Critical Thinking Skills of Mathematics Prospective Teachers: An Exploration Study at Medan State University

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Abstract. This study aims to examine mathematics prospective teachers’ critical thinking skills at mathematics education program, Medan State University. This research is intended to contribute to the program to improve the professionalism of prospective mathematics teachers in critical thinking, one of the important skills in the 21st century. The results of this study will be the basis for further action in developing a learning models with reference to the current status of math prospective teachers’ critical thinking skills. In this study, data analysis was carried out through quantitative analysis. The Watson and Glaser Critical Thinking Appraisal in the Indonesian version was administered for data collection. Data was collected from 165 prospective teachers during the first semester of the 2019-2020 academic year. The results showed that prospective teachers’ critical thinking grades are in average level. Therefore, further studies must be carried out to identify and overcome deficiencies, to enhance critical thinking in math prospective teacher students.

1. Introduction
One of the main goals of higher education is to encourage students’ critical thinking to prepare them to function in a complex and rapidly changing society. However, several studies showed that critical thinking skills do not develop automatically as a product of higher education [1]. This result may not be surprising given that critical thinking skills are rarely taught explicitly [2] although several studies have shown that students need explicit teaching to improve their critical thinking skills [3][4]. Definitions of critical thinking range from abstract construction to specific and measurable skills. The National Council for Excellence in Critical Thinking [5] proposed a definition with two components: (1) a set of information and beliefs that produce and process skills, and (2) habits, based on intellectual commitment, use these skills to guide behaviour. In comparison, Paul & Elder [6] defined critical thinking as the art of analysing and evaluating thinking to improve it. Vaughn [7] provided a concise working definition for building critical thinking as a systematic evaluation or formulation of beliefs or statements, with rational standards. Watson & Glaser [8] viewed critical thinking as a combination of attitude, knowledge and skills, including: (1) an attitude of inquiry that involves the ability to recognize the existence of a problem and accept the general need for evidence to support what is considered true; (2) knowledge of the nature of valid conclusions, abstractions, and generalizations where the weight or accuracy of various types of evidence is logically determined; and (3) skills in using and applying the above attitudes and knowledge. Although this small sample of available critical thinking definitions provides additional and valuable insights, the focus remains on the systematic evaluation of individual's thoughts with rational standards.

The ability to think critically is the ability of rational and reflexive thinking that focuses on deciding what to believe and what to do [9]. This ability can be taught and specifically mathematics has a potential role in developing it [10]. Therefore, mathematics teachers have an important role to help
students develop their critical thinking skills [11]. Teachers are also required to show their critical thinking skills explicitly during teaching [12], because one of the prerequisites for teachers to be able to provide teaching and guidance to students on a subject is that the teacher himself has the necessary skills [13]. Thus, the critical thinking skills of prospective mathematics teachers must be improved before they are expected to develop their students’ critical thinking skills at school.

A common phenomenon that occurs in the learning process in mathematics education program at Medan State University is that in solving problems, most students simply believe the solutions given by the lecturers and that are available in textbooks in lectures. They cannot explain why their solution is appropriate or not. This condition needs to get serious attention considering the students are prospective mathematics teachers who are expected to be able to solve the national problem related to low achievement in students’ critical thinking skills.

Critical thinking has been perceived as a key skill in the latest educational program which have been put into practice by Indonesian Ministry of Education since 2013. That is why prospective teachers should be trained so that they can engage in the teaching of critical thinking. However, although the importance of critical thinking is underlined in national school curricula, no published data exists to address the current state of critical thinking skills in Medan State University. Therefore, this study mainly aims to contribute to the literature by giving an idea about the levels of critical thinking of prospective teachers in mathematics education program at Medan State University.

2. Method
This study was an exploration study with descriptive analysis. A total of 165 mathematics education students’ responses were analysed and reported within the scope of this study. The Watson Critical Thinking Appraisal was used to measure the critical thinking skills of prospective teachers. It includes series of test exercises which in which several central abilities for critical thinking are required [8]. The sub tests included in appraisal are: 1) Arguments; 2) Assumptions; 3) Deduction; 4) Inference; and 5) Interpreting information.

