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Students' Inquisitive Questions Predict Their Understanding of Mathematics Texts

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ABSTRACT

Background: Inquisitiveness plays an important role in learning. Inquisitiveness encourages a person's natural tendency to ask questions when faced with a confusing situation. However, students are often unable to generate effective questions to understand information from mathematics texts. **Objectives**: This study investigates the characteristics of inquisitive questions that arise from students in understanding mathematical texts and their impact on students' understanding of texts. **Design**: This study uses qualitative data and analysis of students' questions about mathematics texts. **Setting and Participants**: This research was conducted at Darul Ulum Islamic Boarding School University in Indonesia with 11 students. Data from three students as the most extreme cases were chosen for further discussion. **Data collection and analysis**: the data were obtained from observations of questions and student behavior during discussions, content analysis of written questions, and reading comprehension tests. **Results**: The types of questions students ask can be a predictor of their understanding level of math texts. Questions that are limited in depth, such as the questions about formulas and procedures, can indicate a lack of conceptual understanding and students' mathematical reasoning. The ability to raise inquisitive questions corresponds to an increase in understanding of mathematical texts. For students with high motivation to ask questions in the discussion, interventions to read carefully and write down questions in each part of the text can increase their understanding. **Conclusions**: Low motivation in asking inquisitive questions can be related to a lack of understanding of math texts and low academic achievement. The results of this study do not conclude a causal relationship. Investigations over a longer period of time toward more subjects may be able to provide more information.

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Keywords: *inquisitiveness; student's question; mathematics textbook; reading comprehension*.

Perguntas Inquisitivas dos Alunos Preveem sua Compreensão de Textos de Matemática

RESUMO

Contexto: A curiosidade desempenha um papel importante na aprendizagem. A curiosidade incentiva a tendência natural de uma pessoa de fazer perguntas quando se depara com uma situação confusa. No entanto, os alunos muitas vezes não conseguem gerar perguntas eficazes para compreender as informações dos textos de matemática. **Objetivos**: Este estudo investiga as características das questões inquisitivas que surgem dos alunos na compreensão de textos matemáticos e seu impacto na compreensão dos textos pelos alunos. **Design**: Este estudo utiliza dados qualitativos e análise de dúvidas dos alunos sobre textos de matemática. **Ambiente e participantes**: Esta pesquisa foi conduzida na Universidade Islâmica Darul Ulum, na Indonésia, com 11 alunos. Dados de três estudantes como casos mais extremos foram escolhidos para discussão posterior. **Coleta e análise de dados**: os dados foram obtidos a partir de observações das questões e do comportamento dos alunos durante as discussões, análise de conteúdo das questões escritas e testes de compreensão de leitura. **Resultados**: Os tipos de perguntas que os alunos fazem podem ser um preditor do seu nível de compreensão de textos de matemática. Perguntas com profundidade limitada, como questões sobre fórmulas e procedimentos, podem indicar falta de compreensão conceitual e de raciocínio matemático dos alunos. A capacidade de levantar questões inquisitivas corresponde a um aumento na compreensão de textos matemáticos. Para alunos com alta motivação para fazer perguntas na discussão, intervenções para ler atentamente e anotar perguntas em cada parte do texto podem aumentar sua compreensão. **Conclusões**: A baixa motivação em fazer perguntas inquisitivas pode estar relacionada à falta de compreensão de textos de matemática e ao baixo desempenho acadêmico. Os resultados deste estudo não concluem uma relação causal. Investigações durante um longo período de tempo em mais assuntos podem fornecer mais informações.

Palavras-chave: inquisitividade; pergunta do aluno; livro didático de matemática; compreensão de leitura.

INTRODUCTION

Inquisitiveness plays a role in initiating inquiry (Watson, 2015b, 2018). Inquisitive people are quicker to raise questions that inspire them to inquire (Baehr, 2011). Therefore, inquisitiveness is a necessary disposition in learning. Based on the relationship between the role of questions in the learning process, inquisitiveness is the primary intellectual virtue in education (Watson, 2015b). Inquisitiveness is also a dimension of critical thinking disposition. A person with low inquisitiveness has limited potential to expand knowledge in his profession (Facione et al., 1995).

Inquisitiveness relates to the one's ability to raise questions based on their desire to seek knowledge (Watson, 2019). Gao et al. (2022) distinguish the characteristic of inquisitive questions from informative questions. Informative questions ask for information at the surface level, while inquisitive questions used to ask for more in-depth information. Students usually have inquisitiveness in learning since an early age (Fusaro & Smith, 2018; Smith & Fusaro, 2020). Humans naturally can construct meaningful inquisitive questions that arise from knowledge gaps (Ko et al., 2020). Therefore, an environment full of problems should more easily trigger inquisitiveness (Bardone & Secchi, 2017). However, raising questions in learning is also not always easy. We have observed student activity in learning mathematics and found that sometimes students disable to construct many deep questions to reinforce their mathematical understanding. The following is an example of a student class discussion situation when learning material in mathematics available in the textbook.

> Student 1: *To determine the characteristic equation, we substitute the assumed solution into the general equation of the differential equation so that we get* $e^{rt}(ar^2 + br + c) = 0$. *Next we write* $ar^2 + br + c = 0$ *and see the discriminant. Any questions?*
>
> Students (all): *no sis, go to the next*
>
> (It ended without any further questions about the implication i.e. $ar^2 + br + c = 0$)

The lack of student's ability to ask questions can hamper mathematical understanding. Students sometimes immediately accept what is said in the textbook and are not always able to raise questions, as reflected in student statements in the following class conversations.

> Instructor: *But why can it be concluded like this? (refer to* $ar^2 + br + c = 0$*)*
>
> Students: (looks confused)
>
> Instructor: *Why was there no one asking about this?*

Students: *Because it's already in the book ma'am*

Questions are the key to active and meaningful learning, where questions by students help them fill in the knowledge gaps they are aware of, also to solve problems, guide knowledge construction, and can be worth information for teachers about student understanding (Chin, 2004). Inquisitiveness is a disposition that can make it easier for students to raise questions. Therefore, students' lack of questions can be associated with low inquisitiveness.

