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Assessment Instrument of Critical Thinking Skills for Student on Light Interaction with Organisms

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Abstract

Critical thinking skills are one of the skills needed in the 21st century. These skills can be developed and measured in science learning. This study aimed to produce an assessment instrument that can be used to measure critical thinking skills of junior high school students. This assessment instrument was developed in the multiplechoice test. The stages of development include a preliminary study, preparation of item questions, test of content validity by experts and empiric validity, and reliability test. A total of 60 junior high school students in Tebing Tinggi became the research sample. This assessment instrument consists of five aspects of critical thinking skills, basic clarification, basic support, inference, advance clarification, and strategy and tactics. 7 of the 25 items are valid with high criteria, 11 are valid with medium criteria and 7 others are valid with low criteria. Reliability test used the Kuder-Richardson (KR-20) approach and the results are reliable with high criteria. The analysis showed that the developed critical thinking skills of junior high school students on the theme of light interaction with organisms.

Keywords: *critical thinking skills, instrument for assessing, validity, reliability, light*

Introduction

The challenges in the 21st century according to Martin (2007) are climate change, global poverty, population growth, war, species extinction, creativity, transhumanism, and the gap between skill and wisdom. These challenges must be faced through education, including science education. The quality of science education in Indonesia needs to be improved in cognitive, attitudes and skills. This is in accordance with the objectives of national education, namely developing abilities and forming a dignified national character and civilization in order to educate the nation's life, aiming at developing the potential of students to become human beings who believe and fear God Almighty, competent, creative, independent, and become democratic and responsible citizens. This indicates that the quality of science education must be able to develop the skills needed in the 21st century.

21st century skills are divided into 4 categories by Assessment and Teaching of 21st Century Skills (ATC21S), namely way of thinking, way of working, tools for working, and skills for living in the world (Griffin, McGaw, & Care, 2012). They divide way of thinking skills category into creativity, innovation, critical thinking, problem solving, and decision making, way of working category into communication skills, collaboration and teamwork, tools for working category become awareness as global citizens and citizens, local, life and career development, and a sense of personal and social responsibility, and skills for living in the world into skills based on information literacy, mastery of new information and communication technology, and the ability to learn and work through digital social networks.

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The demands for skills in the 21st century have been included in the 2013 curriculum, presented in the science learning syllabus in accordance with Permendikbud Number 20 of 2016 concerning Primary and Secondary Education Graduate Competency Standards in the skills dimension, namely having creative, productive, critical thinking and acting skills, independent, collaborative, and communicative through a scientific approach according to what is learned in educational units and other sources independently (No. P, year 2016). Critical thinking skills are one of the skills listed in the Graduate Competency Standards that need to be trained and developed.

Critical thinking are skill that use basic, reflective, and active intellectual thought processes to skillfully analyze arguments, generate insights into certain meanings and interpretations, conceptualize, apply, and evaluate information gathered by observations and experiences that focus on determining what to believe or what to do (Peter, 2015, Oguz and Saricam, 2016, Mu'iz, 2018). A person who is skilled in critical thinking is someone who is honest with himself, can resist manipulation, does not feel confused, judges based on evidence, and can look for relationships between topics intellectually (Ruggiero, 1996), so this is in line with Ennis who has developed 12 indicators in 5 aspects, namely basic clarification, basic support, inference, advance clarification, and strategy and tactics. Table 1 describes critical thinking skills (Ennis, 1985).

Table 1. Critical thinking skills descriptions

Aspek	Indikator
Basic clarification	a. focus question
	b. analyze questions
	c. ask and answer about an explanation or challenge
Basic support	a. consider whether the source can be trusted
	b. observe and consider an observation report
Inference	a. deduce and consider the results of the deduction
	b. induce and consider the results of the induction
	c. make and determine decisions
Advance clarification	a. define terms and consider definitions
	b. identify assumptions
Strategy and tactic	a. determine action
	b. interact with other people

Rahmawati, Hidayat, and Rahayu (2016) have conducted research by providing critical thinking skills test questions to junior high school students that measure five aspects of critical thinking skills and conclude that the critical thinking skills of junior high school students are still low, amounting to 45.09%. In line with the research of Susilowati, Sajidan, and Ramli (2017) with a percentage of 51.60% of students having low category critical thinking skills.

