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PRE-SERVICE TEACHERS' INQUISITIVENESS IN MATHEMATICS LEARNING

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ABSTRAK

Inquisitiveness merupakan disposisi berpikir kritis yang penting dalam proses inkuiri karena berkaitan dengan kecenderungan dalam mengajukan pertanyaan. Akan tetapi, kajian tentang *inquisitiveness* pada domain pembelajaran matematika masih terbatas. Beberapa penelitian terdahulu hanya menjelaskan inquisitivenes berdasarkan sikap umum tanpa melibatkan konteks matematika. Penelitian ini bertujuan untuk mendeskripsikan *inquisitiveness* mahasiswa calon guru matematika yang diwujudkan dalam pengajuan pertanyaan. Penelitian ini merupakan penelitian kualitatif dengan subjek penelitian mahasiswa calon guru di Universitas Pesantren Tinggi Darul Ulum. Data penelitian ini dikumpulkan melalui tes, observasi, dan wawancara. Hasil penelitian menunjukkan bahwa kecenderungan mahasiswa calon guru matematika dalam mengajukan pertanyaan yang efektif ketika menanggapi informasi dalam masalah matematis terbukti masih rendah. Calon guru tidak selalu dapat mengajukan pertanyaan walaupun belum memahami alasan rasional di balik suatu pernyataan. Temuan lain dari penelitian ini meskipun calon guru dapat mengajukan pertanyaan dalam diskusi, namun pertanyaan mereka belum dapat memenuhi kriteria *inquisitiveness* karena kurang berhasil dalam mengembangkan pemahaman secara mendalam.
Kata Kunci: berpikir kritis, disposisi, inquisitiveness, pengajuan pertanyaan

ABSTRACT

Inquisitiveness is a critical thinking disposition that is important in the inquiry process because it relates to the tendency to ask questions. However, studies on inquisitiveness in the domain of mathematics learning are still limited. Several previous studies have only explained inquisitiveness based on general attitudes without involving the context of the field of mathematics. This study aims to describe the inquisitiveness of mathematics prospective teacher students which is showed in asking questions. This research is a qualitative research with prospective teacher students at Universitas Pesantren Tinggi Darul Ulum as the participants. The research data was collected through tests, observations, and interviews. The results of the study show that the tendency of prospective mathematics teacher students to ask effective questions when responding to information in mathematical problems is still low. Prospective teachers cannot always ask questions even if they do not understand the rationale behind a statement. Another finding from this study is that even though prospective teachers can ask questions in discussion, their questions cannot meet the inquisitiveness criteria because they are less successful in developing in-depth understanding.
Keywords: critical thinking, disposition, inquisitiveness, questioning

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INTRODUCTION

Inquisitiveness is an important critical thinking disposition in scientific learning because it plays a role in initiating inquiry (Watson, 2015b). The dimensions of critical thinking dispositions explained by various researchers (Ennis, 1996; Facione et al., 1995; Halpern, 1998; Perkins et al., 1993) indicate that inquisitiveness is an element that should exist in critical thinking dispositions. Because it contains an element of motivation, inquisitiveness is the primary intellectual virtue in education, which is central and has its role in intellectual virtue (Watson, 2015b). Inquisitiveness relates to the ability to raise questions (Chin, 2004; Fusaro & Smith, 2018; Gao et al., 2022; Smith & Fusaro, 2020; Watson, 2019), based on one's desire to find out more to encourage the emergence of other thinking dispositions, including to be open minded. Inquisitiveness should be motivated to ask questions and manifest in good questions to develop an epistemic position (Watson, 2015a, 2018a). Watson added that the characteristics of a good question must meet the criteria, including targeting relevant information, being in the right context, and being formulated effectively.

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 nature of 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. Inquisitiveness discussed in this study focuses on virtue inquisitiveness to develop knowledge as an intellectual virtue, distinguishing it from non-virtue inquisitiveness.

Inquisitiveness is one of the intellectual virtues that can encourage inquiry activity which is important in learning. In this context, the inquiry is an active and intentional search for the truth about several statements. Inquisitiveness acts as initial motivation, which means it is needed to start an inquiry because inquisitive people quickly raise the question 'why' so that it inspires inquiry (Baehr, 2011). To have the initiative to start an inquiry, students certainly need motivation. However, not every inquiry starts from inquisitiveness because other conditions make the learner start it not based on his initiative to ask questions but are given directions. Furthermore, virtue inquisitiveness also initiates virtue inquiry, which is very important in developing epistemic positions (Watson, 2015b, 2018b, 2018a) so that one is not limited to studying only for certain situations, for example, for success in exams. Suppose students are used to having virtue inquisitiveness. In that case, the tendency to ask questions will be internalized within them even when there is no intervention from the tutor or lecturer who forces them to find out so that it will encourage independent learning and thinking.

