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Students' Questions in Mathematics Learning Through Collaborative Problem-Solving Learning Model

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ABSTRACT

Mathematics learning activities are inseparable from questioning activities from students with teachers and students with each other. One of the learning models that potentially supports active students and can raise many questions is the collaborative problem-solving learning model. Activities in the collaborative problem-solving learning model direct students to collaborate in problem-solving. This mixed-method research aims to analyze students' questions based on the categories of lower cognitive level questions, higher cognitive level questions, and task-oriented questions in collaborative problem-solving learning. The subjects of this research were 33 students from grade VIII in one of the junior high schools in Indonesia. The research instruments used were observation and interview. The data analysis process in this research includes data collection, data display, data reduction, and drawing verification conclusions. The results showed that collaborative problem-solving learning models had an advantageous effect on the development of students' questions. More importantly, most questions are in the type of higher cognitive level thinking questions.

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INTRODUCTION

One of the main characteristics of student-centered learning is the active involvement of students in learning. Evidence that students actively participate in learning can be seen from the submission of questions (Jacobs & Renandya, 2021), which are asked to the teacher or to their friends. Every student fundamentally has a tendency to ask questions to find out the information they want to know, but whether this is facilitated in class is another matter entirely. Nevertheless, questioning is an important step in promoting student learning (Kemmerle, 2013; Wong, 2015). Furthermore, student questions can enhance engagement with the material and challenge students (Caspari-Sadeghi et al., 2021). These illustrate the significance of student questioning activities and can be a pivotal factor in determining learning outcomes (Ili et al., 2021).

High-achieving students tend to ask detailed questions (Leikin et al., 2017). Additionally, students who proactively ask questions demonstrate a better understanding of mathematics (Umah et al., 2023). The quantity of student questions is correlated with students' comprehension of reading (Taboada & Guthrie, 2006). Therefore, students must develop their competencies or take the liberty of raising questions. There are several ways to develop students' questions. In this case, teachers should facilitate students' asking questions to encourage the development of student knowledge (Kemmerle, 2013). Therefore, creating active learning is a potential tool to develop students' questioning skills. Thus, this research aims to determine students' ability to ask questions in a learning environment.

Previous research has not addressed the questions raised by students in the collaborative problem-solving learning model. Given the significance of students' questions and the potential for collaborative problem-solving learning models to facilitate students' questions during the learning process, researchers are interested in conducting research that focuses on analyzing the questions asked by students during learning using collaborative problem-solving learning models. The research questions of this study are as follows:

1) How is the collaborative problem-solving learning model in learning Pythagoras theorem?
2) What type of questions do students use in the collaborative problem-solving learning model in learning Pythagoras theorem?

LITERATURE REVIEW

Questioning in a learning environment

Questioning is a high-level cognitive skill that is integral to critical thinking, problem-solving, decision-making, creativity, evaluation, cooperation, and science literacy (Chin & Osborne, 2008). For students, questioning skills can serve as a self-regulation strategy with numerous benefits (Stokhof et al., 2019). These benefits include improved mathematical understanding (Teodoro et al., 2011), encouraging students' metacognition in monitoring students' thinking processes (Hamzah & Santoso, 2019). For teachers, questions serve as an effective tool during the teaching and learning process (Basri et al., 2019; Mahmud & Mohd Drus, 2023). Teachers can use students' questioning skills as a tool to ascertain the extent of students' understanding of the material being studied. By posing inquiries to students, teachers can ascertain the efficacy of the educational materials they provide, thereby ensuring that students are adequately comprehended (Meldina, 2019).

Research on students' questioning skills is very interesting to study, therefore, teachers must facilitate students regarding questioning. Research conducted by (Özpinar, 2023) indicates that more than half of students refrain from asking questions in mathematics classes due to feelings of frustration and fear. Factors influencing students' questioning skills include their ability to comprehend the material and tasks, the availability of learning facilities and infrastructure, and the teacher's response to student questions (Hidayah et al., 2019). The studies presented indicate that the process of asking questions by students and teachers plays an important role in learning mathematics. But at the same time, students have not asked questions in learning optimally.