The emergence of questions in the inquiry process can be stimulated by or without inquisitiveness (Watson, 2015a). However, the question from inquisitiveness reflects the person's motivation to seek understanding without being asked. An example of an inquiry process that does not start from inquisitiveness is that students are asked to find some information to initiate the inquiry process in learning so that the questions asked do not come from themselves. The level of teacher questions can also affect the types of student questions (Chin, 2004), but the results of previous research also show that teacher questions cannot always be adapted by students to ask questions independently based on inquisitiveness (Watson, 2019). Meanwhile, learning in college requires students to have higher learning independence than in primary and secondary schools because the key to improving student mathematics performance besides conception mastery, is self-directed learning skills (Alotaibi & Alanazi, 2021). The inquiry process begins with student inquisitiveness showing independence in developing knowledge. Therefore, questions in the context of inquisitiveness in college students are important.

Learning mathematics consists of responding to questions posed by the teacher or text (Mason, 2020). Many previous studies have discussed effective teacher questioning strategies. This research, among other things, discusses the role of teacher questions on the success of discussions and increasing the participation of discussion participants (Davies & Sinclair, 2014; Katsara & De Witte, 2019; Lee et al., 2014; McCrone, 2005; Yang et al., 2005), increasing students' self-directed learning (Katsara & De Witte, 2019), as well as critical thinking skills (Yang et al., 2005). However, students' questions about mathematics texts received less attention. Taboada & Guthrie (2006) studied that high or low question levels were associated with reading comprehension, but this did not include studies on mathematics text comprehension. Understanding various mathematics texts is a must for pre service teachers because it will affect the ability to design constructivist mathematical questions for students (Purdum-Cassidy et al., 2015).

It is necessary to study the role of student questioning for the success of students learning. Students should not only be accustomed as answerers but also as question takers (Chin, 2004; Di Teodoro et al., 2011). In learning mathematics, many factors and conditions affect the effectiveness of a particular type of question (Mason, 2020). Mason (2020) prefers further investigation of situations that encourage or hinder the emergence of specific questions rather than investigating what types of questions or their sequences are effective in learning mathematics. The effectiveness of a question can be affected by its depth, while question depth describes one's inquisitiveness.

Inquisitiveness has been studied as one of the dispositions of critical thinking, but most of it focuses on its relationship with other variables such as age, experience, gender, and field of knowledge (Colucciello, 1999). ; Cubukcu, 2006; Emir, 2009; Emİr, 2013; Giancarlo et al., 2004; Lampert, 2006; Lang, 2001; Noone & Seery, 2018; Rimiene, 2002; Suliman, 2006; Tsai, 2019; Wangensteen et al. , 2010; Zhang & Lambert, 2008). These studies use a global domain perspective that is not describe specific activities related to a discipline. Meanwhile, the investigation of inquisitive questions in learning situations is still limited. Several studies investigate inquisitiveness through the characteristics of the students' questions but are limited to the context of early childhood learning (Fusaro & Smith, 2018; Smith & Fusaro, 2020), the effect of giving examples of teacher questions toward encouraging student inquisitiveness questions (Watson, 2019), in the context of management teamwork (Bardone & Secchi, 2017), and related to inquisitiveness about oneself (Miscevic, 2018; Robinson & Demetre, 2017). These studies are not sufficient explanations for inquisitive questions in understanding mathematics texts.

Based on the problems encountered by researchers regarding the lack of critical questions in understanding mathematical texts, this study will investigate the types of inquisitive questions that arise in students when understanding mathematical texts and provide an overview of the mathematical understanding they obtain based on the text. This research is an urge to do because students' understanding of mathematics textbooks is crucial in college, considering that students need more self-directed learning, even though it is still facilitated by instructors. Student inquisitiveness is needed in understanding information, including mathematics texts, to encourage an effective inquiry process. We expect that the results of this research can add insight into the importance of inquisitiveness in learning and provide information as a background for developing strategies for learning mathematics in college.

THEORETICAL BACKGROUND

Inquisitiveness

The study of inquisitiveness stems from two different main focus studies. The focus of the first study is related to the disposition to think critically (N. C. Facione et al., 1994; P. A. Facione, 1990; P. A. Facione et al., 1995). Critical thinking dispositions are described as covering seven dimensions, namely Inquisitiveness, Open-mindedness, Systematicity, Analyticity, Truth-seeking, CT Self-confidence, and Maturity (Facione et al., 1995). Facione defines inquisitiveness as a disposition related to intellectual curiosity. This curiosity does not only arise when knowing the benefits that one gets from that knowledge. Facione et al. (1995) provide examples of statement items that are in accordance with the nature of inquisitiveness. Inquisitiveness can be predicted when someone agrees with the statements “It doesn't matter what the topic is, I would love to know more about it”, “Learn everything you can, you never know when it will come in handy”, “Learning new things makes life so much fun ”. While statements that show a tendency away from inquisitiveness include "most lectures are uninteresting and not worth taking".

