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The Development of Assessment Instruments of Critical Thinking Ability in Mathematics Learning in Elementary School

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Abstract
The purpose of This research is to develop assessment instruments of critical thinking ability in mathematics learning in elementary school. This research using mixed methods research. The planning and preparation mechanisms for critical thinking ability assessment instruments in elementary mathematics learning in this study are adapted from the Borg and Gall models and the Dick, Carey and Carey models. Based on this model, the stages of the research: (1) Research and information gathering that includes preliminary study and needs analysis; (2) development of a draft that includes the planning and development of the initial form of the product; (3) product trials and revisions that include expert judgement, one to one evaluation, and field test; and (4) finalization and dissemination. The results showed that the assessment instruments of critical thinking ability in elementary school especially in mathematics learning have qualified aspects of materials, construction, and language. Thus, this critical thinking ability assessment instrument can be used as one of the instruments used in carrying out the assessment of mathematics learning in elementary school. The results of this study recommend that other assessment instruments be produced that can be used to assess other skills in mathematics learning in elementary school, such as creative thinking ability, systematic thinking ability, associative, evaluative, and others in order to help the pupil to fulfill their competencies.

Keywords: Assessment Instruments**,** Critical Thinking Ability, Learning Math, Elementary School.

INTRODUCTION

The rapid development of information and communication technology in the 21st century demands quality human resources. To produce quality human resources, it is necessary for people who have the ability to think who are able to face the challenges of the industrial era 4.0 and society 5.0. One of them is critical thinking ability. Critical thinking is an essential skill for life in the information age (Connor-Greene & Greene, 2002). According to Thompson (2011), the most important skills for problem solving, research and discovery" (Sanja Maričića and Krstivoje Špijunovićb, 2015). Critical thinking skills should be empowered through learning in schools, especially science learning, because of in the 21st century, the students must have critical thinking skill (Saavedra et al., 2012).

The importance of critical thinking ability, requires teachers to practice critical thinking skills early on. Education should aim to support the development of independent thinkers who understand problem solving, as well as be able to use a variety of cognitive skills and strategies, including critical thinking, to solve problems (McGregor, 2007). Critical thinking skills should be important because these critical thinking skills are not brought to birth (Redhana and Liliasari, 2008).

One of the critical thinking skills required in the face of the challenges of the 21st century marked by the industrial era 4.0 and the society 5.0 era is the ability to think critically mathematically. This is considering the importance of the role of mathematics in everyday life. Mathematics is a universal science that underlies the development of modern technology, has an important role in various disciplines and advances human thinking. Mathematics is a tool to develop thinking ability, therefore

mathematics is very necessary both in daily life and in the advancement of science and technology..

Critical thinking skills should be incorporated into daily instruction to adequately prepare students for school assessment, strict college expectations, employer demands, and complex life situations. Equipping students with critical thinking skills allows them to reason effectively, make rational judgments and decisions, and solve problems (Rebecca Stobaugh, 2013).

However, the critical thinking ability of mathematics achieved by students is still categorized as unsatisfactory. This is in accordance with the stated by The Minister of Education and Culture Muhadjir Effendy, did not show the spotlight of a number of domestic and foreign studies, related to Indonesia experiencing a Mathematical emergency. Various studies show that students ranging from elementary to high school level, are considered less able to solve simple math problems. It was stated that "Emergency mathematics, yes we (Kemendikbud) from the past already know, if mathematics is severe. So this is not a new issue, Dikbud already understands it," said Muhadjir Effendy at the Ministry of Foreign Affairs office, Jalan Medan Merdeka Barat, Central Jakarta, Monday, November 12, 2018 (Yaspen Martinus, 2018).

To improve critical thinking ability in mathematics learning is the utilization of learning evaluation, one of which is the assessment instrument. This is in accordance with the results of research conducted by Amalia, that well-designed assessment instruments and in accordance with the level of thinking ability can improve the thinking of students, especially critical thinking (Amalia, 2014). Implementation of low critical thinking skills assessment impacts the critical and creative thinking skills of graduates in elementary schools up to low universities in Indonesia (Reta, 2012).

Considering that assessment instruments are able to improve critical thinking ability, researchers are interested in developing critical thinking ability assessment instruments in mathematics learning. It is expected that the results of the development of critical thinking ability assessment instruments in mathematics learning is able to contribute in improving students' critical thinking ability so that they are ready to face the challenges of the industrial era 4.0 and society 5.0.

METHOD

The development of critical thinking ability assessment instruments in mathematics is Research and Development (R & D). Models used in this study were Borg and Gall and Dick, Carey and Carey. Stages in this model: (1) Study and information gathering which includes preliminary study and needs analysis, (2) drafting which includes planning and development of the initial form of the product, (3) product trials and revisions that include expert testing, one-on-one evaluation, and field tests, as well as (4) finalization and dissemination. This research was conducted in grade 4 at SDN Rawamangun 12 Pagi East Jakarta. The data in this study was netted using questionnaires, interview guidelines, and tests. This instrument is used for needs analysis, trial, and product validation.

