resolution. This study aims to describe the process of Collaborative Problem Solving (CPS) among students at SMPN 22 Surabaya on the topic of sets, based on the heterogeneity of their mathematical ability, namely the high-medium, high-low, and medium-low groups. The research employed a descriptive qualitative approach, utilizing problem-solving tests, video interaction observations, and semi-structured interviews. The data were analyzed using established CPS indicators and standard problem-solving steps. The findings reveal that the high-medium group successfully executed a complete CPS process characterized by balanced interaction. In contrast, the high-low group exhibited unequal collaboration, marked by the dominance of the high-ability student. Furthermore, the medium-low group experienced significant obstacles in nearly all problem-solving stages and was heavily dependent on researcher assistance. The study concludes that the range of mathematical ability within a group is a determining factor for the success of CPS, as ability gaps impede the necessary exchange of ideas, negotiation of meaning, and joint strategy formulation. The practical implications of this research underscore the importance of mapping student capabilities and reinforcing fundamental concepts prior to implementing CPS in mathematics instruction.

Keywords: Collaborative Problem Solving (CPS), Junior high school, Problme Solving, Sets, Ability Heterogenetity.

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INTRODUCTION

Education aims to stimulate intelligence and shape the character of students to be independent and skilled. In this context, mathematics plays a crucial role because it is a basic science for analysis whose reasoning aspects are important for mastering science, technology, and knowledge. Current mathematics learning should include formulating, defining, applying, and considering various solutions to problems.

Problem solving *skills are* recognized as one of the core competencies in the 21st century, along with critical thinking, creativity, communication, and collaboration. This ability is essential to prepare students to tackle social, scientific, and practical problems in the future. The National Council of Mathematics Teachers (NCTM, 2000) places problem-solving as the primary goal of mathematics learning.

However, students' mathematical problem-solving skills are still relatively low, which is also influenced by learning interests that are not optimal. This reality is reflected in the results of academic achievements that are often below the Minimum Completeness Criteria (KKM). This situation shows the need for more effective learning methodologies to develop these essential skills.

One approach that is considered efficient is *Collaborative Problem Solving* (CPS), which combines cognitive problem-solving skills with collaborative social skills. CPS has been proven to improve students' problem-solving skills and concept understanding. In the context of collaboration, discussing and exchanging ideas is more effective than individual problem-solving.

Furthermore, CPS success tends to be higher in groups of students with heterogeneous math abilities. This heterogeneity triggers cognitive and multiperspective conflicts, which encourage students to acquire new knowledge and experiences. This research selected the material of the Association, which is a basic discussion and foundation of modern mathematics and has great potential to develop problem-solving skills.

Taking into account the urgency of developing problem-solving skills and the potential for optimization through heterogeneous collaborative groups, this study focuses on describing students' processes in dealing with mathematical problems.

Based on the background described, this study formulates the following problems: (1) how is the collaborative problem-solving process of junior high school students in set materials in groups with high and medium mathematics students, (2) how is the collaborative problem-solving process of junior high school students in set materials in groups of high and low math ability students, (3) how is the collaborative problem-solving process of junior high school students in the set material in groups of students with medium and low math ability.

The main objectives of this study are: (1) to describe the collaborative problem-solving process of junior high school students in the set material in the group of students with high and medium mathematical ability. (2) Describe the collaborative problem-solving process of junior high school students in the set material in the group of students with high and low mathematical ability. (3) Describe the collaborative problem-solving process of junior high school students in set materials in groups of students with medium and low math skills.

This research has strong relevance because it specifically seeks to understand how *the Collaborative Problem Solving* (CPS) process takes place in the Kumpulan material, which is a fundamental material in mathematics, with a focus on group dynamics that have heterogeneous levels of mathematical ability. Theoretically.

The results of this research are expected to (1) contribute to the development of mathematics learning theory, especially in deepening knowledge about the application and process of collaborative problem-solving skills. (2) to be a reference for teachers and curriculum developers for the process of collaborative problem-solving in optimal learning, especially in assigning students in heterogeneous groups to improve problem-solving skills.

RESEARCH METHOD

This research is a qualitative research with a descriptive approach that aims to describe the process of solving collaborative problems of junior high school students in set materials based on heterogeneity of mathematical ability. There are 3 instruments used, namely: Mathematical Ability Test (TKM), Collaborative Problem Solving Task (TPMK), and interview guidelines, with the researcher acting as the main instrument.