The concept of inquisitiveness from Facione's study was widely used by subsequent researchers, by using the California Critical Thinking Disposition Inventory (CCTDI) instrument, to measure the level of inquisitiveness along with other dimensions of critical thinking. The results of this study show inconsistent conclusions regarding the relationship of inquisitiveness with other variables. Some research results show that normally, the higher a person's age, the better his disposition (Emir, 2009; Lampert, 2006; Wangensteen et al., 2010). However, this condition does not always occur (Zhang & Lambert, 2008). The difference in these results may be due to the interference of other variables, for example, the amount of learning and experience gained by the subject. In terms of learning success, the findings of some studies show that there is an increase in general disposition but not significantly in inquisitiveness (Giancarlo & Facione, 2001; Lang, 2001; Rimiene, 2002), but this is not always found in other studies. Some researchers hypothesize that inquisitiveness is a disposition that tends to be stable and innate, but they also provide views on the possibility of a lack of attention to that aspect of learning or programs that are designed. Inquisitiveness is also associated with the characteristics of certain learning styles or thinking styles (Emİr, 2013; Suliman, 2006). Viewing inquisitiveness as an innate trait or the result of habituation can also be analogous to how we view the emergence of a dominant learning style in a person. Next, academic achievement and length of education are found not always to be positively correlated with inquisitiveness (Emir, 2009; Noone & Seery, 2018; Zhang & Lambert, 2008). This can be seen as a recognized meaning of achievement in an educational program that does not always reflect the critical thinking abilities of its students. The results of increasing inquisitiveness may also depend on the type of intervention experienced during education. Differences in inquisitiveness based on gender differences are also not consistent findings between studies. While the advantages of inquisitiveness associated with certain scientific fields can be understood as a tendency due to the way of working in certain fields (Cubukcu, 2006), it can also be seen the other way around, namely the choice of fields that are the preference of someone with certain dispositional characteristics. On the other hand, there are also findings that there is no significant difference between the inquisitiveness of students in the arts and non-arts (Lampert, 2006) and between students of different fields in the scope of science (Kezer & Turker, 2012).

Research on inquisitiveness using the CCTDI instrument has limitations because it only reveals the subject's perception of himself, making it more susceptible to biased conclusions. In addition, the assessment of thinking dispositions cannot be done in such a simple way. Assessment of critical thinking dispositions cannot only be carried out by ordinary observation but must be under conditions that can trigger the emergence of a characteristic behavior of that disposition without the subject being aware of what behavior is being studied (Ennis, 1996). Ennis does not suggest multiple-choice questions to assess disposition. Meanwhile, observations on the subject's actual performance can also be carried out but this makes the observations unfocused and it may take a long time for indications of a natural disposition to emerge. He prefers assessments based on focused open-ended tasks. Nonetheless, research on inquisitiveness as a critical thinking disposition based on authentic assessment still requires a long period of observation.

The second root of the study comes from Watson's definition of inquisitiveness as a tendency to ask questions that contain components of motivation and success, showed in Figure1 (Watson, 2015a). Even though he uses the term "tendency", this study does not focus on the emergence of the trait of wanting to ask someone who is consistent all the time. The studies of inquisitiveness here focus more on the characteristics of motivation and good questions (Watson, 2015b, 2015a, 2018b, 2018a, 2019).

Figure 1

The component of inquisitiveness (Watson, 2015a)

Watson's focus on inquisitiveness is related to intellectual virtue. Inquisitiveness can be distinguished as virtuous inquisitiveness and non-virtuous inquisitiveness (Watson, 2015a). People who ask lots of questions do not always mean inquisitive, that is, if they ask questions not to expand their knowledge. Watson (2015a) defines inquisitiveness as a virtue that distinguishes it from the meaning of "to know" in ordinary language. He gives an example of the meaning of inquisitiveness in the context of general language, which does not fulfill the virtue, including cases where a student asks a lot about the private life of his tutor, or a student asks to develop knowledge but limits it only to the content to be tested. This example illustrates students who are motivated and successfully ask questions to develop knowledge, but their curiosity lacks the positive evaluative dimension as an attribute of intellectual virtue. To be virtuously inquisitive, a person must not only demonstrate the characteristics of the motivation to engage genuinely in asking (sincerity), but they must also be able to ask good questions. The characteristic of this question is also a special feature of inquisitiveness that distinguishes it from the general understanding of curiosity. Good questions required in virtuous inquisitiveness must at least meet the following criteria (Watson, 2015b):

a. Selecting and targeting the information needed to improve epistemic standing in a relevant way,

b. Identifying appropriate conductive contexts to improve epistemic standing based on the areas discussed, as well as

c. Formulating questions effectively

Even though they appear to depart from different points, the two studies are related, namely regarding the purpose of questions to deepen understanding and their role in building critical thinking. Inquisitiveness defined by Watson is related to intellectual virtues, which is also an emphasis in defining critical thinking by Richard Paul (Paul, 2005). According to Paul, a critical thinker routinely applies standards (clarity, accuracy, relevance, logicalness, breadth, precision, significance, completeness, fairness, depth) to elements (objectives, questions, viewpoints, information, inferences, concepts, implications, assumptions) as he learns to build intellectual traits (Intellectual Humility, Intellectual Courage, Intellectual Empathy, Intellectual Autonomy, Intellectual Integrity, Intellectual Perseverance, Confidence in Reason, Fairmindedness) (Paul & Elder, 2020). The intellectual qualities of critical thinkers are intellectual virtues inherent in their abilities and dispositions. In Paul's view, critical thinking is the art of analyzing and evaluating thinking processes with a view to improving them, which is a way of thinking that is self-directed, self-disciplined, self-monitored, and self-corrective (Paul & Elder, 2020). One of the results of critical thinking will make a person have the characteristics of raising vital questions and problems and formulating them clearly and precisely.

Another research focus is related to inquisitive questions which are defined as questions aimed at deepening understanding (Chin, 2004; Fusaro & Smith, 2018; Gao et al., 2022; Ko et al., 2020). The emergence of inquisitive questions can be an indication of someone's inquisitiveness. Gao et al. (2022) distinguished inquisitive questions from informative questions. Informative questions ask for surface-level information, while inquisitive questions ask for more in-depth information. Inquisitiveness in learning has been possessed by students from an early age (Fusaro & Smith, 2018; Smith & Fusaro, 2020). Humans naturally have the ability to construct meaningful inquisitive questions that arise from knowledge gaps (Ko et al., 2020). Therefore, an environment full of problems should more easily trigger inquisitiveness (Bardone & Secchi, 2017). Inquisitive questions can have different ranges of information seeking. Ko et al. (2020) distinguished the types of inquisitive questions that a person uses in understanding information that requires high levels of cognitive ability.