Classification of questions in the learning environment

Graesser and Person (1994) classified questions asked by students into two categories: those requiring short answers and those requiring long answers. Erdogan and Campbell (2008) improved Graesser and Person (1994) taxonomy of question types to analyses the types of questions asked by teachers into 3 categories, including closed questions, open questions, and task-oriented questions. To analyses questions asked by students, Erdogan (2017) improved the taxonomy of question types categorized by Graesser and Person (1994) into 3 categories, including lower cognitive level questions, higher cognitive level questions, and task-oriented questions.

The cognitive level of a question determines the complexity of the response required. Lower cognitive level questions require simple answers, recall of factual information, and recognition processes. Higher cognitive level questions require more detailed relational responses, encourage creativity, encourage critical thinking skills, and involve the process of analysis, synthesis, and evaluation. Task-oriented questions are a type of question that expresses sentences necessary to maintain classroom discipline (Erdogan, 2017). An illustrative example of questions can be found in Table 2.

Collaborative problem-solving learning model

Collaborative problem-solving learning model is a combination of collaborative learning and problem-based learning. Collaborative learning involves thinking efforts to explore understanding, solutions, and meaning and produce something based on mutual agreement (Schwarz et al., 2021). Meanwhile, problem-based learning is learning that is caused by problems to encourage students to work in groups to find solutions to problems, which prioritizes problem-solving (Rézio et al., 2022). The collaborative problem-solving learning model involves cognitive and social skills (Griffin & Care, 2014). The cognitive skills are problem-solving, while the social skills are collaboration skills.

The existence of a collaborative problem-solving learning model can increase student learning activities because, in this learning model, the teacher's role is to create situations that can facilitate the emergence of questions from students. Thus, the collaborative problem-solving learning model will motivate students to actively ask questions through the collaborative problem-solving learning stages, which require students to identify a problem, plan problem-solving individually and work together in a group to present the results of the collaboration (Sulistyowaty et al., 2019). Faizah et al. (2021) also argue that group discussions can lead to interactions in the form of expressing opinions, rebuttals, asking questions, and answering the questions asked. The foundation of collaborative learning is the premise that students are willing to dedicate effort to contributing their own ideas and to providing constructive feedback on the contributions of their peers (Hoek & Seegers, 2005).

Collaborative problem-solving model learning was carried out through six stages of learning (Ummah & Fathani, 2018). The first stage is engagement or grouping. At this stage, students form groups consisting of 6 or 7 students. The potential for unexpected outcomes between students with disparate mathematical abilities was heightened when the utility of grouping students according to prior performance was overlooked (Russo et al., 2020). Instead, students are permitted to select their own group members, who will collaborate and deliberate to resolve the issue at hand. This approach was selected to foster a more conducive environment for students to inquire about the subject matter. In the engagement phase, we comprise the exploration of needs and the formulation of preliminary goals. The second stage of collaborative problem-solving learning is exploration or giving problems. The teacher provides students with activity sheets to solve problems. At this stage, students who have questions are encouraged to ask them of the teacher or their group mates. Students attempted to understand the problems on the student activity sheet and none of them asked questions about the material.

The third stage in collaborative problem-solving learning is transformation or collaborative discussion. This is the process of solving problems together in a group that has been formed. At this stage, students exchange opinions and ideas in discussions to solve a problem that has been given by the teacher. This stage involves many questions being asked by each student individually. At the third stage, students are also required to demonstrate their ability to collaborate effectively. This includes the ability of collaborative problem-solving skills.

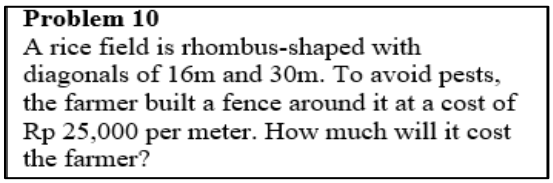
The fourth stage of collaborative problem-solving learning is the solution or checking of the results of group discussions. At this stage, the results of group discussions that have obtained mutual agreement through exchanging opinions or ideas will be provided to the teacher for assessment. The teacher will then ask questions about the results of the discussion in order to ascertain whether the problem-solving solution is indeed good and correct. Additionally, the teacher will inquire as to how the group plans to obtain the results of the problem solution if the proposed solution is deemed correct. At this stage of collaborative problem-solving learning, students demonstrate their ability of D2 (see Table 1 for details).