Data processing validation results using a likert scale with a score range of 1-5. Questionnaires used during product trials and validations use the "Yes" (score 1) and "No" (Score 0) (Riduwan, 2015) options. Validation expert in this research is validation of constructs and reliability between raters. Expert validation is carried out by three experts, namely elementary mathematicians, learning evaluations, and

languages. Calculation of validation results using Aiken's statistics (Azwar, 2016). In this study, content validation was analyzed by using Aiken's V formula, the valid items with provisions ≥ 0.87 (Hartanto, Ani Rusilowati, and Kartono, 2019). The reliability of critical thinking ability assessment instruments is inter-rater reliabiliy. This reliability is calculated using Hoyt's variance technique (Habiby, 2017). To find out the reliability of critical thinking ability assessment instruments using the category of reliable and consistent when the coefficient of reliability ≥ 0.6 (Rusilowati & Sujarwanto, 2015). After all the instrument items are declared valid and the instrument is reliabel, validation of material, construction, and language aspects is carried out. To determine the feasibility of critical thinking ability assessment instruments according to the results of the following calculations:

$$Response\ (\%) = \frac{Total\ Score}{Toral\ Maximum\ Score} \times 100\%$$

Feasibility of critical thinking ability assessment instrument in mathematics learning is done by interpreting validation data in percentage form using the following table:

Table 1. Interpretation Criteria Score

Value	Criteria
0 - 20	Not Feasible
21 - 40	Less Feasible
41 - 60	Quite Feasible
61 – 80	Feasible
81-100	Very Feasible

The feasibility of critical thinking ability assessment instruments in mathematics learning is declared feasible if it obtains a ≥ of 61% (Riduwan, 2015).

Results and Discussion

The stages in the development of critical thinking ability assessment instruments in mathematics learning are as follows:

a. Research and Information Collection

The needs analysis stage was conducted by observation of geometric mathematics learning materials in grade 4 at SDN Rawamangun 12 Pagi East Jakarta and interviews with grade 4 elementary school teachers about the use of critical thinking ability assessment instruments in mathematics learning. The results of direct observations found that teachers rarely use critical thinking ability assessment instruments in mathematics learning. When conducting learning evaluations, teachers only use instruments designed in accordance with the learning indicators. Teachers rarely make assessment instruments based on higher order thinking.

b. Draft Development

Development of critical thinking ability assessment instruments in mathematics learning as an effort to support the improvement of students' critical thinking ability in mathematics learning. Critical thinking ability assessment instruments in mathematics learning are instruments used for formative tests. The instrument is designed in the form of an essai of 10 grains.

c. Product Trials and Revision

Product trials and revisions are conducted through expert assessment, one-on-one evaluation, and field tests.

a) Expert Review

Expert assessment of the product is carried out by three people, namely mathematicians, learning evaluation experts, and linguists. Assessment of the product is carried out validation, namely the validity of the construction and relibilitas. Furthermore, determine the feasibility by using a questionnaire consisting of material, construction, and language aspects. Recapitulation of product assessment by experts as follows:

Tabel 2. Koefisien Validitas Butir Instrumen

No. Item	Skor Aiken's V	Criterion
1	0.9	Valid
2	0.9	Valid
3	0.89	Valid
4	0.87	Valid
5	0.88	Valid
6	0.9	Valid
7	0.89	Valid
8	0.91	Valid
9	0.89	Valid
10	0.88	Valid

The coefficient of reliability of critical thinking instruments using Hoyt variance technique obtained 0.98. These results suggest that the instrument of critical thinking ability assessment is reliabel.

The results of feasibility validation are reviewed from the material, construction, and language aspects carried out respectively as follows:

a) Mathematics Learning Expert Evaluation

The results of product assessment conducted by mathematicians on material, construction, and language aspects can be seen in the following table:

Table 3. Results of Mathematics Learning Expert Eligibility on Instruments of Critical Thinking Ability in Mathematics Learning in Elementary School

No.	Aspect	Eligibility Score	Criterion
1.	Materials	89%	Very Feasible
2.	Construction	90%	Very Feasible
3.	Language	87%	Very Feasible
Average Score		86.7%	Very Feasible

b) Learning Evaluation Expert Evaluation

The results of product assessment conducted by learning evaluation experts on material, construction, and language aspects can be seen in the following table:

Table 4. Results of Learning Evaluation Expert Eligibility on Instruments of Critical Thinking Ability in Mathematics Learning in Elementary School

No.	Aspect	Eligibility Score	Criterion
1.	Materials	90%	Very Feasible
2.	Construction	91%	Very Feasible
3.	Language	89%	Very Feasible
Average Score		90%	Very Feasible

c) Linguist Evaluation

The results of product assessment conducted by linguists on material, construction, and language aspects can be seen in the following table:

Table 5. Results of Linguist Eligibility on Instruments of Critical Thinking Ability in Mathematics Learning in Elementary School

No.	Aspect	Eligibility Score	Criterion
1.	Materials	88%	Very Feasible
2.	Construction	89%	Very Feasible
3.	Language	88.9%	Very Feasible
Average Score		88.7%	Very Feasible