Reading Comprehension of Mathematics Textbook

Literature or textbooks have the main role in learning mathematics. The ability to understand mathematical texts is needed to improve mathematical understanding, and its role increases as independent learning and self-directed learning are promoted. Therefore, the ability to understand mathematics texts is necessary for students and pre service teachers of mathematics. However, difficulties in understanding textbooks also often occur in students. Shepherd et al., (2012) identified the types of difficulties that most often arise for students in understanding the content of mathematics reading. The difficulties related to definitions, theorems, examples, and further exploration, namely, among others, a lack of sensitivity or an inappropriate response to confusion, insufficient or incorrect prior knowledge, as well as a lack of attention to the specific parts of the textbook. In addition, students often regard mathematics textbooks only as a source for finding examples of questions similar to assignments or exams and tend not to take advantage of sections that contain "big ideas" to deepen their understanding (Weinberg et al., 2012). Student's difficulties in understanding high-level texts can be associated with a lack of ability to ask questions (Ko et al., 2020; Taboada & Guthrie, 2006).

METHODOLOGY

This study aims to explain a situation that occurs in a class and is not intended as a generalization. Therefore, a qualitative methodology is used in this study. The formulated research question is: "what are the characteristics of inquisitive questions that arise from students in understanding mathematical texts and their impact on students' understanding of texts?". The mathematics text in this study is specific to the topic of combinatorics in college, which is learned in student presentations and discussions in class based on college textbooks.

Participants

The participants involved in this study were 11 second-year pre service teacher students at Darul Ulum Islamic Boarding School University who were taking a discrete mathematics course on the topic of combinatorics. All participants were female students, but this was not part of the intentional arrangement. Data collection is carried out during learning with combination material. Three students who attended all section in seminar, text review, and forum group discussion were selected for further description as compared cases based on maximum variation sampling represented a general characteristic from the data that emerged during the study. The sample selection is by considering changes in students' understanding, as well as the frequency and depth of questions, to provide an overview of the relationship between students' questions and their understanding of mathematical texts.

In order to fulfill the ethic social research, the Informed Consent Form (ICF) has been duly prepared and signed by all participants involved in the research. To uphold participant confidentiality, we have taken measures to guarantee anonymity. By obtaining their signatures, we have ensured that all participants are fully aware of their involvement and have given their informed consent voluntarily. We have conducted a thorough assessment of the project's ethical risks and have determined that the research carries minimal ethical risks to the participants. Our assessment is based on a comparison with previous similar projects and common practices within our institution, all of which adhere to ethical guidelines and standards. We exempt Acta Scientiae from any consequences arising, including full assistance and possible compensation for any damage to any research participants, per Resolution No. 510, of April 7, 2016, of the National Health Council of Brazil.

Instrument and Data Collection

The data was collected through observation, content analysis, interviews in a forum group discussion, and test. The first stage of data collection was carried out during the learning session using the seminar method. The material presented by students as presenters in this activity is the summary of understanding gained from reading the textbooks provided. In the seminar, a group of presenters consisting of two students was doing a presentation. Furthermore, all participants discussed the material presented.

During the discussion, students' activities were observed to identify any inquisitive questions that arose.

To anticipate the possibility of students who have questions but are not comfortable conveying them directly in the forum, the researcher also assigned students to conduct a written review in pairs with their team of the presentation material presented. This review can be in the form of questions to criticize or ask for clarification. These written questions were considered research data.

Next, we investigate students' understanding of a part of the text that contains reasoning by test before and after the focus group discussion. This data is collected from the results of tests on problems related to 'over-counting' in combinatorics. The problem has been exposed in one part of the text that was presented before but in a different form of context information. This part was selected from the textbook based on the consideration of the cognitive level needed to understand it. Procedural understanding alone is not enough to understand this 'over-counting' problem, students need justification skills based on proper reasoning. The test is carried out openly, which means that students can freely view all sources of information. The following is a problem in the test adapted from the over-counting problem in calculating how many ways to draw cards. This problem shows that there is over-counting in answer B resulting in the wrong answer.

A fashion designer offers a boutique entrepreneur in the form of 4 different clothing models. Each has variations in the colors brown, black, white, pink, purple, and green. The boutique entrepreneur wants to choose five types of clothes to sell in his shop with different models and colors according to his observations of consumer tastes. He wants at least one type of black clothes. How many ways can you choose the five types of clothes?

From the questions above, it is known that there are four models of clothes and six different colors, so there are 24 different types of clothes.

<u>Answer A</u>

First, we count the number of ways to choose five types of clothes without black, namely $\binom{20}{5}$. While the number of ways to choose five types of clothes from all the choices provided by the designer is $\binom{24}{5}$.

So, the number of ways to choose five types of clothes with at least one type of black clothes is $\binom{24}{5} - \binom{20}{5} = 42.504 - 15.504 = 27.000$

Answer B

First, we count the number of ways to choose one type of black shirt, namely $\binom{4}{1}$. Furthermore, the number of ways to freely choose the other four types of clothes is $\binom{23}{4}$.

So, the number of ways to choose five types of clothes with at least one type of black clothes is $\binom{4}{1}\binom{23}{4} = 35.420$.

In your opinion, which answer is correct? Give reasons for each answer.

Further data collection was carried out through interviews and observations in a focus group discussion which lasted about 90 minutes. Focus group discussions are held two weeks after learning. The focus of this discussion is over-counting problems section from the mathematics textbook. However, the presentation of the problem is carried out by the instructor with simplified language. In this focus group discussion, we explored the questions students had based on their inquisitiveness. Therefore, students are asked to perceive themselves as someone who has a great curiosity to understand the mathematical content presented and ask questions. Data collection at this stage is intended to find out more about inquisitive questions that focus on one part of the text that has been previously studied in seminar activities and the effect it has on students' understanding of over-counting problem. Students held discussions without the instructor's intervention in the first data collection, but in the second stage, there was an intervention to ask students to read detail of the text and write questions on the whiteboard carefully. In this activity, students' behavior in asking questions in discussions was observed.

