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# The use of oral questioning to improve students' reasoning skills in primary school mathematics learning

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Reasoning skills are essential mathematical skills that need to be taught to students starting in primary school and have even become the main domain in global assessments such as TIMSS and PISA. Therefore, this study aimed to explore the implementation of the use of oral questioning in improving students' reasoning skills in mathematics at the primary school level. Data for the qualitative case study were collected through semi-structured interviews, observations, and field notes. Six mathematics teachers from six different primary schools were selected as participants in the study using the purposive sampling method. The data were then analyzed using a constant comparative method to identify the patterns and themes that emerged. The study found six types of oral questions that are identified as being used by mathematics teachers to help students improve their mathematical reasoning skills and thinking, namely, provocative mathematical questions, puzzle-shaped questions, breaking down hard problems into easier parts, contextual questions, questions to explain the mistakes, and questions asking for clarification. The findings showed that primary mathematics teachers used a variety of oral questions to help students develop their mathematical reasoning skills and, at the same time, assist them in developing higher order thinking skills. This research has implications for expanding the literature and understanding of how primary school teachers perceive that using certain oral questions can help improve students' mathematical reasoning. In addition, the study's results revealed the importance of oral questioning in teaching mathematical reasoning skills.

KEYWORDS

**oral questions, reasoning skills, primary school, mathematics teaching, mathematics learning**

## 1. Introduction

Mathematical reasoning is a critical skill that entails analyzing and evaluating mathematical statements or hypotheses without regard for context or meaning (Mueller et al., 2014). It is a mathematical concept that allows students to determine the truth values of given statements. Mathematical reasoning enables people to solve math problems without using algorithms or predefined processes (Curriculum Development Division, 2019). It entails applying logical and critical thinking to a mathematical problem to make connections and determine the best solution (Steen, 1999). Mathematical reasoning is an essential foundation for understanding mathematics more effectively and meaningfully. The development of mathematical reasoning is closely related to students' intellectual and communication development. Reasoning can develop logical thinking and even increase the capacity for critical thinking, which is the basis of understanding mathematics profoundly and meaningfully (Payadnya, 2019). Therefore, teachers need to provide space and opportunity by designing teaching and learning activities that require students to do mathematics and be actively involved in discussing ideas in mathematics.

Mathematical reasoning is a fundamental part of the education system in many countries. For instance, the Common Core State Standards for Mathematics in the United States emphasize the importance of mathematical reasoning and problem-solving skills. In the United States, mathematical reasoning tends to focus on problem-solving and the application of mathematical concepts to real-life situations. The education system encourages students to think critically, analyze data, and communicate mathematical ideas effectively (Resnick et al., 2023). The National Curriculum for Mathematics in the United Kingdom also focuses on developing mathematical reasoning and problem-solving skills (Jones et al., 2004). Mathematical reasoning is taught in Japan using a problem-solving approach that emphasizes visual aids and real-life scenarios. In Japan, mathematical reasoning emphasizes the importance of visual representations in understanding mathematical concepts, such as diagrams and graphs. Students are encouraged to think creatively and solve problems through trial and error (Fujita et al., 2022).

Mathematical reasoning is an essential skill that needs to be applied by teachers in mathematics teaching activities to ensure that students' thinking can be improved (Morsanyi et al., 2018). Mastery of reasoning skills by students allows them to understand abstract mathematical concepts. Furthermore, it assists students in solving various mathematical problems, particularly non-routine mathematical problems, by employing various logical and creative solution methods. Therefore, the Malaysian Ministry of Education, through the Mathematical Curriculum Framework that was introduced, has emphasized the importance of mastering mathematical reasoning skills to form students' mathematical thinking because it involves the process of creating mental associations and thinking in increasingly complex ways, a process which develops students' mathematical reasoning abilities and takes time and ongoing effort (Ministry of Education Malaysia, 2014). Moreover, it allows students to deal with increasing amounts of simultaneity in order to help the brain build a complex web of connections. Therefore, mathematical reasoning is an essential foundation for students to understand the content of learning mathematics more effectively, in addition to fostering understanding related to the knowledge of mathematics in a more meaningful way (Mahmud et al., 2020b).

Issues related to the level of reasoning skills possessed by students, as well as students' weaknesses in applying reasoning skills in mathematics learning activities and solving various non-routine problems, need to be given attention because this issue is also linked to mathematical achievement in the Global TIMMS assessment where the average score obtained is still below the minimum level (Ministry of Education Malaysia, 2020). This is because the issues of the questions found in the TIMMS global assessment focus very much on aspects of students' thinking and reasoning skills. For example, suppose students have low levels of thinking and reasoning skills. In that case, students will find it challenging to plan various solutions to various mathematical problems where the importance of applying skills is expressed. Hence the importance of mastering reasoning skills such as problem-solving, analytical thinking, inductive and deductive reasoning, and creative thinking for students because mathematical reasoning is closely related to developing a student's intellect and communication. Applying good reasoning skills can develop logical thinking capacity and even increase critical thinking capacity, which is also the basis for a deep and meaningful understanding of mathematics (Mahmud, 2019). Therefore, to achieve this goal, students should be trained and guided to constantly provide logical explanations and analyze, judge, evaluate, and justify all mathematical activities. In addition, teachers need to provide space and opportunities for mathematical discussions that are not only engaging but allow each student to be involved.