The developed instrument assesses students' critical thinking skills in integrated science learning. One type of integration in science learning is the connected type. Connected learning is learning that links concepts in a topic or a theme. This learning provides opportunities for students to study, conceptualize, improve, and assimilate concepts continuously so as to facilitate the concept transfer process in solving problems (Fairuz, 2019). The theme of the interaction of light with organisms is a theme that assimilates the concepts of biology, physics, chemistry, and IPBA in a connected way. Figure 1 describes how the concepts connected to the theme of light interaction with organisms.

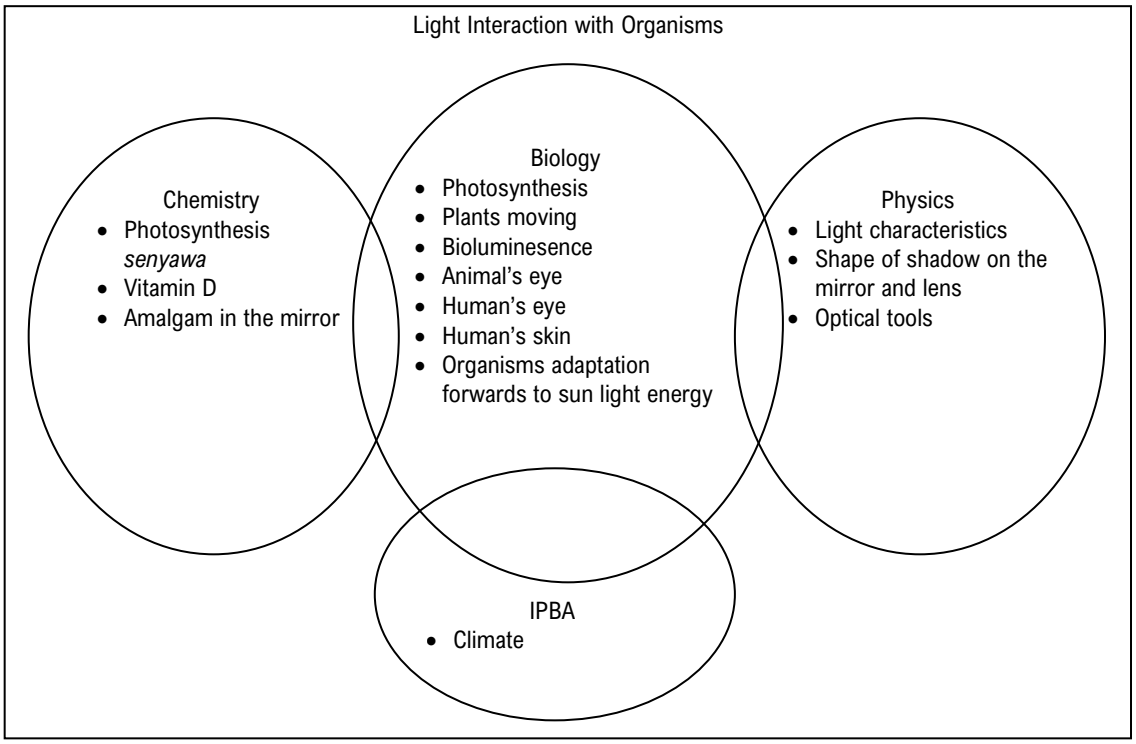


Figure 1. Theme of light interaction with organisms

The type of critical thinking skills assessment is generally paper & pencil test with multiple choice forms (Watson and Glaser, 2008). The critical thinking skills assessment instrument is adjusted to the level of cognitive of the students and contextual, so that the critical thinking skills test instrument must be developed as an adjustment. Development of critical thinking skills instruments must refer to the indicators that build critical thinking skills itself and follow the instrument development procedures in general. A good assessment instrument is an instrument that meets criteria such as validity and reliability. Valid instruments will provide assessment results that can be accepted legally, while reliable instruments will produce instruments that can be used repeatedly (Eldridge, 2017). The final objective of this research is to produce valid and reliable assessment instruments to measure critical thinking skills of junior high school students.

Method

This study used research and development methods that adapted from Sugiyono (2019) and Sukmadinata (2013). The stages of developing the instrument of critical thinking skills in this study were developing indicators of critical thinking skills from every aspect, compiling item questions, testing the validity and testing the reliability of the test instruments. Figure 2 illustrates the stages of this research method.

