Mathematical critical thinking skill and self confidence according to student’s cognitive stage

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Abstract. The purpose of this survey is to examine attainment of student’s mathematical critical thinking skill (MCTS) and mathematical self confidence (MSC) according to its cognitive stage. The survey concerns with 36 eighth grade students’, test of logical thinking (TOLT), an essay MCTS test, and a MSC scale. Analysis data of this survey are computation on percentage and testing existancy of association between MCTS and MSC, and analysis rational on other findings. By using TOLT, survey invented some interesting findings among other were: a) 11\% at formal stage, 53\% at transition stage, and 36 \% at concrete stage; b) The survey detected that mathematical critical skill on formal stage students obtained higher grade than transition stage students and the transition stage students obtained higher grade than the grade of concrete stage students. The survey detected that Mathematical self confidence on formal stage student and transition stages have high mathematical self-confidence compared to students who are still in the concrete stage; c) There is a association between mathematical critical thinking skills with self confidence.

1. Introduction

Basically, teachers aware that student’s learning success was affected by some variables namely student’s variables and teaching-learning variables. Among other things of student’s variable is student’s learning readiness such as student’s cognitive stage which illustrating student’s ability to accomodate and to assimilate a new information with prior student’s knowlegde and construct new meaningfull knowlegde. One aspect that supports student’s in learning is to develop cognitive aspects. By developing cognitive aspect will also determine success in other aspects. It is necessary to conduct a deeper study of the cognitive development of children to be able to realize good cognitive development. One theory of cognitive development that is often used is the theory developed by Jean Piaget. Piaget [1] categorizes student’s cognitive phase occurs in four stages such as: a. sensori-motor cognitive stage (0-2 years old); b.pre-operational concrete stage (2-7 years old); c. concrete operational stage (7-13 years old); d. formal operational stage (13 years old-adult).

Some experts argue that to measure an accurate cognitive stage requires quite a long time. Therefore, Tobin and Capie [1] conducted a logical thinking test (TOLT) as a substitute for inhelder and piaget techniques. The TOLT test consists of eight items in the form of multiple choices out of five options accompanied by 5 choices of reasons, and the remaining two items in the essay reasoning test without calculation.
The critical thinking is needed and must be the main goal of all educational institutions [2,3]. The developing critical thinkers is the basis for good education and that critical thinking skill’s are needed to solve the problems of daily life [4].

Many definitions about critical thinking are presented by some experts. Critical thinking means reflective thinking that focuses on deciding an action that is believed or something done [5]. Another idea which was stated critical thinking is the skill in examining assumptions, discerning hidden values, evaluating evidence, and assessing conclusions [6]. Critical thinking is a process that is based on steps to analyze, examine, evaluate arguments [7]. Meanwhile, [8] argues that critical thinking is thinking that involves reasoning and logic to solve problems. Hashemi [9] argues that critical thinking is a skill needed to grow students' thinking skills.

There are 12 indicators of critical thinking according to Ennis [10] which are grouped into five groups of thinking abilities. The following explanation of the five indicators of critical thinking: a) Provide a simple explanation (Elementary Clarification), namely identifying the adequacy of the elements to solve the problem; b) Building basic skills (Basic Support) that is identifying the concepts that underlie problem solving; c) Making conclusions (Inferences), namely doing deduction and induction; d) Making further clarification (Advanced Clarification), namely proving the truth of the statement and explaining it; e) Manage strategies and tactics (Strategies and Tactics), which are looking for alternative solutions to problems.

In addition to mathematical critical thinking skills, there are affective aspects that contribute to students' success in the process of learning mathematics. One of the affective aspects is student's self-confidence. Students who have self-confidence will tend to prefer to study mathematics, so that in the end it is expected that mathematics learning achievement is also more optimal. This is in line with the results of research conducted by Suhendri [11], TIMSS [12] revealed that there is a positive association between self-confidence in learning mathematics and mathematics learning outcomes. Hendriana [13] argues that there is a positive association between self-confidence and mathematics learning outcomes including: 1) Students who have an attitude of confidence in mathematics tend to be more courageous in taking steps to solve problems, outside the procedure in general; 2) Students who have confidence in mathematics tend to have many ideas in solving problems or have more than one way to solve problems.