The subject of the study is located at SMP Negeri 22 Surabaya with the main subject being grade VIII students. The criteria for selecting subjects are based on the level of students' mathematical ability (High, Medium, and Low) TKM contains 5 description questions and is assessed using scoring guidelines developed by the researcher. The Mathematics Ability Test (TKM) using a range of scores categorized as high $80 \leq x < 100$, medium $60 \leq x < 80$, or low $0 \leq x < 60$ based on TKM scoring guidelines. Then three heterogeneous collaborative groups were formed to observe the CPS process which includes, group 1 consisting of students who have high and medium ability (T-S), group 2 consisting of students who have High and Low (T-R) abilities, and group 3 consisting of students who have Medium and Low (S-R) mathematical skills, the material in this study is a set. The results of the Mathematical Ability Test (TKM) can be seen in Table 3.1

Table 3.1 Results of the Mathematical Ability Test

NO	Student Initials	Gender	TKM Value	Category
1	ANKL	P	79	Medium
2	AAR	P	92	Height
3	AS	L	80	Medium
4	ALPS	P	84	Height
5	ASR	P	92	Height
6	ASA	P	82	Medium
7	AFM	P	74	Medium
8	CRH	P	52	Low
9	DKD	P	78	Medium
10	DN	P	73	Medium
11	FNA	L	88	Height
12	FAR	L	85	Height
13	GRM	L	70	Medium
14	HDES	L	58	Low
15	SMALL	P	78	Medium
16	KNY	L	94	Height
17	BECAUSE	L	56	Low
18	KSZ	P	86	Height
19	LTT	P	85	Height
20	MKS	P	52	Low
21	MNAZ	P	78	Medium
22	MKZR	L	75	Medium
23	PLM	P	86	Height
24	RKR	L	90	Height
25	RCA	L	55	Low
26	SLS	P	78	Medium
27	SSN	P	52	Low
28	SZPW	P	80	Medium
29	TCG	L	82	Height
30	YBG	L	74	Medium
31	YKA	P	73	Medium
32	YDN	L	70	Medium

Source : Gender Data and TKM Results

Based on Table 3.1, 32 students with a gender of 14 male students and 18 female students. This study aims to describe the Collaborative Problem Solving Process of junior high school students in solving mathematical problems. Fiore

(2017) said that the likelihood of success in the problem-solving process is higher if the collage group consists of students with heterogeneous abilities. Therefore, the six students who were selected as the subjects of the study were divided into three collaborative groups consisting of two students with different mathematical abilities. The three groups include students with High-Medium (TS) mathematical ability, students with High-Low (TR) mathematics skills and students with Medium-Low (S-R) mathematics skills. Six research subjects were selected based on the results of TKM and the consideration of mathematics teachers in grade VIII divided into three groups as follows.

Table 3.2 List of Research Subjects

Yes	Groups	Subject Name Research	Math Ability
1	Group 1 (consisting of students with high and moderate math ability)	KYN	Height
		MKZR	Medium
2	Group 2 (consisting of students with high and low math ability)	ASR	Height
		KER	Low
3	Group 3 (consisting of students with medium and low math ability)	SLS	Medium
		HDES	Low

The selected subjects then worked on the Collaborative Problem Solving Task (TPMK) which consisted of two questions describing the set material prepared by the researcher with the approval of the supervisor.

Table 3.3 Collaborative Problem Solving Task (TPMK)

Yes	Questions
1	In a school activity, students can join the Music Club (M), the Science Club (S), or both. Of the 40 students who participated in the activity:• 22 students participated in the Music club; •18 students joined the Science Club;• 10 students participated in both;• The rest did not participate in both clubs. a. Determine the number of students who do not participate in the two clubs and explain the analysis steps.
2	One of the 7th grades consists of 120 students. They were provided with three extracurricular activities, namely Scouting, Paskibra, and Basketball. Of the number of students in the class, 100 students participated in at least one extracurricular activity, 65 students participated in Scouting, 45 students participated in Paskibra, 42 students participated in Basketball, 20 students participated in Scouts and Paskibra, 25 students participated in Scouts and Basketball, and 15 students participated in Paskibra and Basketball. Determine the number of students participating in each of these extracurricular activities and explain your group's strategy for finding the Venn diagram.

The answers are analyzed based on the indicators of the Collaborative Problem Solving Process using the OECD theory (2017) can be seen in Table 3.4 as follows.