In an effort to improve students' reasoning skills in mathematics in the process of teaching one of the techniques that can be used is to use effective oral questioning (Mahmud et al., 2019). The teacher's oral questioning as a teaching strategy can stimulate students' thinking and enable the teacher to understand the level of student achievement in addition to allowing students to explain their understanding (Çelik and Güzel, 2016). In addition, teachers can use oral questioning to challenge and elicit students' thoughts, increasing students' curiosity, and interest in a topic being taught (Rini et al., 2020). The teacher's oral questioning practice in the mathematics teaching process allows students to get ideas and strengthen them through their speech and writing.

However, teachers must diversify strategies, techniques, and levels of oral questioning (higher-order or lower-order) to suit the students' conditions and needs (Johar et al., 2017). The teacher's ability to practice effective questioning skills and strategies is an essential element in the effort to instill and apply thinking skills, and it is an art that needs to be mastered and practiced (Curriculum Development Division, 2016).

The use of high-order questioning techniques is seen as a more effective questioning technique to enhance students' critical thinking than low-order questioning, which only focuses on knowledge and understanding (Larson and Lovelace, 2013). This is very important because higher-order thinking skills (HOTS) is one of the six main features emphasized by the government through the Malaysian Education Development Plan (PPPM) 2013–2025. This is in line with the findings of (Mahmud, 2019), which stated that emphasis should be placed on the quality of questions teachers ask and not the quantity, i.e., a large number of teacher questions does not reflect the teacher as a better questioner, and it also does not help in improving students' high-level thinking (Hassan et al., 2016). In their study, they also found that the most frequently used strategy for teaching with elements of HOTS is questioning. Therefore, to ensure that oral questions improve student learning, teachers should use the appropriate level of questions so that the teaching objectives can be achieved. Gaspard (2013) stated that there are two levels of questions that teachers often use in their teaching activities, namely, low-level and high-level questions. Using high-level questioning skills by teachers through questions in the form of problem-solving can open up space for in-depth discussion, encourage exploration, and increase student involvement in the teaching process (Mahmud et al., 2020a). The implementation of good oral questioning does not only focus on high-level questions but also needs to be diversified according to circumstances and situations although (Hassan et al., 2016) it has been suggested that teachers need to focus on using high-level questions. Mirza (2018) explains that teachers need to diversify their level of questioning to equip students with clearer mathematical senses and thinking. Therefore, teachers should diversify the level of oral questioning in the class in a balanced manner and in accordance with the learning objectives so that the learning process becomes more meaningful (McAninch, 2015).

Mullis et al. (2016) in the TIMSS 2015 results report for mathematics subjects, it was reported that Malaysia experienced a decrease in scores obtained from 1999 to 2011. Still, there was a slight increase in mathematics achievement in Shahrill and Clarke (2014) stated that one of the causes of the decline in the performance of students in Malaysia in the TIMSS global assessment is the lack of oral questioning activities that can stimulate students' reasoning in the mathematics teaching process. Students found it difficult to understand the questions used in the TIMSS test, which focuses more on exploratory questions where students not only have to remember and understand mathematical facts but also make connections between the knowledge they have and make explicit judgments about solving a mathematical problem. Students' weaknesses in reasoning aspects also contribute to students' weaknesses in understanding abstract mathematical concepts, making justifications, and analyzing and translating mathematical problems that require higher-level thinking and reasoning skills (Wong, 2015). Not only that, but ineffective oral questioning makes it difficult for students to argue and defend their solution to a mathematical problem.

It is possible that the type of oral questions asked by the teacher is not appropriate, so the understanding of mathematical concepts is too complex for students to master and cannot improve the level of students' thinking in learning mathematics (Kaya et al., 2014). Studies (Belcher, 2016) show that teachers are more fond of asking convergent questions than divergent-type questions that can elicit students' thinking. The use of convergent questions causes students' thinking not to diverge and not to develop (Subramaniam et al., 2022). This also indirectly affects the level of students' reasoning because their thinking is less trained to think creatively and critically, thus causing students' reasoning skills to be affected. The correct use of oral questions can help students improve their ability to reason logically and present arguments honestly and convincingly. This is because mathematics is a science based on well-defined objects and concepts that can be analyzed and transformed in various ways using "mathematical reasoning" to reach certain and timeless conclusions.

Thus, in planning oral questions that can help students improve their mathematical reasoning, there are six key understandings proposed by PISA 2022 to provide structure and support for mathematical reasoning. These key insights are:

1. Understanding quantity, number systems, and their algebraic properties.
2. Understanding the influence of symbolic representation and abstraction.
3. Recognizing regularities in mathematical structures.
4. Recognizing functional relationships between quantities.
5. Using mathematical modeling to view problems from the real world (such as those from the physical, biological, social, economic, and behavioral sciences).
6. Realizing that variation is the core of statistics.

In addition, mathematics teachers are more fond of using only low or medium-cognitive level questions and focus less on high-cognitive-level questioning, causing the mathematics teaching activities that are implemented to be less stimulating and provoking to students' thinking (Mahmud et al., 2022). Low-level questions in this context refers to questions that focus on specific details or facts within a mathematical concept or problem such as "What is the formula for finding the perimeter of a rectangle" and "What is the square root of 64?" (Hauser, 2017) stated that this happens because a lack of knowledge and skills in oral questioning among mathematics teachers makes it challenging to construct high-level questions in mathematics teaching.

Past studies report that one of the issues or problems that students often face while learning mathematics in mathematics class is difficulty solving math problems (Setiyani et al., 2020; Pazin et al., 2022). It has been explained that this happens because of the lack of effective oral questioning activities implemented to train and improve students' mathematical reasoning skills. Students' weaknesses in the reasoning aspect contribute to students' weaknesses in understanding abstract mathematical concepts, making justifications, and analyzing and translating mathematical problems that require higher-level thinking and reasoning skills (Morsanyi et al., 2018). Not only that, the result of ineffective oral questioning also makes it difficult for students to argue for and defend the solution to a mathematical problem.