Beside aforementioned studies, other studies namely [14-17], reported the grade of student’s mathematical critical thinking skills, were still at medium level. Hidayat and Sari [18] found that all Adversity Quotient Levels make a good contribution to students' abilities. Some other studies found that students obtained selfconfidence at fairly good grade level. Based on those findings, seemingly for high school students, mathematical critical thinking skills tasks was more difficult to do than to perform self confidence behaviour [19,20].

The aforementioned arguments and findings, motivate researchers to execute a study for analyzing students’ mathematical critical thinking skills and self confidence according to student’s cognitive stage, and formulate research questions as follow. a) Based on the TOLT test, how big is the percentage of student distribution at each cognitive stage?; b) What is the percentage of students’ scores on mathematical critical thinking skills and confidence based on their cognitive stage? c) Is there a relationship between mathematical critical thinking skills and self-confidence?

2. Method
The research method used in research is quantitative descriptive research. The sample in this study consisted of 36 junior high school students in the city of Cimahi. Analysis of the data used is the calculation of percentages, and testing for contingency associations. The instruments used in this study include logical reasoning tests in the form of tests and TOLT, tests of mathematical critical thinking skills, self-confidence scale. TOLT was adopted from McDonald, 1982 and translated into the Indonesian version in [1]. In the following, we attach the characteristics of the instruments as in Table 1.
Table 1. Characteristics of instruments of survey

| Test and Scale | Subject | n | Item Test/Scale | DP | DI | IV | Reliability | Source |
|----------------|---------|---|-----------------|----|----|----|--------------|--------|
| TOLT           | 92      | 10| 0.42 - 0.84     | 0.37 - 0.83 | 0.59 - 0.81 | 0.66 | Sumarmo, 1987 |
| MCTS           | 36      | 5 | 0.32 - 0.45     | 0.23 - 0.58 | 0.62 - 0.91 | 0.89 | This survey, 2019 |
| MSC            | 36      | 25| 0.34 - 0.70     | 0.26 - 0.82 | 0.47 - 0.78 | 0.72 | This survey, 2019 |

Note: DP: discriminant power; DI: difficulty index; IV: Item validity

3. Result and Discussion

By using TOLT Indonesia version [1], the survey investigated percentage of student distribution at each cognitive stage as in Table 2.

Table 2. Distribution of student’s cognitive stage by using TOLT (Indonesia version)

| Subject         | n  | Concrete Stage | Transition Stage | Formal Stage |
|-----------------|----|----------------|------------------|--------------|
| 8th grade student | 36 | 36             | 53               | 11           |

This finding show that there are 4 student’s or 11% student’s were at formal stage, 19 student’s or 53% student’s were at transition stage, and 13 student’s or 36% student’s were at concrete stage. This finding can be concluded that eighth grade student’s are in a transition stage.

Table 3. Description of student’s score on mathematical critical thinking skills and student’s mathematical self confidence based on student’s cognitive stage

| Variable | Statistics | Concrete Stage | n (%) | Transition Stage | n (%) | Formal Stage | n (%) | Total | n |
|----------|------------|----------------|-------|------------------|-------|--------------|-------|-------|---|
| MCT (IS: 18) | $\bar{x}$ | 11.46 | 13 | 13.94 | 19 | 17.25 | 4 | 13.42 | 36 |
|           | ➥ IS (36%) | 63.6% | 77% | 53% | 96% | 11% | 74.5% | 36 |
|           | s          | 0.88 | 1.13 | 0.5 | 2.04 |     |      |      |
| SC (IS = 100) | $\bar{x}$ | 72.30 | 13 | 84.63 | 19 | 92.75 | 4 | 81.08 | 36 |
|           | ➥ IS (36%) | 72.3% | 84.6% | 53% | 93% | 11% | 81% | 36 |
|           | s          | 4.38 | 4.13 | 4.57 | 8.25 |     |      |      |

Description of student’s scores on mathematical critical thinking skills, and on mathematical self confidence, based on student’s cognitive stage were attached in Table 3. According to Table 3, the survey detected that in entirely students the grade of student’s mathematical critical thinking skills was at medium level (74.5%). Formal stage students’ get higher grades (96%)
than the grade of transition stage students (77%), and both of them were higher than the grade of concrete stage students (63.6%). This findings were similar to findings of previous studies [14-16,21,22] reported the grade of student’s mathematical critical thinking skills, were at medium level. In addition, other findings of this survey also similar to Sumarmo [1] and Piaget’s conception that formal stage students were more capable to complete high order thinking (HOT) mathematics tasks which required formal operational abilities.