The fifth stage of collaborative problem-solving learning is the presentation of group discussion results. At this stage, one group will present the results of their discussion on Pythagoras material to the

class. During the presentation, students from other groups observe, comprehend, and respond to the results of the discussion presented. Subsequently, students may ask questions about the results of other groups' discussions. At this stage the D3 (see Table 1 for details) collaborative problem-solving indicator has been met by the class. The sixth stage in collaborative problem-solving learning is reflection. At this stage, students conclude the Pythagorean Theorem material that has been learned after the question-and-answer process between groups, guided by the teacher. At this stage, there were only a few questions that arose to confirm students' understanding.

METHODS

The current research used a mixed methods design suggested by Creswell and Creswell (2018), the researchers collected data through two types of observations in the mathematics classroom and interviews with students. The first observation was the collaborative problem-solving process, and the second observation was the student's questions in the collaborative problem-solving process. The Preliminary research was conducted in one of the junior high schools in Semarang City, Indonesia, in November 2022. The observations revealed that only a few students asked questions, which were limited to inquiries about the solutions to the problems presented. The same students and school were selected as the subject of the research implementation, which was conducted in February 2023. The subjects in this study consisted of 33 students (S01-S33). The subjects in this study have confirmed that they agreed to be involved in this study.


Problem 10
A rice field is rhombus-shaped with diagonals of 16m and 30m. To avoid pests, the farmer built a fence around it at a cost of Rp 25,000 per meter. How much will it cost the farmer?

Picture 1. Problems in collaborative problem-solving learning

This study consisted of four meetings. At the beginning of learning, students were introduced to the basics of the Pythagorean theorem. A total of 10 questions refers to problems presented to the students were used in the second and third meetings, with each meeting using 5 questions assigned to each group, the following in Picture 1 some of the questions used. The tasks were based on the learning outcome guidelines provided by the Ministry of Education. The tasks encompassed a range of activities, from routine to non-routine and from non-real-life to real-life scenarios. Furthermore, the core principle of problem-solving assessment ability by Chusinkunawut et al. (2018) was also considered. The characteristics of content and teachers in mathematics learning are very influential regarding students' perceptions in students' mathematics learning (Sasidharan & Kareem, 2023). Thus, the researcher ensured that the content of the questions had gone through good criteria through discussions with one experienced mathematics education teachers and one mathematics education researcher.

Table 1. Collaborative problem-solving skills

	(1) Building and maintaining common understanding	**(2) Take appropriate action to solve the problem**	**(3) Establish and maintain team organization**
(A) Exploring and understanding	(A1) Find team members' perspectives and skills	(A2) Find types of collaborative interaction to solve problems together, along with goals	(A3) Understand the role of solving the problem
(B) Representing and formulating	(B1) Building shared representations and negotiating the meaning of the	(B2) Identifying and explaining the tasks to be to be completed	(B3) Describe team roles and organization (communication

	(1) Building and maintaining common understanding	(2) Take appropriate action to solve the problem	(3) Establish and maintain team organization
	problem		protocol)
(C) Planning and implementing	(C1) Communicating with team members about actions that will or are being taken	(C2) Enacting plans	(C3) Following the rules of engagement (Encouraging other team members to perform their tasks)
(D) Monitoring and reflecting	(D1) Monitoring and repairing the shared understanding	(D2) Monitoring results of actions and evaluating success in solving the problem	(D3) Monitoring, providing, feedback and adapting the team organization and roles

The data collection technique used in this research is observation which is located in the second and third meeting. Observations were made throughout the implementation of collaborative problem-solving based on the syntax of Ummah and Fathani (2018), namely, engagement, exploration, transformation, solution, presentation, and reflection. In this study, the six stages were implemented in two learning meetings. In the literature review section, it has been explained that the collaborative problem-solving learning model has an influence on collaborative problem-solving skills, so this research will also ensure that this is achieved. As a result, we also considered collaborative problem-solving skills to construct our observation instrument. There are 3 main competencies of collaborative problem-solving. These core competencies were crossed with four key individual problem-solving processes to form a matrix of specialized skills. Table 1 illustrates the interaction between the three collaboration processes (OECD, 2017). In short, an observation sheet of learning implementation using collaborative problem-solving models consisted of two meetings, this observation sheet was used to ensure that students' collaborative problem-solving skills are also achieved through the learning stages carried out.