Data Analysis

We identified student inquisitive questions during discussions and interviews as well as written questions during text review activities. Types of questions were analyzed based on inquisitive question categories from high-level text comprehension (Ko et al., 2020). This framework was used because it corresponds to the characteristics of mathematics texts that require high-level thinking to understand. The question categories are described in Table 1. We recorded the types and the frequency of questions. We also analyzed students' understanding of mathematical texts by the correctness of the answer choices with the reasoning behind these answers. Furthermore, the questions asked by students before and after the intervention were associated with the development of students' mathematical understanding of the contents of the text.

Table 1

Inquisitive questions from high-level text comprehension (Ko et al., 2020).

Inquisitive question category	Description
Why questions	Causal questions, often also stated with "what is the reason"
Elaboration questions	Questions seeking detailed descriptions, often in the form of “how” questions
Definition questions	Questions about the meaning of technical or domain-specific terminology
Background information questions	Questions to find out more about the big picture of the context being discussed
Instantiation questions	Questions to ask for specific examples
Forward looking questions	Questions that reflect curiosity about what happens next
Others	Questions that do not fall into the above categories. This question can be a rhetorical question

RESULTS AND ANALYSES

Inquisitive questions during seminar and text review

In the first stage of the activity, students were asked to ask questions orally about the text discussed in the seminar as well as questions in writing in the text review activity. The oral questions that arise observed during the seminar, then content analysis is carried out on the questions written in the text review. In this activity, there was no intervention from the researcher regarding how to understand the reading. Student inquisitive questions that arise naturally during discussion and text review are dominated by elaboration and definition questions (Table 2). Most of the questions that arise are clarification in nature. The domain of mathematical knowledge is also dominated by questions about procedures or formulas. Student questions show that their inquisitive questions are still at the surface level and in general. Students also do not ask questions related to over-counting problems in the provided text, in which students will be tested for their understanding of the contents of the text.

Table 2

Student inquisitive questions during seminars and reviews

Question category	Target domains	Sample question
Elaboration questions	Procedure or formula	For that example using what formula?
		Can all combination solutions be written in sigma form?
		How to form sigma notation from combination questions?
	Concept	What is the difference between combination and binomial?
		What is the relationship between the combination and the binomial?
	Ask for a general explanation	I do not understand about this, can you explain again?
Definition questions	Symbol	(wt), what is it?
	Concept	What is the meaning of multinomial coefficients?
		What is the definition of combination?
		What is the binomial theorem?
Forward looking questions	Procedure or formula	Is there another combination formula?

Questions during the forum group discussion

The following are inquisitive questions identified through focus group discussion interviews. In the forum group discussion, students are asked to read carefully per sentence in the text and formulate questions in writing. They were asked to use their curiosity in asking questions. The result of this activity is that less text is discussed, namely only on the over-counting problem, but the types of questions asked are more diverse and in-depth than before. This activity raises questions that have never been asked before, as well as new categories of questions such as why-questions and background information questions. This type of forward-looking question also develops in finding alternative answers. The questions in this session are no longer dominated by questions about formulas. Examples of the types of questions in this session can be seen in Table 3.

Table 3

Student inquisitive questions focused on the text of the over-counting problem.

Question category	Sample question
Why questions	*Text*: She can then choose the other four cards in $\binom{51}{4}$ ways *Question*: Why 51? Where can you get 51 on $\binom{51}{4}$?
Elaboration questions	*Text*: Ellen draws five cards from a standard 52-card deck. How many ways to draw the card without a club card? *Question*: How many club cards? What kinds of cards? What do the 13 cards consist of?
Definition questions	*Text*: She can make a choice in $\binom{51}{4}$ ways *Question*: Why use sign "( )" instead of using ${}_{39}C_5$, is there a difference? *Text*: Now suppose that we want to count the number of choices of five cards that consist of at least one club *Question*: What does the word "at least" mean?
Background information questions	*Text*: Ellen draws five cards from a standard 52-card deck *Question*: With return or not?

Forward looking questions	*Text*: How many ways can the card be selected? *Question*: How is the final solution? *Text*: Something is seriously wrong here! The answers obtained here are greater than the answers in part (b) by more than 1 million. *Question*: Where is the error in answer c? *Text*: Can we get the answer to problem (b) in another way? *Question*: can I use this other method?

Development of students' understanding based on inquisitive questions.

Student test results before the focus group discussion showed a lack of understanding of the part of the text that contains reasoning on the over-counting problem. Even if the student's choice is correct, they cannot explain the mathematical arguments from their answers, even though these arguments are already available in the text they are studying. However, there was an increase in test results after students were able to make more in-depth questions in focus group discussions. Eight students attended the forum group discussion, while the others said they could not take part in the forum. Table 4 shows the types and frequency of students' questions during the focus group discussion and the corresponding changes in students' understanding. There is a tendency to increasing understanding of students who ask more questions.

Table 4.