Having inquisitiveness should be the quality of a pre service teacher because a lack of inquisitiveness can also be a sign of a teacher's limited potential to develop knowledge

(Facione et al., 1995). Therefore, it is urgent to examine how the level of inquisitiveness of pre service teachers is manifested by asking questions. However, some previous research on critical thinking dispositions has discussed inquisitiveness, refers to the description that is still too broad (Colucciello, 1999; Cubukcu, 2006; Emir, 2009; Emİr, 2013; Facione et al., 1995; Giancarlo et al., 2004; Lampert, 2006; Lang, 2001; Noone & Seery, 2018; Rimiene, 2002; Suliman, 2006; Tsai, 2019; Wangensteen et al., 2010; Zhang & Lambert, 2008). The description used the global context in the disposition measurement instrument and does not provide specific information to show the application of inquisitiveness in learning mathematics. The findings from this previous research also do not show a well-established theory about the nature of inquisitiveness. Some indicate it as an innate character that tends to be stable (Giancarlo & Facione, 2001; Lang, 2001; Rimiene, 2002), and others indicate the possibility of an increase influenced by the environment, learning, or experience (Emir, 2009; Lampert, 2006; Suliman, 2006; Tsai, 2019; Wangensteen et al., 2010). On the other hand, findings also show that age and academic year are negatively correlated with inquisitiveness and total CCTDI scores (Zhang & Lambert, 2008).

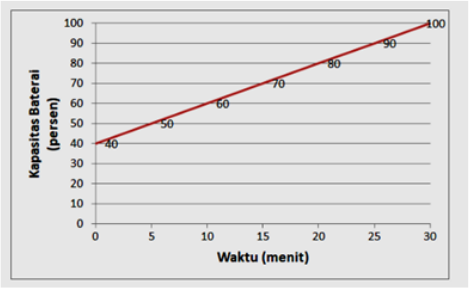
It is also important to examine the assessment of inquisitiveness in the practice of pre service teacher education. Research on inquisitiveness using an attitude scale instrument or questionnaires only reveals the subject's perception of himself, making it more susceptible to biased conclusions. In addition, 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. Still, it must be under conditions that can trigger the emergence of a characteristic behaviour of that disposition without the subject being aware of the behaviour 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, which makes the observations unfocused, and it may take a long time for indications of a natural disposition to emerge. Therefore, he prefers an assessment based on a focused open-ended task. Student discussion situations with colleagues are open-ended and can be focused on inquisitiveness because the questions students ask are more independent of the lecturer's directions.

In the context of learning mathematics, an investigation into student inquisitiveness has been carried out by Kurniati & Zayyadi (2018). However, the context is still limited, namely only on algebraic questions and subjects with characteristics in a particular area. The characteristics of questions as a form of inquisitiveness have not yet been described. Meanwhile, other research has focused on more context, including teamwork management (Bardone & Secchi, 2017) and related to inquisitiveness about oneself (Miscevic, 2018; Robinson & Demetre, 2017). This study aims to describe the inquisitiveness of pre service teachers in the form of asking questions. This description is more in-depth than the inquisitiveness assessment through a questionnaire. We expect that the results of this research will contribute to the development of theories about critical thinking dispositions, especially inquisitiveness. The knowledge gained from this study can be a basis for determining the toughtful assessment of inquisitiveness.

METHODS

In this study we provide two examples of classroom situations to illustrate the inquisitiveness of prospective teachers. The participants were 24 students as mathematics pre service teacher from two classes at Universitas Pesantren Tinggi Darul Ulum. Class A consists of third year students taking Ordinary Differential Equation courses, while class B consists of second year students taking Discrete Mathematics courses. We conducted research on these two classes with different focuses. In class A we provide an overview of how students' perceptions of their curiosity are related to the ability to ask questions in situations facing math problems and a mathematical statement. Whereas in class B, we focused on observing discussion situations that required students' ability to ask questions in order to develop in-depth knowledge. The participants from class A previously filled out an inquisitiveness questionnaire to measure perceptions of their inquisitiveness. The questionnaire used is a critical thinking disposition instrument from Boonsathirakul & Kerdsomboon (2021). The instrument is in the form of 4 scales (strongly disagree, disagree, agree, strongly agree), contain 24 statement items related to the disposition of critical thinking on the dimensions of truth-seeking, open-mindedness, analyticity, systematicity, inquisitiveness, CT-self confidence, and cognitive maturity. These statement items relate to general attitudes, not to specific field contexts. However, here, we only discuss three items on the inquisitiveness aspect so that is is relevant to those discussed in this study. The items are “I am willing to learn what I am interested in”; “I enjoy learning everything around me”; “I enjoy solving complex problems”. Meanwhile, we did not give questionnaires to class B, but made more in-depth observations on discussion activities.