Table 2. Question type taxonomy used

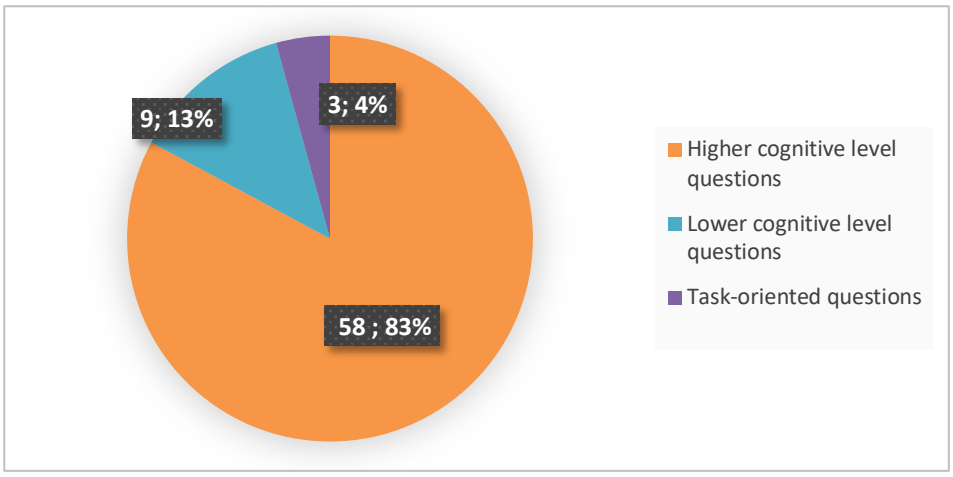
Question type	Description
Lower cognitive level questions	
1. Verification	Questions that require a "Yes" or "No" answer
2. Disjunctive	Questions that need simple decisions between two options
3. Concept Completion	Questions that require to fill in the blanks
4. Feature Specification	Questions on the importance of learning the material being learnt
5. Quantification	Question to determine quantitative attributes of object or situation
Higher cognitive level questions	
6. Definition	Ask the definition of a concept
7. Example	Request for instance of a particular concept or event type
8. Comparison	Questions about the differences between the problems faced
9. Interpretation	Questions about explaining what and how to solve a problem
Causal Antecedent	Ask for an explanation of the situation that occurred when solving the problem
Causal Consequence	Asks for an explanation of the consequences for an event of state
Enablement	Questions about how a problem is solved
Expectational	Ask about predictions or expectations

Question type	Description
Judgmental	Asks about value placed on an idea, advice, or plan
Task-oriented questions	
Group dynamics	Questions about how the discussion went in a group
Monitoring	Help check on progress, request for planning
Self–directed learning	Relate to defining learning issues, who found what information
Need clarification	Questions that require an explanation of something that has not been understood and require confirmation
Request/Directive	Request for action related to collaborative problem-solving process

The reseacher collected all questions asked by students during learning including during discussions in the second and the third meeting using observation sheets. To analyze the questions asked by students during collaborative problem-solving learning, this study used 3 types of questions based on (Erdogan, 2017), which are listed in Table 2. To gain more depth analysis, semi-structured interviews were conducted in the fourth meeting. Students who asked questions representing each type of question were selected for further interviews to ascertain the reasons behind their questions. For example, why did she ask her friend the question "Does it really not fulfil the rules?". This question had a yes or no answer which is categorize as a verification question. Due to the absence of type of student questions, there were only 15 questions for each 15 students.