Description of the students

Students	(Type of question*) (frequency)	Students' understanding in 'over-counting problem'
DR	(el) (1)	From *wrong* choice to *right* choice with more explanation but no detail
AZ	(back) (1); (el) (1)	From *wrong* choice to *right* choice with a short explanation
MK	(def) (1)	From *right* choice with a short explanation without reasoning to *right*

		choice with more explanation but no detail
LA	(back) (1); (el) (2); (forw) (2)	From *wrong* choice to *right* choice with detail explanation including the reasoning
AK	(el) (1); (forw) (1); (why) (1)	From *right* choice with a short explanation without reasoning to *right* choice with more explanation but no detail
UR	(el) (1); (def) (1)	From *right* choice with a short explanation without reasoning to *right* choice with more explanation but no detail
NS	No question	From *right* choice with a short explanation without reasoning to *wrong* choice
SF	No question	From *wrong* choice to *wrong* choice with more explanation

Note: el (elaboration); back (background information); forw (forward looking); def (definition)

We explain examples of the development of understanding associated with activities in asking inquisitive questions based on the results of three students namely LA, SF, and NS (Table 5). The discussion on these three subjects was chosen to provide an understanding of the results of the study through a comparison of the most extreme cases in the group studied. Based on the relative assessment of the class, LA is a student with moderate academic achievement who actively asks questions during focus group discussions and progresses in her mathematical understanding. Although some students showed increasing understanding, LA experienced a more significant increase. LA also has high motivation, as evidenced by how she offers alternative ways of finding answers without being asked during discussion. While SF is classified as a low achiever and is less motivated to ask questions, and does not show understanding development. The third subject, namely NS, is classified as a student with moderate academic achievement. She did not ask questions during the focus group discussion and did not experience growth in understanding, instead, she experienced a change from the correct answer choice to the wrong answer.

Table 5

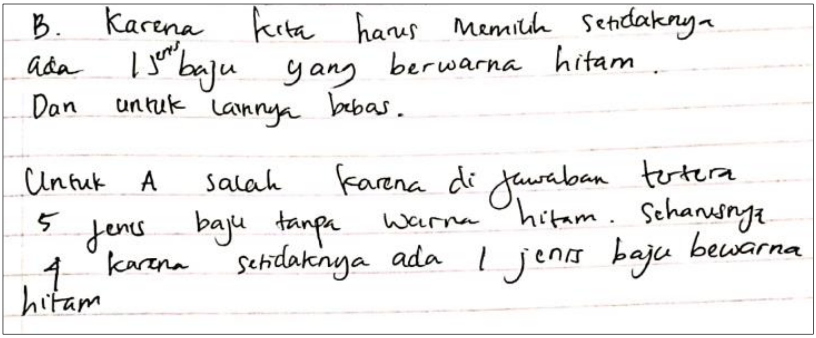
Description of the students.

Students	Questioning activity	Test results
LA	Actively ask questions	There was a change from an incorrect answer choice to a correct one
SF	Never asked a question	The answers before and after the discussion are still incorrect
NS	Never asked a question	There was a change from correct choice (without sufficient explanation) to incorrect choice (with lots of explanation)

The first result shows a high level of participation in asking questions related to increasing student understanding. These results can be observed from LA which is an active and motivated student asking questions during the discussion. In the first test, she gave the wrong answer by assuming the alternative answer error A was because it was written "five types of clothes without black, which should be four because there is at least one type of black clothes". She does not understand that "five types of black clothes" also fulfill the condition "there is at least 1 type of black clothes", not just 4. In the second test, there is an increase in understanding so that she can choose the correct answer along with a more complete written explanation or argument (Figs 2 and 3).

Figure 2

Student (LA) in the first test answers showing wrong answers and lack of understanding.


B. Karena kita harus memilih setidaknya ada 1 jenis baju yang berwarna hitam. Dan untuk lainnya bebas.

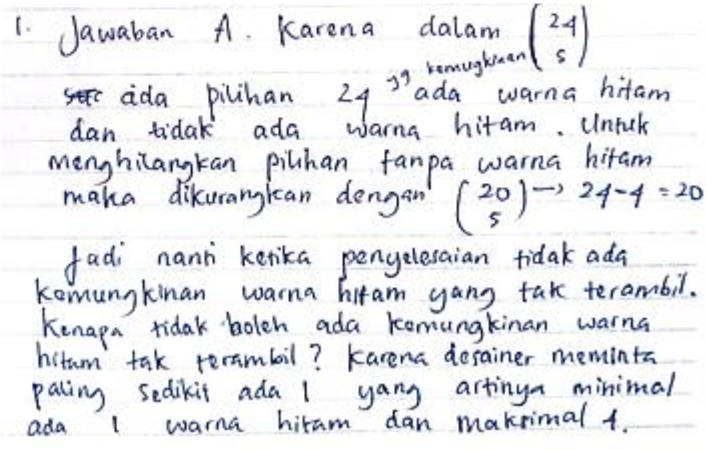
Untuk A salah karena di jawaban tertera 5 jenis baju tanpa warna hitam. Seharusnya 4 karena setidaknya ada 1 jenis baju bewarna hitam

Translation:

Answer B is correct because we have to choose at least 1 type of clothes that is black and the others are free.
Answer A is wrong because the answer says 5 types of clothes without black color. It should be 4 because there is at least 1 type of black clothes.

Figure 3

Student (LA) answers on the second test after the forum group discussion showed an increase in understanding.


1. Jawaban A. Karena dalam $\binom{24}{5}$ kemungkinan ~~sec~~ ada pilihan 24 yg ada warna hitam dan tidak ada warna hitam. Untuk menghilangkan pilihan tanpa warna hitam maka dikurangkan dengan $\binom{20}{5} \rightarrow 24-4=20$

Jadi nanti ketika penyelesaian tidak ada kemungkinan warna hitam yang tak terambil. Kenapa tidak boleh ada kemungkinan warna hitam tak terambil? Karena desainer meminta paling sedikit ada 1 yang artinya minimal ada 1 warna hitam dan maksimal 4.

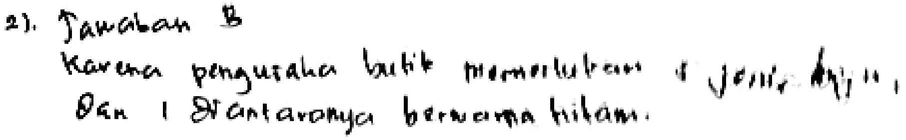
Translation:

The correct answer is A because in $\binom{24}{5}$ there are 24 choices that may or may not contain black. To get rid of options without black, then subtract 4 so that it's $\binom{20}{5}$. So later there is no possibility of black color not being picked up. Why can't there be a black possibility? Because the designer asked for at least 1, which means that there is at least 1 black color and a maximum of 4.