Table 3.4 Collaborative Problem-Solving Process

	(1) Building and maintaining a common understanding	**(2) Take the right action to solve the problem**	**(3) Build and maintain team organization**
(A) Explore and understand	(A1) Finding the perspectives and abilities of team members	(A2) Find the types of collaborative interactions in solving problems	(A3) Understand the role to solve problems

(B) **Representing and formulating**	(BI) Building a shared representation and discussing the meaning of the done	(B2) Identify and describe tasks to be completed	(B3) Describe the role and organization of the group (communication/rules of engagement)
(C) **Plan and execute**	(C1) Communicate with team members about actions to be taken/are being taken	(C2) Execute the plan	(C3) Follow engagement rules (e.g., encouraging other group members to do their jobs)
(D) **Monitoring and Reflection**	(D1) Monitor and improve mutual understanding	(D2) Monitor the results of actions and evaluate success in solving a problem	(D3) Monitor, provide feedback, and adapt organizational and team roles

To reinforce the validity of the findings, the interview was conducted using structured guidelines to validate written responses and explore the reasons behind the completion steps that were not always contained in the answers. Interviews also help ensure the consistency of students' understanding of their thinking process. This stage serves as an important triangulation in qualitative research, so that the results of the analysis can be accounted for scientifically and in-depth.

RESEARCH RESULTS AND DISCUSSION

Results

1. Based on the results of the Mathematics Ability Test (TKM) of SMPN 22 Surabaya students in class VIII-C, 12 students with high ability were obtained, students with medium abilities were 15 students while students with low abilities were 5 students. Through the Mathematics Ability Test (TKM), 6 subjects with high and equivalent abilities were selected, namely group 1 with High-Medium ability KNY (TKM 94)-MKZR (TKM 75), group 2 with high-low ability ASR (TKM 92) KER (TKM 56) and group 3 SLS (TKM 78) HDES (TKM 58). The six subjects underwent a Collaborative Problem-Solving Task (TPMK) and an interview to identify the collaborative problem-solving process based on indicators, namely (1) Finding the perspectives and abilities of team members. 2) Find a type of collaborative interaction in solving problems. (3) Understand roles to solve problems (4) Build a shared representation and discuss the meaning of the task (5) Identify and describe the tasks to be completed (6) Describe the role and organization of the group (communication/rules of engagement) (7) Communicate with team members about actions to be taken/are being taken (8) Execute plans (9) Follow rules of engagement (e.g., encourage other group members to do (10) Monitor and improve mutual understanding (11) Monitor the results of actions and evaluate success in solving a problem (12) Monitor, provide feedback, and adapt organizational and team roles.

The results of the analysis showed significant differences between the three groups, especially in the collaborative problem-solving process. The T-S group tends to be able to plan ideas or strategies, make calculations, and conclude solutions in solving problems and review the steps to solve them. The T-R group is able to solve problems collaboratively but the idea or strategy, do calculations and conclude solutions in solving problems is still lacking. Meanwhile, the S-R group is able to solve problems collaboratively but has not been seen as active in discussions and giving ideas in solving problems. The triangulation process is carried out to ensure data consistency.

1. Key Research Findings

Collaborative problem-solving process for High-Medium (TS) student groups

As a result of written work and interviews, the subjects of the High-Medium (TS) group were able to complete both CPS tasks more completely. Both of them understand information, make illustrations, execute strategies, re-examine answers, and collaborate in a balanced manner. The High–Medium (TS) group is able to complete both CPS tasks more completely. able to solve problems collaboratively. Where the researcher confirms the group's understanding in finding perspectives, communicating with team members about the actions taken and implementing the strategic plan in doing calculations, for example, in the first question he "mentioned the number of students who did not participate in the activities of 10 students" monitored the results of the action and evaluated the success in solving the problem, monitored and provided feedback on the steps to solve the problem, in the first question of TS mentioning the steps to solve the problem of students who do not follow both clubs by writing the formula "n(S) = n(AUB) + n(AUB) ^{c}

However, in solving the collaborative problem in question number 1, the TS group was unable to make illustrations according to the information. TS solved the second problem by planning his idea or strategy by drawing a diagram of the veen.

Collaborative problem-solving process of High-Medium (TR) student groups

As a result of written work and interviews, the Group (TR) can be found that the ability to solve collaborative problems on question number 1, the TR group is able to solve problems collaboratively. Where the researcher confirms the group's understanding in finding perspectives in understanding information and problems, building shared representations and discussing the meaning of the done," wrote down what was known from the total questions of 40 students, joined a music club of 22 students, participated in science 18 students, mn = followed both 10. "monitor the results of actions and evaluate success in solving a problem, find the type of collaborative interaction in solving a problem, write steps to solve the problem by using the formula "n(AUB)= n(A) + n(B)-(AUB) ^{c}. understand the role of problem solving, as well as describe the role and organization of the group. The second question is able to discuss by writing down what SDH knows. And able to write the final result of the student " x = 10, but in solving collaborative problems in question number 2 of the TR group, the ability to plan ideas or strategies, make calculations, and conclude solutions in solving problems. Question no. 2 depicts a veen diagram.