Arguments sub-test has 25 items aiming to assess the ability to distinguish between arguments which are strong and relevant and those which are weak or irrelevant to a particular question at issue. Assumptions sub-test has 14 items aiming to assess the ability to find out the unstated assumptions in a given text. Deductions sub-test has 21 items aiming to assess the ability to discriminate between the necessary inferences or implications from given statements. Inference sub-test has 14 items aiming to assess the ability discriminate the accuracy of inferences drawn from given data. Interpreting information sub-test has 12 items aiming to assess the ability to differentiate generalizations according to the given statements. All the 86 questions are suggested to be completed in 60 minutes. It is reported by the writers that the test is a power test rather than a speed test therefore there is no rigid time limit [8].

| Score                  | Interpretation      |
|------------------------|---------------------|
| 61st percentile and above | above average     |
| 40th – 60th percentiles | average            |
| 39th percentile and below | below average      |

Numerous researchers have considered the Watson-Glaser Critical Thinking Appraisal as a reliable and valid instrument in measuring critical thinking [8]. Likewise, in this study, the test reliability was calculated as 0.76 reliable using Cronbach's alpha. Although the test has been translated into Indonesian, after checking the assessment, it was observed that the proper nouns and currencies remained as they were in the test. The test was written in google form and delivered online on the page https://forms.gle/jFsmT7fUjJ5zcA1x5. The SPSS program was used to determine the mean and standard deviation. The overall performance of the students on the test was scored according to the
correct answers obtained from the test administered. The interpretation of the scores were provided by Watson & Glaser [8] as shown in Table 1.

3. Result
A total of 165 prospective teachers’ critical thinking skills was examined by using descriptive statistics. The data are presented in Table 2.

| Table 2. Prospective teacher’s critical thinking skills. |
|--------------------------------------------------------|
| Number of respondents | minimum | maximum | mean  | standard deviation |
|------------------------|---------|---------|-------|--------------------|
| 165                    | 31      | 91      | 50,03 | 7,89               |

The results indicated that the critical thinking grades of prospective teachers from the mathematics education program varied between 31 and 91. The possible maximum grade is 100. The mean score of 50,03 with a standard deviation of 7,89 fell within the 30th – 60th percentiles which is interpreted as “average.”

Critical thinking skills were examined according to the sub-tests by using descriptive statistics. The descriptive data regarding sub-tests are presented in Table 3.

| Table 3. Prospective teacher’s critical thinking skills. |
|--------------------------------------------------------|
| Sub-test            | minimum | maximum | mean  | standard deviation |
|---------------------|---------|---------|-------|--------------------|
| Arguments           | 28      | 100     | 56,73 | 13,10              |
| Assumptions         | 14      | 100     | 45,28 | 13,47              |
| Deductions          | 29      | 100     | 59,88 | 12,21              |
| Inferences          | 0       | 79      | 25,37 | 11,86              |
| Interpreting information | 17    | 100     | 53,13 | 13,86              |

Except from the Inferences sub-test, all of the sub-tests is fully completed by the participants of this study.

3.1. Arguments
In this sub-test, a statement was presented with an agreeing or disagreeing argument below. Students should regard each argument as true, regardless whether it is weak or strong, agrees or disagrees with the statement. Prospective teachers’ grade related to argument skills shown in Figure 1.
It was found that most of student grades (61%) fell between 40th – 60th percentiles which were interpreted as having average argument skills. There are a few students (7%) who have skills that are below average and quite a number of students (32%) having skills to argument that is above average.

3.2. Assumptions

In assumptions sub-test, students were provided with a number of statements followed by a series of proposed assumptions. Students should decide which assumptions are logically justified based on the evidence in the statement. Prospective teachers’ grade related to assumption skills shown in Figure 2.