However, little is known about how primary school mathematics teachers use oral questioning to improve students' reasoning skills in mathematics, particularly when it comes to the types of questions used in primary school mathematics instruction (Mahmud et al., 2020a). In addition, the absence of a framework for the implementation of oral questioning specifically related to the teaching of mathematics in primary schools in the context of education in Malaysia requires this study to be carried out to help create a deeper understanding of the implementation of the use of oral questioning in improving students' reasoning skills in mathematics at primary school. Thus, this study is expected to show the real scenario of how oral questioning practices are implemented by primary school mathematics teachers so that the problems that arise can be identified and then solved through some suggested solutions.

## 2. Methodology

This is a qualitative study that uses multiple case study methods. The selection of this method meets the research question that needs to be answered because the case study allows for a comprehensive overview and a complete and deep understanding related to the implementation of oral questioning in mathematics teaching in primary school.

Six primary schools in a district in Negeri Sembilan have been selected as venues for research to explore and understand the teacher's oral questioning practices in the teaching process of applied mathematics. The selection of this district as a study location is based on Marshall and Rossman (2014) argument that the characteristics of the place to conduct the study should be easy to enter, there should be no obstacles to conducting research, there should be a high chance of collecting in-depth data, there should be freedom of research, and it should be easy for participants to participate in the study.

A total of six outstanding primary school mathematics teachers from six different schools have been selected as study participants by using the purposive sampling method. The selection of research participants for this study is based on criteria and characteristics determined by the researcher, who is a mathematics option teacher teaching mathematics subjects at primary school, the excellent teachers who received appointments from the Ministry of Education Malaysia and the teacher are willing to be involved in this study. Based on the data, it is difficult for the researcher to obtain participants' studies according to the criteria set in the same school. Thus the participants' studies had to be selected from different schools.

While conducting the actual study, the researcher gave the participants a letter of acknowledgment and consent to be a study participant (informed consent) to be signed by the participant. This acknowledgement is an ethical requirement in research that needs to be obtained voluntarily from the study participants to avoid elements of coercion, deception, pressure, and any influence (Mahmud, 2019). Furthermore, this letter can provide additional protection for researchers in the event of legal issues. In addition to that, the researcher has also obtained permission to conduct the study from the Education Policy Planning and Research Division (BPPDP) of the Ministry of Education Malaysia and the State Department of Education to ensure that all research activities meet all the ethical standards that have been set in addition to ensuring better implementation of the study.

For data collection methods, the researcher used observation, interviews, and field notes. Using various data collection techniques can help researchers make data triangulation and strengthen the results obtained (Miles et al., 2014). The non-participatory observation process was carried out according to the actual teaching schedule of the study participants. The observation process is carried out using an observation protocol adapted from a previous study (Ling and Mahmud, 2023). The number of observations carried out depends on the topic taught and the level of data saturation obtained by the researcher. The process of making observations is done consecutively for each study participant. This procedure will indirectly increase the validity and reliability of research findings (Miles et al., 2014). The mathematics teaching process was observed to see the implementation of oral questioning recorded using a video recorder to obtain information and to get a more comprehensive picture of the behavior of study participants during the teaching process. During the observation process, the researcher took written field notes that provide information about the classroom that cannot be seen through audio recordings and transcripts and other matters related to the aspects studied. For example, field notes contain information about students, the classroom environment, the overall atmosphere in the school that may affect the teacher in making decisions, and information about student behavior as well as notes about what the teacher presents that are not recorded, such as examples written or shown on the whiteboard.

As for the interview method, two interview sessions were conducted for each study participant, namely, an initial interview and a stimulated-recall interview. The first session was an initial interview that contained questions on the teacher's philosophy for teaching, the teacher's philosophy on questioning, the classroom environment, and the roles of the teacher and students during class discussions. The interview protocol for this initial interview was adapted from the interview protocol built by Mahmud et al. (2020b). The second interview session was a stimulated-recall interview, a more specific and in-depth interview based on observations (Iksan and Daniel, 2015). The second interview session contained questions about the decisions made by the teacher during the mathematics teaching process. In conducting this second interview, the researcher adopted the interview protocol developed in a previous study (McAninch, 2015). This interview is also a reflection on the instructions that were followed. In addition, the document used for analysis is the record book of the daily teaching plan, which contains a daily plan for each teacher's teaching session in mathematics subjects.

The data obtained were analyzed using the constant comparative analysis method by the researcher himself to see patterns and themes contained in the data obtained, where this data is primary (Kolb, 2012). The constant-comparison analysis is focused on qualitative research to see the similarities and differences of each theme. This is a data coding process where the data is broken down to be filtered and then interpreted in a meaningful way to build a theme. There were three stages of coding in the data analysis process: open coding, axial coding, and selective coding. Similar themes are grouped in a category, and this comparison will continue until the data reach saturation (Marshall and Rossman, 2014). In this context, saturation refers to a situation where the researcher feels that there is no longer any new data or information obtained to support the theme and information to the researcher from three data sources, namely, observation, interviews, and field notes. The first stage of data analysis is open coding, breaking down, examining, comparing, conceptualizing, and categorizing data. This process aims to collect as many themes and categories as possible related to the study phenomenon and to identify categories related to the theoretical foundation. The researcher reads the data several times before creating tentative labels for pieces that summarize what is happening, not based on existing theories but only on the meaning that emerges from the data. The researcher obtained preliminary concepts, categories, characteristics, and dimensions at this open coding stage. As a result, the researcher identifies and categorizes categories based on emerging themes.

