Critical thinking skills and self-confidence of high school students in learning mathematics

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Abstract. This study aims to determine the mathematical critical thinking skills and the level of self-confidence of high school students in solving vector problems. Mathematical critical thinking skills and self-confidence are basic capital that students must have, so students are confident in solving each vector problem based on critical thinking processes. The type of this research was a qualitative descriptive. Participants in this study were high school students of class X IPA in a public high school in Cimahi city, consisting of 30 students who were determined by purposive sampling technique. The instruments in this study were researchers as the main instruments and supporting instruments, namely a test of mathematical critical thinking skills, a self-confidence questionnaire, and an interview guideline. The results are students have low critical thinking skills and medium self-confidence. The low of critical thinking is indicated by students unable to provide reasons, evaluate answers and identify data/concepts/definitions. Suggestions for further research are habituation of students with mathematical critical thinking skills.

1. Introduction

The Government in the 2013 Curriculum developed HOTS thinking skills or Higher Order Thinking Skills. One of the thinking skills in HOTS is the skills to think critically. PISA is an international program that is held every three years which aims to monitor reading literacy, mathematical capacity, and scientific skills for 15-year-old students. PISA released the results in 2015 where Indonesia's position in mathematics was ranking 63 of 69 countries [1]. This result indicates that the high-level thinking skills of Indonesian students are still low. Therefore mathematical critical thinking skills must be developed and cultivated in mathematics learning.

Gokhale [2] defines critical thinking as thinking that involves analyzing, synthesizing, and evaluating concepts. In critical thinking, there is a systematic process that allows someone to formulate and evaluate their own beliefs and opinions. Critical thinking is also an organized process that allows one to evaluate the evidence, assumptions, logic, and language that underlies his opinion. Ennis [3] lists critical thinking, namely: (1) Focus on a question; (2) Analyze arguments; (3) Ask and answer clarification; (4) Judge the credibility of a source; (5) Observe, and judge observation reports;
(6) Deduce, and judge deduction; (7) Make material inferences; (8) Make and judge value judgments; (9) Define terms and judge definitions, using appropriate criteria. Three basic dimensions are forms, functions (act), and content; (10) Attribute unstated assumptions (an ability that belongs to both basic clarification and inference; (11) suppositional thinking; (12) Integrate the dispositions and other abilities in making and defending a decision.

Self-confidence is needed in mathematics learning because with self-confidence, students are confident in what they are doing and believe that solving problems that are being resolved is true and in accordance with definitions, formulas and other reasons. Yates [4] revealed that self-confidence is very important for students to learn mathematics to success. In line with Yates, Kloosterman [5] stated that students with self-confidence are more motivated to learn mathematics than students with low self-confidence. Siregar [6] revealed students with bad self-confidence will be worried about mathematical learning.

The previous study indicated that students’ self-confidence have no significant contributed to student achievement [7]. The other studies reported by Gun [8] that the students’ self-confidence in learning mathematics is significantly differentiated. Students from the high achievement group had higher confidence than students from the moderate and low achievement group [8]. Hannula [9] stated that the weak students had the weakest self-confidence, but contradiction with the good students, and the average students were between these [9].

In a public high school in Cimahi city, many students have medium of mathematics abilities. Through critical-thinking mathematics and self-confidence, it is expected that students get more abilities in learning mathematics. Based on that, the researcher wanted to know the mathematical critical thinking skills and self-confidence of high school students of class X IPA in a public high schools in the city of Cimahi, especially in chapter vector.

2. Methods
The research was a qualitative research with descriptive approach. This study was conducted on class X students of science in one of the public high schools in the city of Cimahi with participants consisting of 30 students. Participants are selected using a purposive sampling method because students are selected according to research needs and conditions in the field.

The instruments in this study were researchers as the main instruments. The supporting instruments, namely the test questions of mathematical critical thinking skills of high school students in vector chapter consisting of 5 items, a self-confidence scale consisting of 30 statements, and interview guidelines. After completion of the study, a mathematical critical thinking skills test and a self-confidence scale questionnaire were given, followed by interviews with participants. After obtaining the necessary data, it was continued with qualitative data analysis.

2.1 Mathematical critical thinking skills
The indicators of mathematical critical thinking skills were adapted from Hendriana [10] which were adjusted to the mathematical critical thinking skills of high school students of class X IPA and the chapter to be tested were vector.

| Number | Mathematical Critical Thinking Skills |
|--------|--------------------------------------|
| 1      | Analyze the truth of the two vector scalar multiplication process with the two vectors known. |
| 2      | Analyze the correctness of the process of calculating the angle cosine value between vector \( \vec{u} \) and \( \vec{v} \) with the two vectors known. |
| 3      | Answer questions with relevant reasons |
| 4      | Evaluate relevant arguments in solving problems |
Identify data / concepts / definitions that underlie problem solving