RESULT

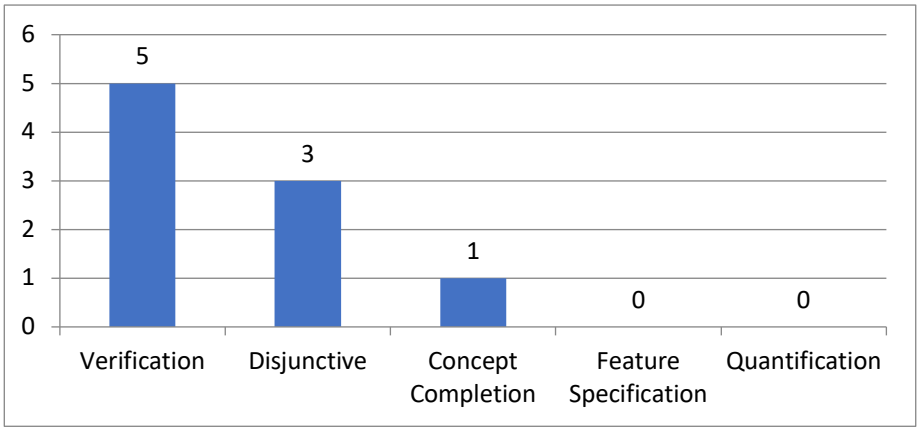
The implementation of collaborative problem-solving learning models in this study showed that each stage was well implemented. In addition, most of the collaborative problem-solving skills can also be achieved, although there is one collaborative problem-solving skill that has not been achieved, namely the C3 indicator. This good implementation at least ensures that the questions asked by students are integral to the implementation of collaborative problem-solving learning.



Picture 2. The frequency of the number of questions asked by students.

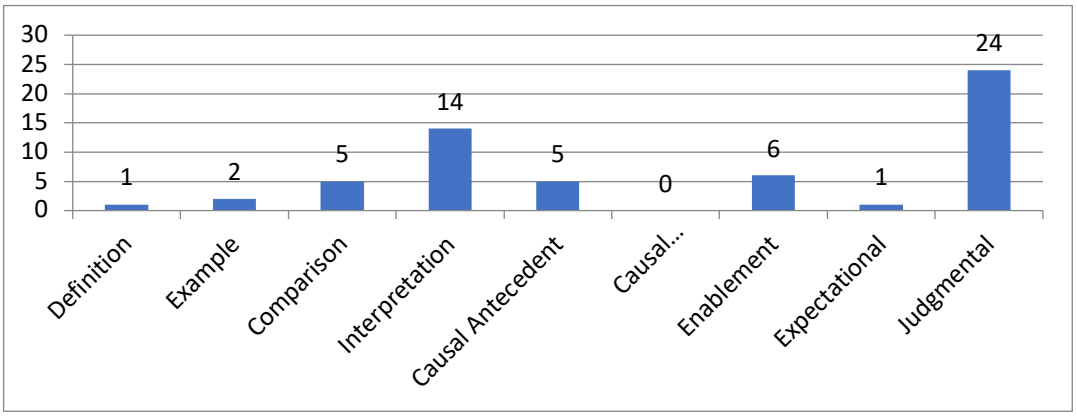
Students' questions were categorized based on the types of lower cognitive level thinking questions, higher cognitive level thinking questions, and task-orientated questions. Based on that presented in Picture 2. There were 69 questions asked by students in three types of questions. In the lower cognitive level question type, there were 9 questions asked by students. In the higher cognitive level question types, there were 58 questions asked by students. In the type of task-orientated questions, there were 3 questions. This result is in line with research conducted by (Erdogan, 2017) that higher cognitive level questions appear the most and the least are lower cognitive level questions.

Lower cognitive level thinking questions consist of 5 types of questions that appear. Among them were verification, disjunctive, concept completion, and feature specification question types. Verification type questions appeared with the highest frequency. The question type that did not appear at all in this study was the feature specification and quantification question type. The grouping of lower cognitive level thinking question types can be seen in Picture 3.