Ani is charging her cellphone. The following is a graph of battery capacity (percent) vs time (minutes) of charging Ani's cellphone.



Do you agree with the statement that "It takes 1 hour to wait until the cellphone battery is fully charged"? Why?

Figure 1. Justification question

This study uses qualitative methods to reveal the inquisitiveness of pre service teachers. The qualitative data was obtained from observations, tests, and group interviews. The test was conducted in class A. The test given is in the form of contextual questions, in which students need confirmation about the related situation to answer the questions. It is expected that the design of this question can trigger the emergence of an inquisitive disposition manifested by asking questions naturally, not because of orders to ask questions. The context in the questions was adapted from the AKM question bank by modifying it to become a justification

question. In facing the problem (Figure 1), the subject needs to ask further questions about the condition of the electric current. This test item has been validated by a professor in mathematics education who is concerned with critical thinking research.

Next, observations during courses in class A are intended to investigate how students react to mathematical statements that seem simple but contain reasoning and the tendency to ask a question to deepen their understanding. The reactions observed were related to how students asked questions. Meanwhile, we were observed students' behavior in class B in discussions to build knowledge. After the test and observation, the follow-up group interviews were conducted to confirm data.

Data analysis was carried out qualitatively by collecting written data and verbal responses and then categorizing them according to the characteristics of inquisitiveness. Data collection and analysis were carried out simultaneously during the research. Furthermore, conclusions about the level of inquisitiveness are drawn based on the appearance of student questions in response to situations that require further information.

RESULT AND DISCUSSION

Results from Class A

To explain the characteristics of research participants of class A, we show the results of filling out student questionnaires on the critical thinking disposition scale. Inquisitiveness is one of the dimensions that has the highest score. The average score of inquisitiveness reaches 3.53 out of a maximum score of 4. This result can be interpreted that students have attitudes with relatively high indicators of inquisitiveness. Most students strongly agreed or agreed with the statement items supporting inquisitiveness (see Table 1)

Table 1. Inquisitiveness Statement Item Scores

Student	Item 1	Item 2	Item 3
S1	4	3	3
S2	3	4	4
S3	4	4	4
S4	4	4	3
S5	3	2	2
S6	4	4	2
S7	4	4	3
S8	4	4	2
S9	4	4	3
S10	4	4	4
S11	4	4	2
S12	4	4	4
Mean	**3,83**	**3,75**	**3**

Item 1: I am willing to learn what I am interested in
Item 2: I enjoy learning everything around me
Item 3: I enjoy solving complex problems

The test results in a mathematical context (Figure 1) provide other information about students' inquisitiveness. This test was attended by 11 students because there was 1 student was not present when the test was carried out. Student responses did not show a tendency to find out more about the context of the problem, such as how the condition of the electricity

was flowing during the charging of the battery, whether it was continuous or interrupted before it was full.

Figure 2 shows an example of a response from subject S10, who has a high perception of curiosity based on her score on the Critical Thinking Student Disposition Scale. These subjects agreed that the battery charge lasted for one hour, but this answer was based on misreading the information on the graph. Subjects considered that the value 5 (minutes) on the horizontal axis corresponded to 45(%) on the vertical axis, which should be 50%.