2.2 Self-Confidence
The self-confidence indicator that used in this study are:

**Table 2. Student self-confidence scale**

| Indicator Self-confidence | Sub Indicator                                                                 |
|---------------------------|-------------------------------------------------------------------------------|
| Have confidence in their abilities | a. Have the confidence to be able the chapter                                |
|                           | b. Skills to express ideas or ideas                                           |
| Think and act positively in the face of problems | a. Able to get up if failure                                                   |
|                           | b. Always think rationally and act realistically                               |
| Showing optimism, calmness, and never giving up | a. Able to maintain opinions with strong arguments                           |
|                           | b. Optimistic on expectations or ideals                                        |
| Able to adapt and socialize | a. Have empathy for friends who have difficulty                               |
|                           | b. Able to express and exchange ideas with friends and teachers                |
|                           | c. Able to adapt to the learning environment                                  |

3. Result and Discussion

3.1 Mathematical critical thinking skills
The average value of mathematical critical thinking skills is 41. The value is categorized into low category. It is below the minimal completeness criteria value which is determined by the school where the study was conducted, that is 70.

**Table 3. The average of Mathematical critical thinking skills score for each indicator**

| critical thinking skills | 1 | 2 | 3 | 4 | 5 | Average Score |
|-------------------------|---|---|---|---|---|----------------|
|                         | 7.60 | 8.00 | 3.20 | 1.97 | 0 |                |

In the Table 3, for indicators 1 and 2, the average scores are in the high category. It is illustrating that students' critical thinking skills mathematical are high in analyzing the questions. The average scores for indicators 3 and 4 are very low. It means that they are very low in expressing arguments and evaluating arguments. For indicator 5, the average score is 0. A problem with this indicator, i.e. no student can do it. This shows that students' critical thinking mathematical very low in identifying data/concepts/definitions that underlie problem-solving. The following illustrates the score and number of students in answering each indicator of the given problem.

**Table 4. Student scores for each indicator of critical thinking mathematical**

| Scores | 1 | 2 | 3 | 4 | 5 | Indicator test/ the number of students |
|--------|---|---|---|---|---|----------------------------------------|
| 8 < S ≤ 10 | 19 | 20 | 8 | 5 | 0 | 0                                      |
| 6 < S ≤ 8 | 4 | 3 | 0 | 0 | 0 | 0                                      |
| 4 < S ≤ 6 | 0 | 3 | 0 | 0 | 0 | 0                                      |
| 2 < S ≤ 4 | 3 | 0 | 3 | 1 | 0 | 0                                      |
| 0 ≤ S ≤ 2 | 4 | 4 | 19 | 24 | 0 | 0                                      |
From the Table 4, it can be seen that for indicators 1 and 2, 23 students can work on this problem, which is equal to 76.67%. It shows that the question can be categorized into the easy category. There are 8 students for indicators 3 who can solve this problem. It means that students who are able to work on the problem are 26.67%. It shows that students have difficulty working on this problem. There are 5 students (or 16.67%) who can solve this problem and fulfil criteria for indicator 4. It shows that many students also have difficulty in solving this problem. For indicator 5 no one can work on the problem. It means that this question is a very difficult problem.

Table 5. Student Mathematical critical thinking skills (MCTH)

| number | number of students | MCTH Value | Category |
|--------|--------------------|------------|----------|
| 1      | 0                  | MCTH ≥ 84  | Higher   |
| 2      | 4                  | 68 ≤ MCTH < 84 | High     |
| 3      | 5                  | 52 ≤ MCTH < 68 | medium   |
| 4      | 10                 | 36 ≤ MCTH < 52 | low      |
| 5      | 11                 | MCTH < 36  | lowest   |

The assessment criteria for the students' mathematical critical thinking skills are provided in Table 5. From the Table 5, for the higher category of MCTH, there is no single student who represents. This is because all of students cannot answer question number 5. So, the obtained maximum value is only 80. To answer question number 5, students must use some preliminary concepts. This condition illustrates that the preliminary concepts that has been obtained by students are less meaningful, so the students cannot afford to remember it. This condition is in line with Ausebel’s state that one important factor that influences learning is what learners already know [11].

There are 4 students in the high category. This condition illustrates that only 4 of 30 students have high mathematical critical thinking skills. These four students also have high mathematical abilities, so it is natural that they do not have significant difficulties to solve the vector problems. The result of this study is in accordance with the results of the Hanifah [12], that the high group already has good mathematics motivation and mastery so that even though given less supportive learning, the results are still good. In the medium category, there are 5 students representing them. This condition illustrates that only 16.67 % is in the medium category.

For low and lowest categories, there are 21 students. It shows that most students cannot work vector chapter. If it is viewed from theirs mathematical ability, 14 students have medium mathematical abilities and 7 students have low mathematical abilities. Why do students with medium mathematical abilities not be able to solve vector problems? Based on the answer sheet, it appears that students are not familiar with the type of critical thinking problems, so the students have difficulty in solving the given questions.