The following stage is the axial coding process, in which the data is reorganized in a new way after open coding by connecting categories. This is accomplished through a coding paradigm involving situations, contexts, action/interaction strategies, and their consequences. According to Corbin et al. (2014), the main emphasis of axial coding is constantly asking questions and making comparisons, as well as inductive and deductive thought processes related to subcategories to categories. It is critical to verify the details of a category to see the relationship between the categories and explain the relationship between them. During this process, the researcher reads the verbatim data repeatedly, attempting to identify passages or sentences that provide an idea of the studied issue and are relevant to answering the research question. If a quote has the same meaning or description of the same category, then the quote is coded into the category that has been created. Yin (2013) mentions that this process is known as pattern matching, where the coded sentences are based on existing categories. However, if the found sentence does not match the existing category, a new category must be formed. This process continues until no more new categories can be formed.

The final stage is the selective coding process, which is a process of identifying and selecting core categories, systematically linking them with other categories, verifying similarities and relationships, and then settling on categories that may need to be further refined or developed. During this selective coding process, the categories and their relationships are combined to form a "storyline" that describes "what is happening" in the phenomenon being studied and answers the research question.

In this study, the researcher used several methods to increase the validity and reliability of the study, including the triangulation method, an audit trail, and long periods in the field. To ensure the reliability of the research findings, this study also used an analysis of Cohen Kappa to measure agreement between raters for the themes and subthemes obtained in this research. In this study, the data were verified by two expert raters in Mathematics Education who are lecturers in mathematics education at two leading universities in Malaysia and a district education officer skilled in mathematics education pedagogy. The Cohen Kappa coefficient (κ) is a statistic that measures agreement between raters for qualitative items (categories). Cohen Kappa analysis also refers to finding the reliability of the unit of analysis from verbatim qualitative data and is also known as inter-rater reliability. The importance of inter-rater reliability lies in the extent to which the data collected in the study can truly represent the variable being measured. McHugh (2012) stated that this analysis can also determine the extent to which the selected analysis unit can accurately describe the themes that arise from the interviews and directed to the questions to be studied. Thus, the Cohen Kappa Index analysis aims to find the degree of agreement between experts on the unit of analysis with the theme or construct being studied (Wilhelm et al., 2018).

Therefore, once all the data has been processed and the themes of the research findings have been produced, the researcher prepares a set of expert consent forms to evaluate the themes created. This is important to ensure high reliability for each find to describe a theme (Landis and Koch, 1977). It was stated that a Kappa coefficient value that exceeds 0.75 is the best agreement above 50 per cent of expected agreement, a value of 0.40–0.75 is a moderate value above the expected percentage of agreement, and a value of 0.40 and below is weak because the value is below 50 per cent expected approval. Thus, the agreement value experts on the theme successfully produced in this study are $K = 0.89$, which is very good.

## 3. Findings

The findings of this study have identified and classified several types of oral questions used by the study participants throughout their teaching, where the questions are used to help improve students' reasoning skills in mathematics. In this study, there are six types of oral questions that math teachers can use to help students improve their mathematical reasoning and thinking. These are provocative mathematical questions, puzzle-shaped questions, questions that help students break down hard problems into easier parts, questions about the context, questions that ask students to explain their mistakes, and questions that ask for clarification.

In this study, the researcher used pseudonyms to represent each participant to protect the confidentiality of participants. Each discussion of research findings is supported by excerpts from the teacher's observation, interviews conducted, and field notes. An example of a label for observation is (Azah, P3/12452–12723) where "Azah" is the name of the study participant, "P3" is the third observation for Teacher Azah, and "12452–12723" (is he position of the sentence in the analyzed teaching transcript document). Then for the interview transcripts, the researcher used the label "SRI" or "II" where "SRI" refers to the reflective teaching interview while "II" refers to the initial interview. For example, the label (Roza, SRI3/4751–5047) refers to "Roza," which the name of the study participant, "SRI3," which the third teaching reflective interview for Teacher Roza, and "4751–5047," which refers to the position of the sentence in the transcript document. In addition, for data involving field notes, the researcher uses the "NL" label such as (Ada, NL/17082022) where "Ada" is the study participant name, NL the field note, and "17082022" the date of the field note, which is August 17, 2022.

### 3.1. Provocative mathematical questions

The study found that participants used provocative questions at the beginning of the mathematics teaching session. Provocative questions are said to challenge students' thinking, check the intellectual level of potential employees, and even be used to encourage students to think more actively. In the following interview excerpt, Teacher Ada discusses the significance of using provocative questioning:

> *"As mathematics teachers, we need to constantly provoke students' thinking to improve their reasoning skills. With this, students can challenge their thinking and find creative and logical solutions without relying on the mathematical solution procedures they usually use."*

(Ada, SRI2/34212–34557).

Not only that, but Teacher Ada also explained that, when the teacher asks provocative questions, the teacher needs to challenge the students to prove their answers mathematically: *"We also need to challenge them so that they can prove their answers through logical solutions but cannot run away from the actual concepts of mathematics"* (Ada, SRI2/34212–34557). The excerpt below shows the provocative questions asked by the participants in the mathematics teachneacher Nadia explained that throughig session:

> *Teacher Okay, I have a question for you all to think about. Please listen carefully. The question is, Cindy wants to buy a*

> *lollipop priced at RM 0.70. Name the coin that Cindy can use to pay for the lollipop.*
> *Student Let me try, teacher! (Students raise their hands to answer the question).*
> *Teacher Ok, good, please.*
> *Student 20 cents and 50 cents, so we get 70 cents.*
> *Teacher Yes, it's good. Is there anything else?*
> *Student Let me try: 20 cents plus 20 cents plus 20 cents and 10 cents.*
> *Teacher Yes, good, Ahmad.*

(Raha, P2/32114–33001).