Collaborative problem-solving process for High-Medium (S-R) student groups

As a result of written work and interviews, the subjects of the High-Medium (S-R) group can be found to be able to solve collaborative problems in question number 1, the SR group is able to solve problems collaboratively. Where the researcher confirms the group's understanding (SR) in finding the perspective and ability of team members to "dislike both Clubs", build a shared representation and discuss the meaning of the action, communicate with team members about the action to be done/is being done, "formula s = music + science + dislike both" monitor the results of actions and evaluate success in solving a problem, "able to write x = 10". In question number 2 "describe a diagram of the veen" and understand the role of solving problems, identify and describe the tasks that must be completed." write down the number of each person who participates in extracurriculars. However, in solving collaborative problems in question number 1, "the SR group still does not seem active in discussions and giving ideas in solving problems.

2. Analysis and Interpretation of Findings

2.1. Cognitive Dynamics in CPS

In the TS group, both students showed the ability to understand information, build representations, and execute strategies in order. This indicates that despite the differences in ability levels, students still have sufficient cognitive capacity to verify and criticize ideas from high students. Such interactions—criticism, clarification, and verification—are key indicators of effective CPS.

In the TR group and especially SR, failure arises because the students' conceptual ability is not adequate to understand basic information on the set problems. When one member's cognitive abilities go too far, CPS loses the "exchange of ideas" that is at the heart of collaboration. This explains why the TR and SR groups only solve the problem when the researcher provides an external stimulus.

Core interpretation: Understanding the concept of sets is a prerequisite for meaningful CPS. When one member does not master the basic concepts, the group loses the mechanism of negotiating meaning, so collaboration turns into a tutor–novice relationship.

2.2. Collaborative Interaction Patterns

The TS group showed the most balanced interaction pattern. Mutual questioning, clarification, and strategy negotiation occur naturally. This indicates that group members recognize each other's competence.

In the TR group, the interaction pattern shifted to pseudo-collaboration. High students are the center of decision, while low students are passive. This suggests that too large a capability gap can hinder the division of roles, even though in theory CPS involves the active contribution of all members.

In the SR group, interactions hardly occurred without the intervention of the researcher. The problem is not only in mathematical ability, but also in students' low confidence in conveying ideas.

Core interpretation: CPS is not simply "clustered", but requires minimal equality in contribution capacity. Extreme inequality causes collaboration to collapse into one-way instruction.

3. Researcher's Argument on the Academic Meaning of the Results Based on the findings and analysis:

CPS is not only a matter of learning techniques, but about the composition of group abilities. The results of the study showed that early mathematical ability was a determinant of the quality of CPS interaction. This contributes to a literature that previously emphasized the CPS process rather than a pre-condition for its success.

The balance of abilities in the group determines the effectiveness of CPS more than the number of members. These findings reinforce Fiore's (2017) argument about the importance of contribution balance, but provide additional empirical evidence in the context of junior high school mathematics and set materials.

Set material as a basic concept of mathematics requires a strong symbolic and representational understanding. The results of the study show that the vulnerability of this basic concept can be a major obstacle in CPS. This provides methodological insight for teachers that CPS must begin with strengthening basic concepts.

This study makes a special contribution to the CPS literature in Indonesia, as it combines cognitive and collaborative indicators in detail (A1–D3 and K1–K4), providing a replicable analytical model.

CONCLUSION

This study shows that the success of Collaborative Problem Solving (CPS) in set materials is greatly influenced by the heterogeneity of mathematical abilities in the group. Groups with a not-so-distant range of abilities, such as the high–medium (TS) group, are able to run the CPS process in its entirety: understand information, build representations, plan strategies, and re-examine answers through balanced interactions. In contrast, groups with sharp differences in ability, such as high-low (TR) and especially medium-low (SR), experienced obstacles in the exchange of ideas, strategy development, and implementation of settlement steps. Interactions within these groups tend to be unequal, resulting in CPS turning into one-party dominance or even not running without researcher intervention.

Academically, this study confirms that CPS is not only determined by the design of the task or collaborative method, but also by the prerequisites of each member's conceptual ability. A basic understanding of the set material is an important foundation for the formation of meaning negotiations, cognitive conflicts, and productive discussions—key elements of effective CPS. These findings expand the literature by showing that the composition of group capabilities is an important variable that is often overlooked in the implementation of CPS. In addition, this study provides practical implications for teachers to pay attention to mapping students' abilities before forming collaborative groups, as well as providing reinforcement of basic concepts so that the CPS process can take place optimally.

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