The description above shows that the 2013 Curriculum learning model with indicators of mathematical critical thinking have not been able to change students' mathematical skills, especially in vector chapter. Students with higher mathematical abilities are still in the higher category. While students with mathematical abilities medium are included in the medium category and some are in a low category. Students with medium mathematical skills many get low results. Because the learning has not been able to make students understand the material presented, so that when given a question about mathematical critical thinking being unfamiliar also they have difficulty in answering the questions given. For students with low mathematical abilities the results also still get low results.
3.2 Self-confidence

The average for students' self-confidence score is 72%. It means that the students have sufficient (medium) levels of self-confidence [13].

| Number | Indicator                                                                 | Percentage (%) |
|--------|---------------------------------------------------------------------------|----------------|
| 1      | Have confidence in the abilities                                          | 58.64          |
| 2      | Think and act positively in the face of problems                           | 69.17          |
| 3      | Showing optimism, calmness, and never giving up                           | 70.31          |
| 4      | Able to adapt and socialize                                               | 72.22          |

Based on the Table 6, students with indicators able to adapt and socialize get the highest percentage compared to other indicators, which is 72.22%. This shows that students have sufficient empathy for friends who have difficulty, have sufficient ability to express and exchange ideas with friends and teachers, and have sufficient ability to adapt to the learning environment.

The first indicator is the lowest score. For this indicator, the students are in the sufficient category (58.64%). This shows that students have enough confidence to be able to work at the vector chapter. Indicators 2 and 3 of self-confidence show that the percentage that is not too far different, that are 69.17% and 70.31%. It means that students have sufficient ability to rise if they fail and students have sufficient ability to always think rationally and act realistically. Students also have sufficient ability to maintain opinions with strong arguments and have sufficient ability to be optimistic about expectations or ideals. The self-confidence level of each student is displayed using a percentage. The percentage value is adapted from the Arikunto attitude criteria [13]. The results is provided in the following table.

| Number | Number of Students | Range of Values (%) | Attitude category |
|--------|--------------------|---------------------|-------------------|
| 1      | 9                  | 85 - 76             | good              |
| 2      | 21                 | 75 - 66             | sufficient        |

From the Table 7, it can be seen that based on the Arikunto attitude criteria, it was found that the 30 participants were in the good and sufficient category (high and medium), with the majority being in the medium category.

The results obtained indicate that 2013 Curriculum learning can produce a medium level of self-confidence, meaning that 2013 Curriculum learning can slowly improve student self-confidence. So that in the future 2013 Curriculum learning needs to be continuously developed and cultivated in mathematics learning.

4. Conclusion

The results of this study can be concluded that of the 30 participants of class X high school science students in one of the public high schools in the city of Cimahi obtained an average value of mathematical critical thinking skills of 41, meaning that students have low critical thinking skills. While the self-confidence conditions of students get a percentage of 72.22%, meaning that students have medium self-confidence.

Low mathematical critical thinking skills are caused by students not being able to give reasons, evaluate answers and identify data/concepts/definitions in solving problems. Regarding the results obtained, in students' critical thinking mathematically skills, 2013 Curriculum learning has not been able to give a positive influence on students' mathematical skills in vector chapter.
Learning Curriculum 2013 can slowly improve student self-confidence. Based on the description above, the suggestion of further research is to familiarize students with 2013 Curriculum learning and with mathematical critical thinking skills.

5. References
[1] Iswadi H 2016 Sekelumit Dari Hasil PISA 2015 Yang Baru Dirilis. [Online]. Available: https://www.ubaya.ac.id/
[2] Gokhale A A 1995 Collaborative Learning Enhances Critical Thinking 7, 1 p. 22–30
[3] Ennis R H 1991 Critical Thinking: A Streamlined Copeception Teach. Philos. 141 p. 5–24
[4] Yates S M 2002 The Influence of Optimism and Pessimism on Student Achievement in Mathematics 14, 1 p. 4–15
[5] Kloosterman P 1988 Self-Confidence and Motivation in Mathematics 80, 3 p. 345–351
[6] Siregar, Darhim E C M A 2017 Increasing Self-Confidence of Indonesian Low Ability Student with Green’s Motivational Strategies J. Phys. Conf. Ser. 755, 1
[7] Kunhertandi K and Santosa R H 2018 The Influence of Students’ Self Confidence on Mathematics Learning Achievement J. Phys. Conf. Ser. 1097, 1 p. 0–6
[8] Gün Ö 2018 Views and Beliefs in Mathematics Education Views Beliefs Math. Educ. p. 33–42
[9] Hannula M S Maijala H Pehkonen E and Nurmi A, 2005 Gender comparisons of pupils’ self-confidence in mathematics learning Nord. Stud. Math. 10, 3 p. 29–42
[10] Hendriana H Rohaeti E E and Sumarmo U, 2018 Hard Skills dan Soft Skills Matematik Siswa 2nd ed (Bandung: PT Refika Aditama)
[11] Hansen P J K 1968 What do the learner know about clouds, precipitation, wind and greenhouse effect; a short review of research from 1883 to 2009
[12] Hanifah H 2016 Penerapan Pembelajaran Model Eliciting Activities (MEA) dengan Pendekatan Saintifik untuk Meningkatkan Kemampuan Representasi Matematis Siswa Kreano, J. Mat. Kreat. 6, 2 p. 191
[13] Arikunto S 2009 Dasar-dasar Evaluasi Pendidikan (Jakarta: Rineka Cipta)

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