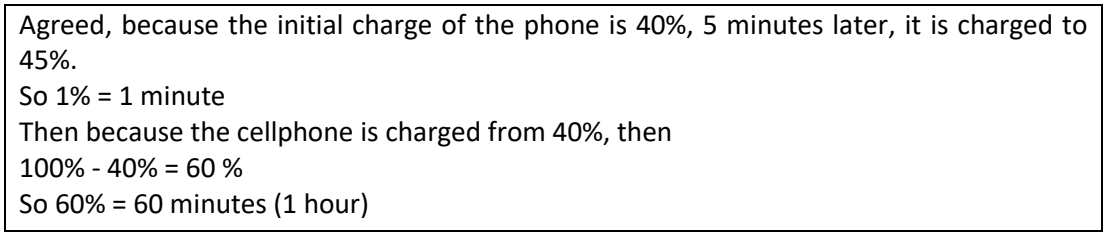

Agreed, because the initial charge of the phone is 40%, 5 minutes later, it is charged to 45%.
So 1% = 1 minute
Then because the cellphone is charged from 40%, then
100% - 40% = 60 %
So 60% = 60 minutes (1 hour)

Figure 2. Subject S10 did not question the condition of the electric current and made a mistake reading the graph

Another example of a response comes from subject S3, who disagrees because it takes 30 minutes to charge the cellphone battery (Figure 3) fully. She also strongly agreed with the inquisitive statement items on the Critical Thinking Student Disposition Scale. Although the S3 and S10 had different responses, they did not indicate any further questions about the state of the power supply. Responses from S10 and S3 indicated that they tended to focus on getting the final answer without reflecting on the information provided. This finding may reflect habit patterns formed from school days. They may be accustomed to being asked to provide answers with a result orientation, not on the arguments that underlie the answer.

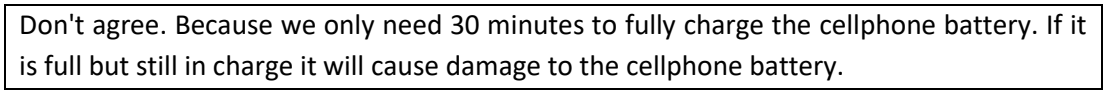

Don't agree. Because we only need 30 minutes to fully charge the cellphone battery. If it is full but still in charge it will cause damage to the cellphone battery.

Figure 3. Subject S3 does not question the condition of the electric current in the context of the problem

In the following, we will explain the results of the analysis of the data we obtained through observations. Our findings based on observations show the lack of a tendency for students to ask questions about things they don't understand. Students tend to accept information as it is without showing indications of inquisitiveness. Students at that time were presenting material and wrote $e^{rt}(ar^2 + br + c) = 0$, then wrote down the implications, $ar^2 + br + c = 0$. They continued their presentation until they reached a final conclusion without explaining the arguments of the statement $ar^2 + br + c = 0$. None of the other students asked questions about this. However, when the instructor asked why they concluded that way, they showed confusion, were unable to answer immediately, and some tried to answer but were not based on valid arguments. They don't realize that $e^{rt} \neq 0$ forms the basis of the inference argument. Through group interviews, the instructor asked why they didn't ask beforehand, some students answered that it had been written about in the lecturer's books

and teaching materials. The results of this observation indicate that the tendency of students to find out and ask questions is still low.

Results from Class B

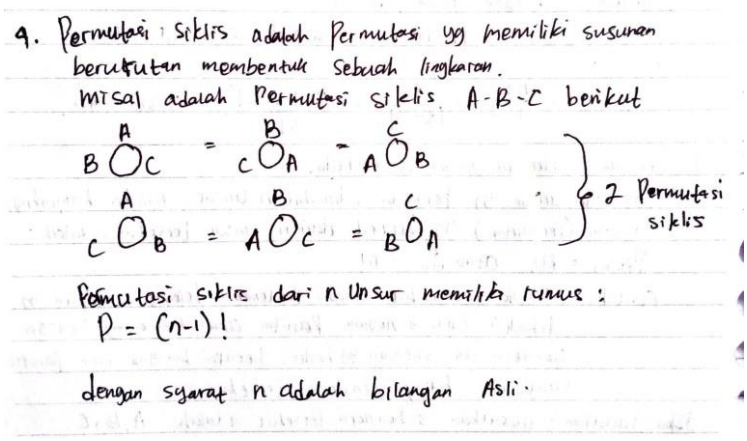
Observations in another course also show that students are not always able to raise effective questions to develop mathematical understanding. For example, in presentations and discussions, peer questions naturally arise, to clarify, ask for further explanation, or in the form of "why" questions which are triggers in completing arguments. These questions qualify as good questions based on Watson's (2015a) framework for defining inquisitiveness. However, sometimes the question is not explored further so it does not produce a complete argument.

The following is the observed another situation in the class discussion. Students discuss permutation problems in class discussions. A student (M1) question about how to get a cyclic permutation formula. A student as a member of the presenter (P1) then simplifies the cyclic permutation problem of 3 objects to simplify the problem and prove it by matching the experimental results by drawing 3 objects (namely A, B, and C) in a circle with different arrangements and the calculation results are based on the formula. The images produced by students are two different cyclic permutations. After drawing the visual illustration, dialogue occurs between students.