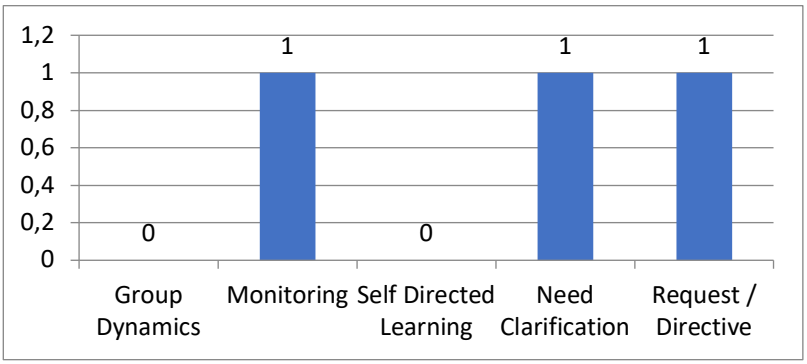
Picture 3. The frequency of questions appearing on lower cognitive level questions

Higher cognitive level thinking questions consisted of 58 questions with 8 types of questions. Among them were definition, example, comparison, interpretation, causal antecedent, causal consequence, enablement, expectational, and judgmental question types. Judgmental type questions appeared with the highest frequency. The question type that did not appear at all in this study was the causal consequence question type. The grouping of higher cognitive level thinking question types can be seen in Picture 4.



Picture 4. The frequency of questions appearing on higher cognitive level questions

The task-orientated questions consisted of 3 questions with 3 types of questions appearing: monitoring, need clarification, and request/directive which had the same frequency of occurrence. The question types that did not appear at all in this study in task-oriented questions type were the group dynamic question type and self-directed learning question type. The grouping of task-orientated question types can be seen in Picture 5.



Picture 5. The frequency of questions appearing in task-orientated question

DISCUSSION

Six stages of the collaborative problem-solving model had been carefully implemented in this study. Additionally, the 12 collaborative problem-solving skills were observed in this study. The majority of the collaborative problem-solving skills were observed in the third stage, which was designated as the transformation-collaboration discussion stage. In terms of checking the results of the group, discussion skill (D2) was located in the 4th stage and presentation of group discussion results (D3) was located in the 5th stage. The results of this study indicate that collaborative problem-solving learning can facilitate students to ask questions in solving problems. By students asking questions, it can be seen how attitudes, skills, and understanding students had of the learning provided by the teacher (Pratiwi et al., 2019). Mostly, students' questions were in the 3rd, 4th, 5th, and 6th stages of the learning process. In addition to that, students' questions appeared between two students, among students in a group and a class discussion. Students also asked the teacher from 3rd stage of the learning process.

The majority of questions were of a higher cognitive level. Subsequently, the questions were of a lower cognitive level and task-oriented. The findings indicated that the collaborative problem-solving learning model has the potential to motivate students to engage in questioning. Pratiwi et al. (2019) posit that discussion activities between students can facilitate the frequent emergence of high-level thinking questions. Furthermore, this study can be regarded as a model for formative assessment. The design of lessons that incorporate effective classroom discussions, questions, and instructional tasks is an essential aspect of effective formative assessment (Leahy et al., 2005). These elements facilitate three key instructional processes associated with formative assessment: identifying students' current understanding and their learning trajectory, and determining the most effective strategies to support their continued growth (Wiliam, 2011).

In lower cognitive level thinking questions, verification questions appear most frequently. The example of student's question in the verification type of task was "Is the side of this triangle half of 30 centimeters?". Verification questions are questions that require verification between yes and no answers, this type of question requires a short and immediate answer (Menezes et al., 2013). Pratiwi et al. (2019) also stated that most of the questions asked by students were still classified at a low cognitive level, this was due to the lack of fluency in the discussion process even though they had used a problem-based learning model. In addition, they added that students were also less interested in problem-based discussion activities, so the quality of questions asked is only classified at a low cognitive level. The fact that future specification and quantification tasks did not appear, it showed a positive impact of the model used.

The most types of question in higher cognitive level questions were in the judgmental question type. This question is asked by students to solve a problem through the results of something that has been designed in the mind. The type of judgmental questions asked by students is asking the results of a calculation and the solution steps in a problem that has been done (Erdogan, 2017). Students tend to

ask judgmental question types because they want to ask the truth about the results of a problem that has been solved. This in accordance with student's answer in the interview section:

R : Why did you ask your friend the question "Is the solution correct?"

S23 : I want to know if the solution and the result I have completed are correct or if there are things I need to change again.