Description of student’s grade on mathematical self confidence, based on student’s cognitive stage were attached in Table 3. According to Table 3, the survey detected that in entirely students the grade of student’s mathematical self confidence was at high level (81.08%). Formal stage students obtained higher grade (93%) than the grade of transition stage students (84.6%), and both of them were higher than the grade of concrete stage students (72.3%). It can be concluded that students with formal cognitive and transition stages have high mathematical self-confidence compared to students who are still in the concrete stage.

To see the association between mathematical critical thinking skills and mathematical self confidence, was analyzed by using contingency such as in Table 4 and by using \( \chi^2 \) testing.

**Table 4. Cross tabulation of mathematical critical thinking and self confidence**

| MCT   | SC  |        |        | Total |
|-------|-----|--------|--------|-------|
| High  |     | 5      | 0      | 5     |
| Medium|     | 12     | 5      | 17    |
| Low   |     | 0      | 8      | 14    |
| Total |     | 17     | 13     | 36    |

Table 4 shows that the number of students with mathematical critical thinking skills at a high level and mathematical self confidence at a high level there are 5 students; students with mathematical critical thinking skills at a medium level and mathematical self confidence at a high level there are 12 students; students with mathematical critical thinking skills at a medium level and mathematical self confidence at a medium level there are 5 students; students with mathematical critical thinking skills at a low level and mathematical self confidence at a medium level there are 8 students; students with mathematical critical thinking skills at a low level and mathematical self confidence at a low level there are 6 students. It can be concluded that the average mathematical thinking ability of students is at a medium level with high mathematical self confidence. To test the hypothesis whether there is an association between the ability to mathematical critical thinking skills with mathematical self confidence can be seen in Table 5.

**Table 5. Test of pearson-chi square and contingency coefficient between mathematical critical thinking and mathematical self confidence**

| Pearson-Chi Square \((\chi^2)\) | Df | Contingency Coefficient \((C)\) | Sig.(2-tailed) |
|----------------------------------|----|---------------------------------|---------------|
| 24.686*                          | 1  | 0.638                           | 0.000 < 0.05  |

Based on table 5 the sig (2-tailed) value of 0.000 < 0.05, this shows that there is an association between the mathematical critical thinking skills with mathematical self confidence. The value of the coefficient of association between mathematical critical thinking skills and
mathematical self confidence of 0.638 is included in the medium category. The coefficient shows that the higher the students' mathematical self confidence score, the students' mathematical critical thinking skills are also higher.

4. Conclusion
Based on findings and discussion, the survey derived conclusion as follow. Distribution of eighth grade students by using TOLT were as follow: 11 % at formal stage, 53% at transition stage, and 36 % at concrete stage. The survey detected that in entirely students the grade of student’s mathematical critical thinking skills was at medium level (74.5%), even if according to student’s cognitive stage, formal stage students obtained higher grade (96%) than the grade of transition stage students (77%), and both of them were higher than the grade of concrete stage student’s (63.6%). Even if, formal stage students obtained higher grade than transition stage students and the transition stage students obtained higher grade than the grade of concrete stage students. The survey detected that in entirely the grade of student’s mathematical self confidence was at high level (81.08%). Formal stage students obtained higher grade (93%) than the grade of transition stage students (84.6%), and both of them were higher than the grade of concrete stage students (72.3%). It can be concluded that students with mathematical self confidence on formal stage students and transition stages have high mathematical self-confidence compared to students who are still in the concrete stage. The other conclusions were that, there is an association between the mathematical critical thinking skills with self confidence.

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