The teaching excerpt above shows Teacher Raha trying to provoke students' thinking through questions that ask students to think of various solutions to the questions asked. This is an important effort that teachers must implement so that students' thinking is more divergent, and they can think of various creative solutions. In addition, provocative questions are also used to change students' perspectives and misconceptions about mathematical concepts. Teacher Nadia explains this in the following interview excerpt:

> *"When a teacher asks a question that makes you think, it's usually because the student's view or understanding of a mathematical concept is too narrow or because they don't know how the concept applies to the real world. So, through students' provocative questions, students' ideas about a mathematical concept are seen to be broader."*

(Nadia, SRI2/34212–34557).

In addition, the study's findings through observation found that provocative oral questions encourage discussions and arguments among students, causing the discussion of a topic to become more in-depth (Roza, P2/11175–11314). Therefore, this indirectly develops and improves students' reasoning skills and understanding of mathematics. This matter was also explained by Teacher Roza in the interview excerpt as follows:

> *"When the teacher gives provocative questions to the students, the discussion activity becomes more lively, and the session of exchanging opinions and finding ideas will certainly happen more actively. Then the students will use their reasoning skills to get various logical solutions."*

(Roza, SRI 3/23132–23997).

## 3.2. Puzzle-shaped questions

The study also found that teachers rarely ask questions directly but more often ask questions in the form of riddles or puzzles. In addition, the researcher's observation found that students are more active in thinking and finding solutions when the teacher asks questions in the form of puzzles (Ada, NL, 20092022). Teacher Ada also explains this in the following excerpt from the interview:

> *"I prefer asking mathematical questions in the form of puzzles because students seem more responsive to such questions. Students are also more active in thinking and enjoying themselves, so they are more active in finding answers to those questions."*

(Ada, SR1/3, 34514–35110).

The interview excerpt above explains that the questions asked in the form of puzzles are more interesting to students, and they prefer to think to solve the questions given to them. In addition, Teacher Ana thinks that the questions asked in the form of riddles encourage more discussion and student interaction, thus improving students' reasoning skills as a result of their discussion on the question. Teacher Ana explains this in the following interview excerpt:

> *"The questions asked in the form of puzzles increase students' interest in thinking and encourage more growth related to logical thinking because they will try to see the patterns that may exist on how to solve the puzzle questions and find more diverse solutions. In addition, they will sometimes think about and discuss among themselves the real purpose of the question and how to solve it."*

(Ana, SRI 1/36617–40012).

The excerpt above explains that questions asked in the form of puzzles will encourage students to think more through their logical thinking to understand a situation and the ideas found in the questions asked. Not only that, but the lively discussion that comes from talking about the puzzle question will also help students think more logically when solving math problems.

The questions asked in the form of puzzles also help students create beneficial habits of mind, such as persistence, thoroughness, creativity in solution-finding, and improved self-monitoring. Teacher Ana explains this in the following interview excerpt:

When we ask a question in the form of a puzzle, students are usually more interested in answering the question, so when students are interested, they will be more persistent, earnest, and thorough in trying to find a solution to the question. They will try various ways, according to their creativity, to get answers. *"With this, students' thinking will be more directed and stimulated to think more creatively to get answers"* (Ana, SRI 2/32114–33101).

In addition, the findings of the study also found that teachers also use "what if" questions to encourage students' mathematical reasoning. The excerpt below shows an example of how Teacher Nadia uses provocative questions in the form of "what if" in teaching mathematics:

> *"What would happen if I added 4 cm to the length of this rectangle?"*

(Nadia, P2/32114–33101).

> *"If eggs are $0.12 a dozen, how many eggs can you get for a dollar?"*

(Azah, P3/31345–31426).

Based on the excerpt above, teachers Nadia and Azah asked students a "what if" question to help them relate the new information found in the teacher's oral question and then draw a conclusion based on the previous situation. This allows students to strengthen the formation of strong conceptual relationships and further build their logical thinking skills.

## 3.3. Questions that break down hard problems into easier questions

Next, the teacher gives questions that break down hard problems into easier questions, almost the same as the original questions the teacher asks the students in mathematics teaching. Easier questions are asked to the students when the teacher finds that they cannot answer the questions asked to give them an idea about the operational procedures that the students need to do in answering math questions (Roza, NL, 23082022). The following excerpt demonstrates how students can be given questions that break down difficult problems into easier parts:

> *Teacher Now convert mm to cm. A total of 59 mm equal to how many cm?*
> *Student . . . (student is silent without any answer).*
> *Teacher Ok, question. Please listen. A total of 20 mm, how many cm?*
> *Student 2 cm.*
> *Teacher How do you get 2 cm?*
> *Students divide by 10.*
> *Teacher How do you divide 10? Ok, 20 divided by 10 gets 2 cm. This question is also the same.*

(Roza, P1/10375–10414).

Teacher Roza initially asked a slightly complex question about how to convert 59 mm to cm. However, the question did not get a response from the students, causing Teacher Roza to use a simpler question where she tried to reduce the numbers and use even numbers to help students understand the concept of unit conversion. Teacher Roza explained that this is intended to help students understand the mathematical concepts discussed more easily (Roza, SRI 3/19407–19708). Teacher Raha also said, *"Yes, we will use a slightly smaller number, but still in the same situation. This is intended to give them an understanding first because this big number will be a bit overwhelming"* (Raha, II, 19956–20138).