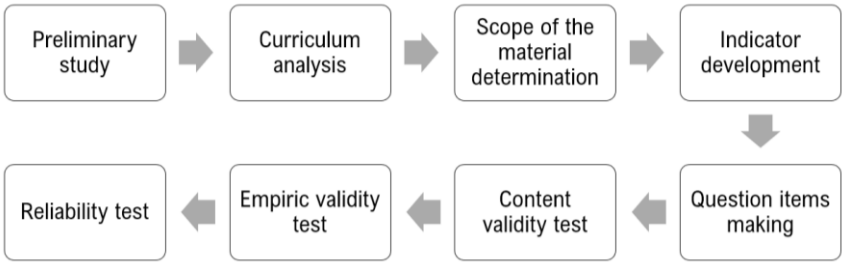


Figure 2. Research method steps

The development of indicators for each aspect of critical thinking skills is compiled based on the aspects of critical thinking skills by Ennis. The arrangement of question items was adjusted to the level of cognitive of junior high school students and the scope of junior high school students' material on the theme of light interaction with organisms. The instrument consisting of several item questions was validated by content validation and empirical validation to determine whether the instrument was appropriate or not in assessing critical thinking skills. Three experts assessed the draft critical thinking skills instrument that was developed. Empirical validity was carried out with limited trials. After the instrument was stated valid, the question instrument was tested for reliability. The sample in this study was 60 junior high school students in Tebing Tinggi. The instrument for assessing critical thinking skills was developed in the form of a multiplechoice test adapted from Watson and Glaser.

Content validity data were analyzed by looking at the accuracy of the instrument material with indicators, objectives, aspects of ability, language validity, and suitability of images. The data of empirical validity were analyzed using the Pearson Product Moment formula which correlates the score of a particular item with the total score. Data to measure reliability were analyzed using the Kuder-Richardson (KR20) approach.

Results

Development of a critical thinking skills assessment instrument in the form of a multiplechoice test adapted from Watson and Glaser. Critical thinking skills include five aspects expressed by Ennis, namely basic clarification, basic support, inference, advance clarification, and strategy and tactics. The indicators are developed from these five aspects and also adjusted to the theme of light interaction organisms.

After the indicators were developed and organized into 25 item questions, the instruments were validated by experts (content validation). Expert judgment is used to improve item that are prone to misconceptions and ambiguity in writing, and the suitability of the questions with the indicators of critical thinking skills to be assessed. The experts stated that the questions developed were feasible with some minor improvements to measure the science process skills of junior high school students. Furthermore, the questions were tried out limited to 60 students in Tebing Tinggi to determine the validity value, the results can be seen in Table 2.

Table 2. Empirical validity each question items

Question number	Validity r_{tab}= 0,2542		Question number	Validity r_{tab}= 0,2542	
	Value	Criteria		Value	Criteria
1	0,4801	Middle	14	0,6410	High
2	0,5143	Middle	15	0,3451	Low
3	0,5429	Middle	16	0,6593	High
4	0,3560	Low	17	0,6297	High
5	0,6493	High	18	0,5160	Middle
6	0,3918	Low	19	0,5964	Middle
7	0,6410	High	20	0,5664	Middle
8	0,3526	Low	21	0,3918	Low
9	0,6402	High	22	0,5449	Middle
10	0,5449	Middle	23	0,5449	Middle
11	0,4003	Middle	24	0,3798	Low
12	0,6493	High	25	0,3978	Low
13	0,5296	Middle			

Based on the results of empiric validity in Table 2, 25 questions to assess critical thinking skills were stated valid even though there were 7 questions with low criteria. The 7 item questions are still used after being fixed for reliability testing. The reliability test was conducted by trying out the valid assessment instruments on 60 junior high school students. The analysis of the reliability test results is shown in Table 3 where the KR-20 coefficient of the critical thinking skills assessment instrument is 0.7359 which means that it is reliable with high criteria. Thus, the instrument for assessing critical thinking skills of junior high school students on the theme of light interaction with organisms was stated valid and reliable.

Table 3. Assessment instrument reliability

Reliability			
r_{count}	r_{table}	Inference	Criteria
0,7359	0,2542	Reliable	High

Discussion

Critical thinking skills are basic skills needed to solve problems in everyday life (Griffin, McGaw, & Care, 2012). This is in accordance with the demands of the 2013 curriculum, as written in Permendikbud Number 20 of 2016 concerning Graduates Competency Standards for Primary and Secondary Education in the skills dimension. An assessment instrument needs to be made to measure the dimensions of critical thinking skills in learning, in this study science learning on the theme of light interaction with organisms.