In the second example, it will be shown how student who is less motivated in asking questions do not experience development in her understanding. SF' answers did not change significantly and still gave wrong answers (Figures 4 and 5). The student had low participation in mathematical discussions, indicating a lack of motivation to seek knowledge. She is also classified as a low achiever compared to her peers.

Figure 4

Student's wrong answer (SF) on the first test.

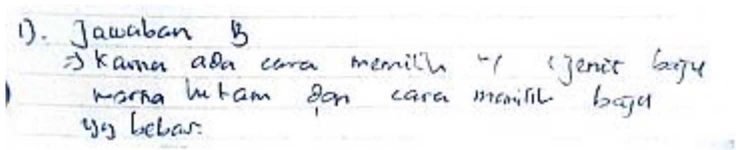

2). Jawaban B
Karena pengusaha batik memerlukan 5 jenis baju,
dan 1 diantaranya berwarna hitam.

Translation:

Answer B is correct because the boutique entrepreneur requires 5 types of clothes and 1 of them is black.

Figure 5

Student's wrong answer (SF) on the second test did not show an increase in understanding.


1). Jawaban B
=> karna ada cara memilih 4 (jenis baju
warna hitam dan cara memilih baju
yg bebas.

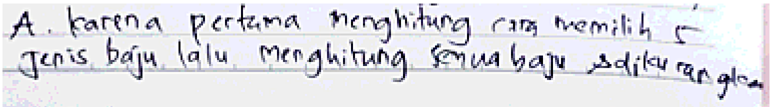
Translation:

Answer B is correct because that is how to choose 5 types of black clothes and how to choose clothes that are free

The third example shows the test results of NS, student who changed from choosing the correct answer to the wrong answer (Figures 6 and 7). Even so, the correct answer she chose on the first test was not based on the proper reasoning. On the second test, NS showed a lack of understanding of the text presented in the questions. She stated that answer A was wrong based on the information in the first sentence "First, we calculate the number of ways to choose 5 types of clothes without black, namely " but did not consider the context of the next sentence. Even so, NS experienced development in communicating ideas and had some incomplete understanding. This student is also a student who does not ask questions even though at an academic level it is almost on par with LA, which is not classified as a low achiever in that class.

Figure 6

Students (NS) in the first test chose the correct answer but without proper arguments.

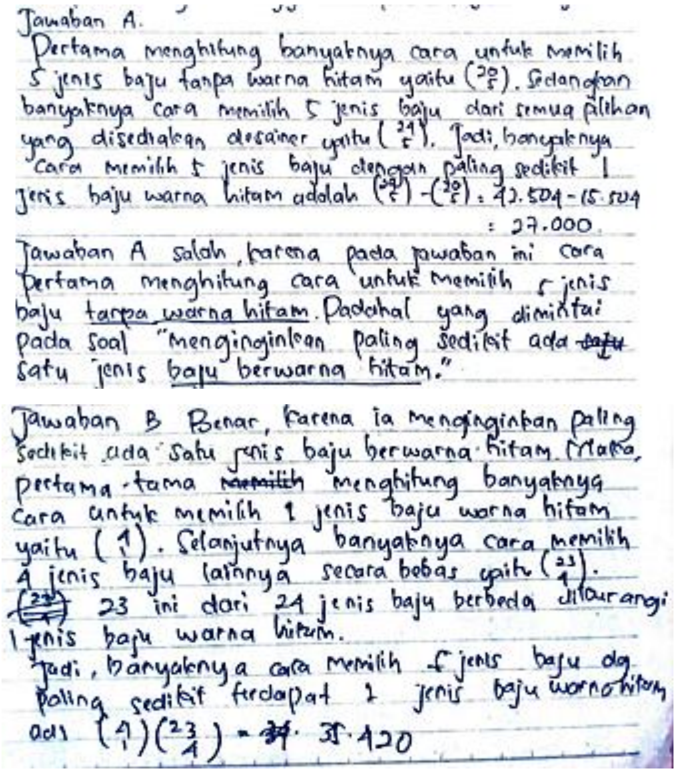


Translation:

Answer A is correct because the first step is calculating how to choose 5 types of clothes, then counting all the clothes, then subtracting them.

Figure 7

Students (NS) in the second test chose the wrong answer.


Jawaban A.
Pertama menghitung banyaknya cara untuk memilih 5 jenis baju tanpa warna hitam yaitu $\binom{20}{5}$. Selanjutnya banyaknya cara memilih 5 jenis baju dari semua pilihan yang disediakan desainer yaitu $\binom{24}{5}$. Jadi, banyaknya cara memilih 5 jenis baju dengan paling sedikit 1 jenis baju warna hitam adalah $\binom{24}{5} - \binom{20}{5} = 42.504 - 15.504$
$= 27.000$

Jawaban A salah, karena pada jawaban ini cara pertama menghitung cara untuk memilih 5 jenis baju tanpa warna hitam. Padahal yang diminta pada soal "menginginkan paling sedikit ada ~~satu~~ satu jenis baju berwarna hitam."

Jawaban B Benar, karena ia menginginkan paling sedikit ada satu jenis baju berwarna hitam. Maka, pertama-tama ~~memilih~~ menghitung banyaknya cara untuk memilih 1 jenis baju warna hitam yaitu $\binom{4}{1}$. Selanjutnya banyaknya cara memilih 4 jenis baju lainnya secara bebas yaitu $\binom{23}{4}$.
$\cancel{\binom{23}{4}}$ 23 ini dari 24 jenis baju berbeda dikurangi 1 jenis baju warna hitam.
Jadi, banyaknya cara memilih 5 jenis baju dg paling sedikit terdapat 1 jenis baju warna hitam adl $\binom{4}{1}\binom{23}{4} = \cancel{34} \cdot 35 \cdot 420$

Translation:

Answer A is wrong because in this answer the first step is to calculate the number of ways to choose 5 types of clothes without black. Even though what was asked in this question was "at least one type of black clothes".