Teacher Azah also said, *"Maybe we will give an example with a small number so that the student can see what he has to do first"* (Azah, SRI 2/2816–3129). In addition, there are situations when the teacher needs to change the situation or "storyline" found in the questions asked to a problem close to the student's environment to help the student understand the question being discussed better. Teacher Ada explains this matter thus: *"Sometimes we need to change the situation in the question to a simpler one so that the students can see what the question wants"* (Ada, SRI 2/32009–32352).

Teacher Ada also added that when the students have successfully answered the easier questions, then the teacher can link back to the understanding the students have gained from the original, more complex questions. In this context, students' understanding is strengthened by responding to easier questions progressively before moving on to more complex questions (Ada, NL, 20092022). This is explained in the following excerpt from the interview: *"Yes. simplify the question first and then relate it to the original question that was a little difficult earlier. Step by step from easy to hard"* (Ada, SRI 1/34917–35403).

Therefore, easier questions given by the teacher as feedback are a form of continuous guidance from the teacher to help students think about and understand the mathematical concepts learned. In this context, the teacher tries to give an easier picture of the problem through smaller numbers, simpler operations, or simpler situations to help students connect with the original, more complex problem. With this, the teaching process can be carried out in an advanced manner.

## 3.4. Contextual questions

The findings of the study also found that teachers use questions based on mathematical modeling. This involves using mathematical concepts to solve real-world problems, providing students with a practical application for the math they are learning. Questions using mathematical modeling help apply mathematics in real-life situations, keeping students engaged and helping them develop deeper mathematical reasoning and critical thinking skills. Using questions based on mathematical modeling allows teachers to help students improve the acquisition and application of mathematical concepts and skills in a wider variety of situations, especially situations related to real-world problems. Here are some examples of contextual questions that can promote reasoning skills in mathematics provided by mathematics teachers in this study.

> *"A bus goes from a supermarket to the park at a constant speed of 70 km/h and returns to the supermarket at a constant speed of 80 km/h. What is the average speed of the bus for the entire trip?"*

(Roza, P3/3765–3912).

> *"A recipe for butter cookies calls for 4 cups of flour, 2 cups of sugar, and 2 cups of butter. If you want to make half of the recipe, how much of each ingredient will you need?"*

(Nadia, P3/1785–1982).

Teacher Nadia explained that through oral questions often associated with various situations in everyday life, students can use multiple mathematical concepts that have been learned and then apply them in various situations in their lives. *"I often give questions related to real-life situations, and then I will encourage students to think logically and creatively by using the mathematical concepts they have learned"* (Nadia, SRI3/20010–20214). Contextual questions give pupils an opportunity to see how the mathematical ideas they are learning are used in real-world situations. Students are better able to comprehend and remember the ideas when they can see how the math can be used in real-world scenarios.

In addition, Teacher Ana also gave her opinion on the oral questions given through the application of mathematical modeling, which she thinks can encourage or give students opportunities for various activities that can improve students' logical thinking through discussion, exploration, and experimentation. Working together on a contextual question can help students share ideas and develop their reasoning skills through discussion and debate.

This can indirectly improve students' mathematical reasoning while providing a good foundation for improving their problem-solving skills.

In addition, the study also found that encouraging questions related to the visualization of real-world problems can boost students' reasoning skills, whereas questions related to the visualization of the real world can provide more explicit ideas and guidance for finding solutions to mathematical problems. Teacher Ada explains this in the following interview excerpt:

> *"If we want to encourage reasoning skills, we need to ask questions to help students visualize the real world. This is because most learning ideas are linked to real-life situations. Through visualization of the real world, students will be able to make logical connections related to mathematical concepts more easily."*

(Ada, SRI 2/31119–31412).

Based on the quote above, Teacher Ada explained that oral questions related to the visualization of the real world provide support for students' logical thinking by helping them relate thoughts to the real world. The teacher also explained that through oral questions that use visualization of situations associated with the real world, it is important that students acquire the ability to represent real-world problems in mathematical terms and construct models to solve the issues. When students are engaged in modeling, their ways of thinking do not manifest as a single, one-dimensional sequence but instead as a series of cycles in which their mental models representing the given situation are expressed, tested, and revised. In other words, knowledge develops along multiple dimensions, from comparing to contrasting, from concretizing to abstracting, from specific to general, from simple to complex, or from a collection of uncoordinated, immature ideas to more coordinated, mature, and practical knowledge.

## 3.5. Questions to explain mistakes

The study also found that teachers give questions in the form of corrections to students' inaccurate or wrong answers. The teacher provides corrective questions to correct students' misconceptions and misunderstandings of the mathematical concepts learned. The following is an example of how corrective explanatory questions are applied in mathematics teaching:

> *Teacher How do you do it if you want to change meters to kilometers?*
> *Students multiply by 100.*
> *Teacher Is it true?!*
> *Students . . . (Student remains silent without giving an answer).*
> *Teacher Actually, you need to divide by 1000 because 1-kilometer equals 1000 m. So, we divide 4075 m by 1000.*

(Ana, P 3/11006–11140).

> *Student "3.7 cm × 10 = 37 mm" (The student writes on the whiteboard in the usual form, but there is an error in the calculation method).*
> *Teacher Alright. The first one does not have this amount of cm when multiplied by ten. You don't have to write this in cm because you want to change it to mm. This 10 is in mm.*

(Roza, P3/4293–4445).