More than half of student (51%) have the average assumption skills. There are quite a number of students (35%) who have this ability that are below average and only 14% of students have assumption skills that is above average.

3.3. Deductions

In this sub-test, a statement was provided followed by a series of suggested conclusions. Students must take the statement to be true and decide whether they think it follows from the statement provided. Prospective teachers’ grade related to deduction skills shown in Figure 3.

Nearly half of student grades (49%) were interpreted as having above average deduction skills. There are quite a number of students (45%) have the average deduction skills and only a few students (6%) who have this skill that are below average.

3.4. Inferences

The questions in this sub-test begin with a statement of facts that must be regarded as true. After each statement, students were presented with possible inferences which might be drawn from facts in the statement. They should analyse each inference separately and decide on its degree of truth. For each inference, students were provided with 5 possible answers: True, Probably True, More Information
Required, Probably False, and False. Prospective teachers’ grade related to inference skills shown in Figure 4.

![Figure 4. Prospective teachers’ inference skills.](image)

It was found that most of student grades (89%) were interpreted as having below average inference ability. There are only a few students (1%) who have abilities that are above average and only 10% of students have average inference skills.

3.5. Interpreting information
In this sub-test, questions consisted of a passage of information, followed by a series of conclusions. Students were instructed to assume all information in the passage is true. The task is to judge whether or not each of the proposed conclusions logically flows beyond a reasonable doubt from the information given in the paragraph. Prospective teachers’ grade related to interpreting information skills shown in Figure 5.

![Figure 5. Prospective teachers’ interpreting information skills.](image)

It was found that most of student grades (67%) fell between 30th – 60th percentiles which were interpreted as having average interpreting information ability. There are 9% of students who have abilities that are below average and 24% of students have this ability that is above average.

4. Discussion
This research is intended to contribute to the program to improve the professionalism of prospective mathematics teachers in critical thinking. The results of this study will be the basis for further action in the development of learning models by referring to the current status of math prospective teachers' critical thinking skills.

From the five subscales in the test, the inference subscale needs special attention where most students are unable to distinguish the wrong and correct conclusions from a given statement. Making inference is an important ability in learning mathematics. Fuchs et al. [14] observes that making inference is a
skill needed to solve mathematical problems. For example, mathematical problems often require more than what is explicitly written that calls for conclusions or draw conclusions. Furthermore, Imam [15] states that making conclusions is a predictor of students' mathematical performance.

In reading a text, especially when the text asks to find out information, reading comprehension is needed. Making inference is a key component for reading comprehension [16]. In the context of learning, students cannot learn science content unless they read science texts with comprehension [15]. In fact, Carnine & Carnine [17] found that text in the science content area is difficult for most secondary school students, especially those who have reading skills below the grade level. Thus, it can be assumed that the cause of the low ability of prospective teacher mathematics in making inferences is the lack of ability in reading comprehension.

This finding highlights the need to re-examine course content learned by prospective teacher mathematics and underlines the need to enrich students' insights through the texts they must read. According to Ediger [18], reading difficulties to understand subject matter can be minimized by developing vocabulary and reading activities need to be centered around mathematics in everyday life. This opinion will be used as material for consideration in subsequent studies related to the development of the ability to make inferences.

5. Conclusion
This study aims to examine the critical thinking skills of prospective mathematics teachers in the mathematics education program, Medan State University. The results showed that the critical thinking skills of mathematics prospective teachers were at an average level. This reflects a serious problem for a prospective teacher who will teach critical thinking skills to students in the future. Thus, it must be addressed through the development of critical thinking instruction, course development, and finally a restructured curriculum to better meet the needs of prospective teacher math students. Without these important skills, prospective teachers are not ready and will ultimately be in a very disadvantageous position when faced with the challenges of the developing world. Further studies must be carried out to identify and overcome deficiencies, to enhance critical thinking in math prospective teacher students.

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