Despite the successful appearance of higher cognitive level questions, it should also be noted that they were not evenly distributed across the categories. For example, the definition, example and expectation question types had fewer than five questions. Additionally, the causal consequence question was also absent. Further research is needed to explore this phenomenon. However, it is beneficial for students to explore all types of higher-order thinking questions.

Higher cognitive level thinking questions are certainly different from higher order thinking skills - although the emergence of questions will lead to critical thinking. Thus, the quality of the questions or mathematics content (Leikin et al., 2017) are also a determinant to raise students' questions. This is related to what is offered by the teacher and what the students may feel (Watson, 2007). The future study may use different higher order thinking skills tasks to see the different/or not on how students rise questions.

Task-oriented questions were the least frequent category. This is in line with (Erdogan, 2017) research, which also shows that task-oriented questions appear the least compared to other types of questions. In the five types of questions in the task-oriented question type, only three categories appear, namely monitoring, need clarification, and request/directive question type with each occurrence of one time. Meanwhile, group dynamic and self-directed learning question types have not appeared in this study. It is understandable because the question was about how the discussion went in a group and the request for action related to the collaborative problem-solving process which is normally done by the teacher. The question did not appear because the question was more in the realm of the teacher. In mathematics learning, teachers can use questions to help students improve mathematical reasoning skills and thinking (Mahmud & Mohd Drus, 2023).

The information acquired from this exploration may provide strategies for guiding students in questioning the teacher's explanation, question, or answer. Aside from that, teachers can prepare constructive feedback to students based on this study. In consequence, teachers can develop more predictable questions that Chusinkunawut et al. (2018) found that it can reduce during classroom setting. When a teacher is aware of a student's questioning, he or she will offer them a chance to ask. As a result, students will ask excellent questions if given the opportunity (Singh et al., 2019). This study is especially crucial to those in an environment that tolerates unquestioned student passivity, as such a culture may be an efficient way of preserving societal norms (Dkeidek et al., 2011). This study can also direct teachers to encourage students to ask questions during mathematics learning. Because in reality, many teachers do not know how to lead discussions and ask questions in class so that students can ask questions (Ghousseini & Herbst, 2016). Teacher's response to questions asked by students can also be used as an option for conducting further research.

CONCLUSION

Collaborative problem-solving learning model delivers knowledge to students by facilitating students through problem solving by utilizing collaboration in groups carried out in 6 stages. The results of the analysis of student questions in the collaborative problem-solving learning model in this study had a favorable effect on the development of students' questions. Students asked three types of questions, including lower cognitive thinking questions, higher cognitive thinking, and task-orientated questions. The most types of questions are in the type of higher cognitive level thinking questions, with the most

types of questions being judgmental questions. Question types that did not appear at all were feature specification, causal consequence, group dynamics, and self-directed learning. The result of this study can be used to map students' questions. More than that, teachers can personalize their approach to facilitate students in need. Additionally, teachers can use the results to encourage students to ask and to prepare better responses for students.

This research only focuses on analyzing students' questions on the implementation of collaborative problem-solving learning model without involving other selected variables. Future research can also be carried out by involving other factors such as grade level or age of students, gender, self-efficacy, or self-regulated, and many other factors. A quantitative analysis is also needed to complement this type of study. In addition, this research also does not discuss how questions appear at each stage in the collaborative problem-solving learning process, and how the questions appear whether individual questions, questions in groups, or questions in class. This research was only conducted on a small sample, so the possibility of generalization is likely to be limited. Similar research in the future can be carried out by involving a larger sample. Despite all the limitations, this research can capture the students' questions which is useful for research development in a similar research direction.

The application of the collaborative problem-solving learning model has been successful in developing students' ability to ask questions during the learning process, specifically in the context of the Pythagorean theorem. This model creates an active learning environment where students are encouraged to collaborate and discuss, which in turn triggers the emergence of various questions. The research results show that the majority of questions asked by students were of a higher cognitive level, indicating that the model encourages critical thinking and a deeper understanding rather than just rote memorization. However, some question types, such as those related to causal consequences, group dynamics, and self-directed learning, did not appear at all. Overall, these findings imply that this learning model is effective in facilitating students' questioning skills, which is a crucial component of student-centered learning.

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