The quote above shows how teachers give students corrective and explanatory questions during the mathematics teaching process. For example, teacher Ana corrected the students' misconceptions about the operation required to change the meter unit to kilometers. The answer given by the student is wrong, so Teacher Ana immediately corrects the mistake made by the student by providing the correct answer, and explaining to the student the right answer. Similarly, Teacher Roza gave feedback and corrective explanations about the inaccurate calculation procedures shown by the students on the whiteboard. Therefore, not only can the student's answers be corrected, but also when the teacher gives explanations as a form of correction, the students will have the opportunity to understand and correct their thinking on the concept being studied, as explained by Teacher Ada in the interview excerpt below:

> "Yes, correcting the answer he gave. Sometimes it's inaccurate because some are right and some are wrong, so we will tell you which is right, and which is wrong. Then, explain back to the students. So, they will better understand what is being studied."

(Ada, SRI 2/21268–21633).

Teachers also give students questions related to corrective explanations to help students understand why they are wrong and how they can learn from the mistakes they make. Teacher Ana explains this in the following interview excerpt:

> *"Being able to assist students in understanding why they are incorrect and learning from their mistakes."*

(Ana, II/22662–22843).

Therefore, the questions asked with corrective explanations allow the teacher to correct the student's answers through the explanations provided and allow students to correct their misunderstandings of the concepts learned. This makes them think from different points of view to figure out why they made mistakes.

## 3.6. Questions asking for clarification

The results of the observation of the teaching carried out by each study participant also found that the study participants used questions asking for clarification to guide and clarify the thinking of the students' reasoning as well as explore the origin of the students' thinking toward understanding the content of the lessons presented. Here is an example of how teachers use questions to ask for clarification in teaching mathematics:

| | |
|---|---|
| *Students* | *15 m (students answer the teacher's questions).* |
| *Teacher* | *How do you get the answer to 15 m?* |
| *Students* | *Multiply1.5 m by 10 to get 15 m.* |
| *Teacher* | *Ok good, so we got 15 m.* |

(Roza, P 2/3049–3422).

| | |
|---|---|
| *Teacher* | *How do you want to find MR, RS, and SN?* |
| *Students* | *Divide by 3.* |
| *Teacher* | *How do you know to divide by 3?* |
| *Students* | *Because there are three parts.* |

(Nadia, P 1/9672–9831).

The researcher found that teachers use clarifying questions to ask students to explain how they got their answers, which in turn can help students strengthen their understanding and thinking about the topic being discussed. Teacher Roza stated that by asking students to explain their answers, they will better understand the content of the discussion and help the teacher assess the level of learning that the students have achieved.

> *"When we ask students to explain their answers, the students will definitely remember and understand what they are learning." In addition, it can allow teachers to assess the level of student understanding.*

(Roza, SRI 3/1166–1400).

Teacher Raha gave the opinion that questions asking for clarification also allow other students to benefit from the explanations provided by their friends. This indirectly helps other students understand the content of the lesson being discussed. Thus, he explained, *"Other students will also benefit and can help strengthen their understanding of the topic being studied"* (Raha, SRI 3/1438–1846). Teacher Ada also expressed the same opinion as Teacher Raha, where questions asking for clarification will help improve other students' understanding of the lesson's content (Ada, SRI 2/16129–16272).

Therefore, questions asking for clarification are used by teachers to help students clarify their understanding of and thinking on the content of the lesson being discussed. As a result, students can think more deeply and explain their understanding of the topic being discussed.

## 4. Discussion

The findings of the study have shown that the mathematics teachers in this study believe the use of certain oral questions can help improve students' mathematical reasoning. The use of various types of oral questions allows students to indirectly stimulate their sense of thinking and use stimuli extensively to generate inference and critical reasoning skills (Mahmud and Law, 2022). As a result, it is the teacher's responsibility to guarantee that the oral questions utilized are not only for remembering and learning mathematical facts but also for applying oral questions in the areas of analysis, synthesis, and assessment to raise thinking to a higher level.

The study found that mathematics teachers use provocative questions to encourage students' reasoning skills in mathematics. Oral questions like this can also increase students' creativity by encouraging them to think more creatively to find various alternative solutions to solving mathematical problems (Subramaniam et al., 2022). Developing ideas creatively is critical to helping students build mathematical skills and increase student inquiry in the context of learning mathematics. Therefore, provocative questions can encourage students to investigate, explore, collect data, draw conclusions to solve problems, reflect on the methods used, make observations, and communicate to share findings about the problem. In addition, provocative questions are also found to improve students' reasoning skills through the discussions that occur after the teacher asks provocative questions. In this context, students can learn to discuss and work mathematically. Students learn to talk and work mathematically by participating in mathematical discussions, proposing and defending arguments, and responding to the ideas and conjectures of their peers. The design and posing of thought-provoking tasks lead to such discussions, leading to a culture of justification and proof (Mueller et al., 2014). Not only that, but through active discussion, students will be able to use the correct mathematical language and apply logical reasoning.

In addition, teachers were also found to ask questions in the form of puzzles to improve students' mathematical reasoning skills. This finding is consistent with the findings of Douglas et al. (2006), who found that puzzle questions can help students develop mathematical reasoning skills. The use of oral questions in mathematics teaching in the form of puzzles provides a platform for learning mathematics that is more fun and indirectly increases students' interest in mathematics learning activities. When students' interest can be increased, they will voluntarily increase their efforts in finding solutions to the questions asked (Mahmud et al., 2020a). With this, students' thinking, and logical reasoning skills can be improved because their mental activity becomes more active in thinking creatively. Furthermore, when asked a question in the form of a puzzle, students will be taught to see patterns and methods of trying to succeed, and they will be given the opportunity to hypothesize the probability of solving a mathematical problem. Therefore, they will also have the chance to improve their ability to make judgments and decisions based on valid reasons and evidence until they can solve the puzzle question. With this, students' mathematical reasoning skills will always be trained and strengthened through active thinking and decision-making activities.