Recapitulation of assessment results on material, construction, and language aspects of critical thinking ability assessment instruments in elementary mathematics learning conducted by mathematics learning experts, learning evaluation experts, and linguists can be seen in the following table:

Table 6. Recapitulation of Expert Test Data Analysis Results

No.	Expert Review	Average Feasibility Score	Criterion
1.	Mathematics Learning Expert	86.7%	Very Feasible
2.	Learning Evaluation Expert	90%	Very Feasible
3.	Linguist	88.7%	Very Feasible
Average Overall		88.5%	Very Feasible

Based on recapitulation results, the average assessment of critical thinking ability assessment instruments in elementary math learning as a whole is 86.4%. In accordance with the product assessment reference criteria, the score of 86.4% means it is very feasible. Thus based on expert assessment, the instrument of critical thinking ability assessment in elementary mathematics learning is said to be very feasible.

b) One to one Evaluation

The evaluation was conducted by three grade 4 respondents at SDN Rawamangun 12 Pagi East Jakarta. The selection of the three respondents was based on the recommendation of grade IV teachers. This evaluation activity was carried out using a questionnaire consisting of 10 statements with the option of answering "yes" or "no". This questionnaire consists of aspects: Students' understanding of the materials, students' interest in the instrument, and aspects of the use of critical thinking ability assessment instruments in elementary mathematics learning. The results of the questionnaire filled by the three respondents are as follows:

Table 7. Recapitulation Results of One to one Evaluation

No.	Expert Review	Average Feasibility Score
1.	Students' Understanding of the Materials	98%
2.	Students' Interest in the Instrument	86.7%
3.	Use of the Instrument	90%
Average Overall		91.6%

The average rating of the three respondents was 91.6%. In accordance with the product assessment reference criteria, the score of 91.6% means it is very feasible. Thus, based on the assessment of stages one to one, the critical thinking ability

assessment instrument in elementary mathematics learning is said to be very feasible.

c) Field Test

The evaluation phase of this field test was carried out by involving 16 grade 4 students at SDN Rawamangun 12 Pagi East Jakarta. This evaluation activity uses a questionnaire consisting of 10 statements with a choice of "yes" or "no" answers. This questionnaire consists of aspects: Students' understanding of the materials, students' interest in the instrument, and aspects of the use of critical thinking ability assessment instruments in elementary mathematics learning. The results of field test evaluation are as follows:

Table 9. Recapitulation Results of Field Test Evaluation

No.	Expert Review	Average Feasibility Score
1.	Students' Understanding of the Materials	91.7%
2.	Students' Interest in the Instrument	87%
3.	Use of the Instrument	88%
Average Overall		88.9%

The average assessment of this field test is 88.9%. In accordance with the product assessment reference criteria, the score of 88.9% means it is very feasible. Thus, based on the assessment of the field test stage, the critical thinking ability assessment instrument in elementary mathematics learning is said to be very feasible.

The test results and product revisions showed that the validity of the items performed using the Aiken's V Score formula stated that the entire instrument item was valid. Using the Hoys formula, it was obtained that the instrument's coefficient of reliability was 0.98 which means that the instrument is assessing the ability to think critically reliable.

Based on validation reviewed from material, construction, and language aspects conducted by mathematics defense experts, learning evaluation experts, and language obtained that critical thinking ability assessment instruments in elementary math learning meet the feasibility of material, construction, and language aspects. The results of the students' trial showed that students' understanding of the materials, students' interest in the instrument, and aspects of the use of critical thinking ability assessment instruments in elementary math learning. Based on the results of this development, the critical thinking ability assessment instrument in elementary mathematics learning can be used to measure students' critical thinking ability in elementary mathematics learning.

Considering that the assessment instrument is one component of the learning device, it is in accordance with its function that the purpose of assessment in learning is improvement. The purpose of assessment for critical thinking is carried out so that students are able to think through content, using discipline skills in reasoning. The more specific we are about what we want students to learn about critical thinking, the better we can design instructions with that specific purpose.

Critical thinking is defined as "self-purposed and self-regulating assessments that produce interpretation, analysis, evaluation, and inference, as well as explanations of the consideration of evidence, conceptual, methodological, critical, or

contextual that form the basis of the assessment." (Facione, 1990). Educators recognize the importance of critical thinking skills as one of the outputs of the learning process. The quality of the instruments used in the assessment directly affects the accuracy of student status (Rahayu, 2016). Therefore, developing critical thinking skills is widely regarded as an important educational goal. Critical thinking is a necessary ability for the 21st century (Trilling & Fadel, 2009). Thus, the development of this assessment instrument is expected to have implications for teachers in primary schools to provide learning that develops critical thinking skills and apply differentiated learning experiences based on evidence of differences developed in those skills.

CONCLUSIONS

Based on the results and discussion of research, it can be concluded that critical thinking ability assessment instruments in developed mathematics learning are declared valid and reliabel. This instrument meets all eligibility criteria, in terms of material, media and language aspects. Thus, this instrument is worthy to be used as an instrument used in measuring students' critical thinking ability in mathematics learning.

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