Answer B is correct because he wants at least one type of black clothes. So first, calculate the number of ways to choose 1 type of black clothes, $\binom{4}{1}$. *Furthermore, the number of ways to choose the other 4 types of clothing freely,* $\binom{23}{4}$. *Then there are 23 of the 24 different types of clothing minus 1 type of black clothing. So, the number of ways to choose 5 types of clothes with at least 1 type of black is* $\binom{4}{1}\binom{23}{4} = 35 \cdot 420$.

Discussion

The ability to raise inquisitive questions corresponds to an increase in understanding of mathematical texts. The more and more in-depth inquisitive questions are associated with an increasingly significant increase in understanding of mathematics texts. This finding supports the results of a study by Taboada & Guthrie (2006) who also found that high or low question levels are associated with reading comprehension levels. Meanwhile, the quality of student questions can be determined by the ability in reading comprehension (Maplethorpe et al., 2022). The results of this study also strengthen the opinion that student questions can provide useful information for instructors about students' understanding levels (Chin, 2004). Thus, the results of evaluations of students' inquisitive questions about mathematics texts have the potential to serve as a source of information on students' mathematical understanding so that instructors can provide appropriate feedback to improve them.

Question data obtained before the intervention in reading comprehension showed that students tended to ask questions that were less in-depth, limited in type, and most focused on formulas and procedures. The "how can" and "why" question types have a high quality of inquisitiveness (Gao et al., 2022), but these types of questions have not appeared in discussion sessions on seminar text review materials. The test results show that with this condition students' understanding is still limited. Even though student questions met the criteria as inquisitive questions, they did not succeed in encouraging students to think at a higher level. Basic information questions are less able to produce productive discussions compared to wonder questions which stimulate students' thinking in more depth (Chin et al., 2002). These results add to the evidence that not every inquisitiveness can drive successful inquiry (Watson, 2015b). Nonetheless, there is an opinion that basically humans have inquisitiveness and the ability to construct questions to fulfill deficiencies in their knowledge (Ko et al., 2020). This findings gives the view that inquisitiveness is not nonexistent, but a person has inquisitiveness at different levels, and only high inquisitiveness can encourage in-depth investigation. Good inquisitive questions need to target relevant information, be in the right context, and be formulated effectively to enhance epistemic standing (Watson, 2015a, 2018).

Another finding is that without intervention to read carefully, not every detail of the text becomes a source of questions, especially texts related to high levels of understanding and reasoning. Research by Shepherd et al.,

(2012) found that the reasons for students' difficulties in understanding mathematics textbooks included a lack of sensitivity, or an inappropriate response to their confusion, inadequate or incorrect initial knowledge, and insufficient attention to the detailed content of textbooks. Students may move on to the next section in response to their confusion. Other research findings also found that students tend to prefer textbooks that provide clear and similar examples of assignments and exams (Weinberg et al., 2012).

Strategies to increase understanding of mathematics texts can be carried out with interventions to read carefully, write down the questions they formulate from the text, and ask students to perceive themselves as someone who have a high curiosity. This intervention is proven to generate more in-depth and varied questions and has a positive impact on increasing students' understanding of mathematics texts. However, this intervention has not proven successful for students with low motivation to ask questions and some students who are classified as low achiever. Because inquisitiveness consists of components of motivation and questions (Watson, 2018), a person will find it difficult to develop knowledge without motivation based on curiosity. Inquisitive questions tend to be difficult for low-achiever students to ask, which may be due to a lack of basic knowledge. A lack of basic knowledge causes a bigger information gap. Previous research found that the smaller the information gap, the higher a person's curiosity (Noordewier & van Dijk, 2020). Curiosity can appear in someone based on an interest in open information to develop their knowledge or based on a desire to reduce uncertainty due to lack of knowledge (Litman, 2005). Searches with a focus on the desire to make up for a lack of knowledge are less enjoyable than the desire to explore broader knowledge (Noordewier & van Dijk, 2020). Low achievers who recognize their lack of understanding of mathematics may have more difficulty building motivation than high achievers who feel they understand basic knowledge and want to build on it.

Unsuccessful interventions did not only occur for low achievers, but also for students with higher academic levels. Not asking questions can also be caused not only by low motivation to learn, but also by a lack of awareness of the misunderstandings they have. Someone with high inquisitiveness will continue to seek understanding until it reaches an equilibrium state (Bardone & Secchi, 2017). This might explain the cause of a person's lack of inquisitive questions as a result of no disequilibrium conditions occurring in their cognitive processes.

CONCLUSIONS

Low motivation in asking inquisitive questions can be related to a lack of understanding of math texts and low academic achievement. Asking students to read carefully each section of the text and formulate questions in writing can help students with high motivation to develop their understanding. However, this strategy is less successful for students with low motivation.

In addition, the types of questions students ask can be a predictor of their level of understanding of math texts. Questions that are limited in its depth, such as the questions about formulas and procedures, can indicate a lack of conceptual understanding and students' mathematical reasoning. Therefore, the task of constructing questions has the potential as a formative assessment tool to assess students' level of understanding.

The results of this study do not conclude a causal relationship explicitly. Whether low inquisitiveness causes the limitations of mathematical understanding or the lack of understanding hinders the emergence of inquisitive questions, or both, needs to be investigated in further research. This research is only limited to subjects in one class and the data recorded is only in limited learning sessions. Investigations over a longer period of time may be able to provide more information.

AUTHORS' CONTRIBUTIONS STATEMENTS

All authors, UU, ARA, Sk, and Ss, have contributed to the design and development of this study and to the writing of this manuscript.

DATA AVAILABILITY STATEMENT

The data presented and supporting this research results are available at a reasonable request to the first author, UU.

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