In addition, the study also found that to help students, especially low-achieving students, improve their reasoning skills, mathematics teachers were also found to break the questions down into simpler parts. This happened when students could not answer the questions posed by the teacher. The purpose of questions like this is to help students restructure their thinking and the mathematical concepts they have learned in accordance with the nature of the question. So, with this, students' thinking will be more organized and further develop students' logical thinking capacity to solve mathematical problems (Pazin et al., 2022). Questions can also be given using simpler questions, but they need to be given in the same context to help students understand the content and the required mathematical solution procedures. In this context, students' thinking will be directed toward planning real solutions to the mathematical problems presented to them and finding them relevant enough to be implemented in low-achieving classes to ensure continuous involvement and interaction from students. This indirectly ensures that the oral questions asked by the teacher can be given according to the suitability and actual abilities of the students (Mahmud and Law, 2022). In addition, this method is an advanced approach that can help students' understanding of the mathematical concepts discussed, as stated in Gagne's Instructional Theory.

In addition, the study also found that teachers ask contextual oral questions or involve mathematical modeling. Mathematical modeling is the process of describing a real-world problem in mathematical terms, usually in the form of equations, and then using these equations both to help understand the original problem and discover new features. In this context, reasoning skills are applied by solving problems related to real life by using knowledge from various disciplines.

A variety of unconventional solution contexts are generated through student thinking using new contextual situations outside the classroom to encourage students to think more deeply and not just recall what was learned in the classroom (MdYunus, 2015). Therefore, this allows students to relate the knowledge gained in the classroom to real life and further develop numeracy skills, reasoning skills, ways of thinking, and problem-solving skills through learning and mathematical applications so that, finally, students can use mathematics to describe the physical world.

In addition, it was found that the teacher also provided corrective explanatory questions to correct students' misconceptions about the mathematical concepts discussed. In this context, the teacher not only tells the students that the response given is wrong but also explains why the answer given is wrong. Giving correction questions in the form of explanations is crucial to helping students correct their understanding and allow them to self-reflect on the mistakes they have made while also assisting them in improving their learning and better organizing their mathematical problem-solving strategies (Shute, 2008). With this, students' reasoning skills will be trained, which will help them build confidence in determining the answers to the questions asked by the teacher.

However, the researcher believes corrective explanation questions should be given according to the situation and the student's ability level. This indirectly supports Gagne's theory of instruction, which emphasizes that the teaching that is planned or implemented should consider the level of student ability so that the implemented teaching process can meet students' various learning needs (Driscoll, 2000). As a result, it is critical to assist students in relating their mistakes to the teacher's corrective, explanatory feedback to modify their understanding to a correct understanding of mathematics (Mahmud and Yunus, 2018). Furthermore, this indirectly encourages students to make a logical analysis to determine the correct mathematical concept and strengthens students' reasoning skills.

It was also observed that teachers ask questions in which they ask students to clarify or expand on their answers. In this context, the teacher asks the students to think again and provide justification for their answers. This is important to ensure that students understand the response they give to the questions asked and to prevent them from answering questions carelessly without thinking or guessing the answer. Thus, by providing questions to ask for clarification from students, it can encourage high-level thinking and communicative competence such as explaining, argumentation, and justification, as well as being a necessity for students to participate in meaningful and authentic conversation and teaching exchanges between students and teachers (Evans, 2020). In addition, questions asking for clarification also help students clarify their ideas and thoughts, encourage the skills of justification and evidence, and allow students to use their existing knowledge in solving various problems. This can strengthen students' conceptual understanding in addition to helping them assimilate and accommodate their original knowledge.

## 5. Conclusion

Overall, this study has sought to expand the research literature by providing a deeper understanding of how oral questions aid the development of student reasoning in the mathematics teaching process. Mathematics teachers can use various types of oral questions to help improve students' logical reasoning skills in teaching mathematics. However, a mathematics teacher should be creative and dynamic in determining the types of questions that need to be used as a tool to develop students' mathematical reasoning skills (Johari et al., 2022). Reasoning is an essential foundation for understanding mathematics more effectively and meaningfully; thus, the oral questions used by teachers during mathematics teaching activities should consider the various needs of the student's environment, such as the student's ability level, the learning environment, and the available learning resources. To achieve this objective, the oral questions asked by the teacher during mathematics teaching should allow students to be trained and guided to make conjectures, prove conjectures, provide logical explanations, analyze, make judgments, evaluate, and provide justification for all mathematical activities. In addition, teachers need to provide space and opportunities for mathematical discussions that are not only engaging but allow each student to be involved.

Overall, this study greatly expands the literature, especially to researchers in the field of mathematics education, about how the use of oral questioning can help improve students' abilities in mathematical reasoning. In addition, the information in this study also gives implications to mathematics teachers, especially pre-service teachers in mathematics education, in understanding the diversity of methods that can be used to build students' mathematical reasoning skills. Finally, the study has obtained extensive qualitative data regarding the phenomenon of oral questioning in the mathematics teaching process, which is implemented to improve students' reasoning skills in mathematics. However, the findings of this study cannot be generalized to other populations. Therefore, a quantitative study should determine whether the findings can be generalized to other populations.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Educational Planning and Research Division (EPRD), Ministry of Education Malaysia. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

MM conceived and designed the study, collected and organized the database, and performed the analysis. MM and NM wrote the manuscript and contributed to manuscript revision. Both authors read and approved the final submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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