M1: Why only two? Sure only two?
P1 : Sure
M2: Why? Should position A always be on top? What if it's moved?
P1: (draw several circular arrangements that correspond to the same cyclic permutation) These results are the same because based on the definition they are considered the same
P1: we calculated based on the formula and the results are also appropriate

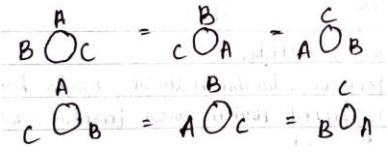
Students' questions trigger the development of arguments in the discussion, but do not end with a sufficiently complete argument because it is still limited to inductive reasoning. The results of this observation show the potential of inquisitiveness questions to build students' mathematical arguments. Although the questions that arise may also explain the disposition of critical thinking in other dimensions, such as truth-seeking and open-mindedness, this process must be preceded by intellectual curiosity and motivation to ask questions.

Based on these observations, it was found that questions originating from their discussion no longer developed when they reached a certain level and had not yet reached a complete conceptual understanding. This can be seen from the results of writing student reflection journals after the discussion. When students were asked to write down some questions based on their understanding of the origin of the formula, some of them wrote based on the knowledge gained from the discussion, which was limited to incomplete inductive arguments (Figure 4), and most of the others wrote the application of the formula, not the argument.



Translation:

Cyclical permutations are permutations that have a sequential arrangement forming a circle. An example is the following cyclic permutation A-B-C



2 cyclical permutations

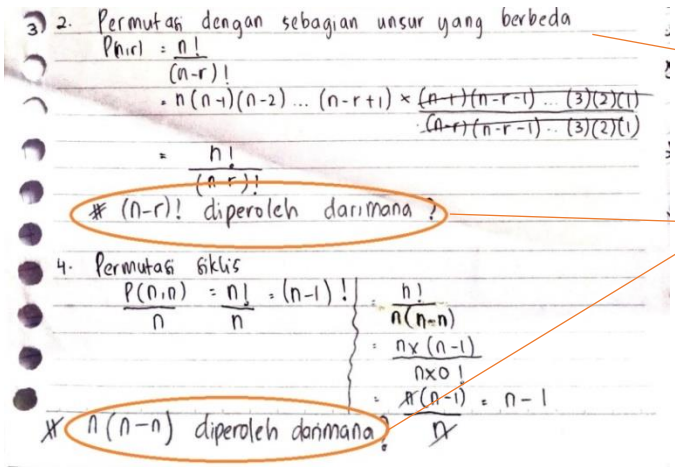
The cyclic permutation of n elements has the formula:

$P = (n-1)!$

With condition that n is a natural number.

Figure 4. Student write her understanding in a reflection journal from the results of discussions with limited inductive reasoning arguments

Some students also have questions that arise when writing reflective journals (Figure 5). Keep in mind that the questions in this reflection journal appear based on the instructor's instructions to write questions, not based on their own initiative.



Translation:
Permutations with several different elements

Translation of student's question:

where did you get it from?

Figure 5. In the reflection journal, student generating questions based on the instructor's instructions

Discussion

Based on the background of the participants in class A in perceiving their curiosity, it can be shown that the results of measuring inquisitiveness with questionnaires or attitude scales are very limited in showing evidence of inquisitiveness in situations related to specific fields. Even though students perceive themselves to have a high disposition, they cannot always construct questions that are effective in specific contexts in mathematics learning situations. These results can be reviewed based on several views on the nature of critical thinking skills in terms of their dependence on specific fields or domains (Lai, 2011). There is an opinion that critical thinking can only be taught in the context of a specific domain. This opinion is based on the assumption that background knowledge is needed for critical thinking, but knowledge alone is not enough. In addition, the transfer of critical thinking between domains is unlikely to occur without the opportunity to practice in various domains and be taught explicitly to transfer. An example of this view is that general teaching about critical thinking will not be successful because critical thinking is a specific domain (Ennis, 1989). On the other hand, critical thinking is seen not as a specific domain, but based on general teaching success in critical thinking skills (Halpern, 2001). In this case, critical thinking may have different criteria between domains, but the meaning of critical thinking remains fundamentally the same sama (Lipman, 1988).

Facione (1990) is the researcher who developed the CCTDI (The California Critical Thinking Disposition Inventory) instrument to test general critical thinking dispositions without including domain-specific contexts, but he also notes the importance of domain-specific knowledge in the application of critical thinking. Meanwhile, Paul (2005) emphasized that critical thinking is done in one's field by applying the standards and values that apply in that field, but he also added that critical thinking can be taught in general or by incorporating it into teaching specific fields. Ennis (1989) also added that although each field has its own standard, there are aspects of critical thinking that are the same between fields of science, which can be taken as a middle view.

From various views about the domain of critical thinking, the results of this study can be interpreted as the failure of students to apply their curiosity to specific contexts in certain fields. From a specific domain perspective, the lack of mathematical knowledge can hinder the emergence of students' inquisitive dispositions in learning mathematics. These results also indicate the need for critical thinking disposition criteria in the context of learning mathematics. The disposition to think critically is a tendency that can only be assessed if a trigger he does not realize can lead to a critical attitude (Ennis, 1996). Measurement with a questionnaire or measurement scale certainly has limitations in revealing the subject's disposition in natural and authentic situations. The results of the attitude scale measurement also depend on a person's perception of himself. The problem is that not everyone has the right self-perception regarding their metacognition, and this is often (Ehrlinger & Shain, 2014). Measurement with an attitude scale is also limited only to the level of motivation. It has not been proven by asking questions. Even though inquisitiveness must be manifested by asking questions, this factor distinguishes it from curiosity (Watson, 2015a). These theories explain why measurements with attitude scales do not meet this criterion to reveal true dispositions.

The results of the following research on critical thinking dispositions in mathematics using the CCTDI instrument also show inconsistent results between critical thinking dispositions and ways of thinking required in mathematics. Incikabi et al., (2013) found a weak and negative correlation between critical thinking dispositions based on CCTDI and logical thinking skills of mathematics teacher candidates. At the same time, logical thinking includes reasoning, while reasoning is part of critical thinking. Meanwhile, Çelik & Özdemir (2020) research did lead to the conclusion that mathematical thinking skills are a significant predictor of teachers' critical thinking dispositions. However, these results do not explain whether measuring the critical thinking disposition scale can predict students' mathematical abilities.

The results from class B showed that students still had difficulty asking questions that succeeded in developing an epistemic standing in a discussion. Even though we know that questioning is important in learning, not every question can guarantee success in developing knowledge to the expected level (Watson, 2018a). Different questions reflect the range of different information-seeking strategies (Ko et al., 2020). Questions have an important role in effective discussion in learning. Questions in learning can come from teachers/instructors and students. However, previous research has focused more on the role of the teacher or instructor in the success of the discussion (Davies & Sinclair, 2014; Katsara & De Witte, 2019; Lee et al., 2014; Yang et al., 2005), even though the questions that arise from discussion members also have a role in developing knowledge and can train intellectual values in students. Questions from instructors or lecturers in student discussions are important, which can trigger discussion consensus based on revision or rejection of ideas during discussion or conflict-oriented consensus building (Lee et al., 2014), which supports critical thinking. Nonetheless, the results of previous research also show that students cannot always adapt instructor questions to raise questions independently based on inquisitiveness (Watson, 2019). The learner should also be positioned as a questioner, not only answering questions (Chin, 2004; Di Teodoro et al., 2011). Thus, students must be trained independently to ask good and effective questions.

CONCLUSIONS

The conclusion that can be obtained from this study is that the ability of the mathematics pre-service teachers to ask good and effective questions is proven to be low even though they show a high perception of their curiosity tendency. Students are unaware of the lack of information in the context of math problems and accept information that is considered normal without the tendency to question it. Students' perceptions about their desire to seek knowledge do not seem to relate to their inquisitiveness in mathematics. These results support the explanation that measuring general attitudes to inquisitiveness dispositions is insufficient to provide comprehensive information. Assessment of inquisitiveness requires situations that can distinguish individual tendencies to ask questions.

Another finding from this study is the lack of ability of pre-service teachers to ask questions to improving epistemic standing successfully. Although they can raise questions during the discussion, these questions cannot go deeper, so that the understanding gained from the discussion is also limited. This question does not meet the inquisitiveness criteria

because even though they have the motivation to ask questions, they have not been able to develop more effective questions.

It is necessary to study further the disposition of inquisitiveness, specifically in the domain of learning mathematics, based on the quality of the questions. Knowledge of the context of mathematical problems also seems to affect the application of student dispositions. They cannot show dispositions in a mathematical context without good mathematical understanding and can be an issue for further research.

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