The assessment instrument developed was adapted from an instrument designed by Watson and Glaser with several stages of development. After determining the theme of the material, the curriculum is analyzed to adapt the material to the demands of the curriculum. So this assessment instrument is in accordance with the science curriculum that is being used in Indonesia. Then, determine the scope of the material to limit the depth of it to suit the level of student cognitive development. The limited material is the basis for the preparation of indicators for critical thinking skills assessment instruments in every aspect. Make questions as an assessment test based on the indicators that have been prepared. As many as 25 items were made and the content was validated by the experts and revised according to the suggestions of the experts from the language and material suitability so that misconceptions and ambiguity would not occur. Misconceptions often occur due to lack of understanding of concepts and lack of information (Erman, 2017). This can cause students to misunderstand the questions given. The next step is to test the validity and reliability to determine whether the instrument is suitable for use or not. The validity and reliability test is limited to 60 junior high school students in Tebing Tinggi randomly. The following are some examples of critical thinking skills assessment items developed in this study in every aspect.

1. Basic clarification aspect. *Indicator:* Focus question Look at Figure 1

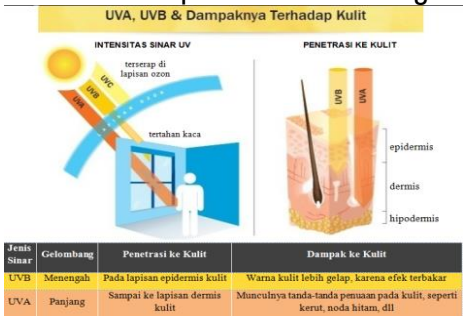


Figure 1. UVA, UVB and the effect on skin

The following are the questions based on Figure 1.

1. What if the skin has been exposed to UV A rays for a long time?
2. What causes Indonesian people's skin to have various colors?
3. Is the dark skin color just due to UV B exposure?
4. How about UV rays in Indonesia?

Based on Figure 1, the most appropriate question is …

a. 1, 2, and 3
b. 1 and 3
c. 2 and 4
d. 4 only

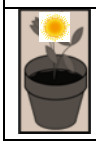
2. Basic support aspect. *Indicator:* Consider the credibility (the criteria of a source)
   Statement
   Bia and friends on a picnic in the park on Sundays. They choose to sit under a shady tree to keep them cool even though the weather is hot. Bia suddenly asked why it was cool under a shady tree.
   Source 1: humans breathe in lots of oxygen. Photosynthesis produces oxygen which is released through the stomata under the leaves. We feel cool because of the large amount of oxygen when we are under the tree.
   Source 2: humans breathe out carbon dioxide which is used as a material for photosynthesis. We feel cool because the level of carbon dioxide in the air increases.
   The correct source of the two sources above is….
   a. Source 1
   b. Source 2

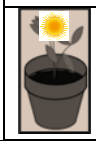
3. Inference aspect. *Indicator:* Induce and consider the results of the induction
   Statement
   
   Fireflies' bellies glow at night to alert predators and signal mating to the opposite sex. Firefly stomachs contain oxygen, calcium, magnesium, and a natural chemical called luciferin.
   The following is the conclusion of the above statement.
   1. The chemicals in the firefly's stomach react and produce light.
   2. The chemicals in the fireflies' stomachs will not react if there is no signal for mating or predators.

   The conclusion that can be accepted from the two conclusions above is …
   a. Conclusion 1
   b. Conclusion 2

4. Advance clarification aspect. Indicator: Identify assumptions
   Statement: Photosynthesis takes place in cells that have photosynthetic pigments. All plants have chlorophyll in the chloroplast. Some plants, such as red leafy plants, have more anthocyanin pigments.
   Assumption 1: Plants that carry out photosynthesis only have green leaves.
   Assumption 2: Plants with green and red leaves both carry out photosynthesis.
   The assumptions that can be correct from the two assumptions above are ...
   a. Assumption 1
   b. Assumption 2

5. Strategy and Tactic. *Indicator:* Determine an action
   Statement
   The teacher gave students the opportunity to propose an experimental design to observe the effect of light on plant motion. The tools and materials provided by the teacher were plants, board, lamps, and scissor.

Design 1	
Action 1 Plant is in a perforated board and exposed to the sun	Perlakuan 2 Plant is in a perforated board and put in the dark place
	

Design 2	
Action 1 Plant is in a perforated board and exposed to the sun	Action 2 Plant is in a perforated board and put in the room with light
	

   The most appropriate experimental design with the aim of the experiment is….
   a. Design 1
   b. Design 2

The instrument for assessing critical thinking skills was developed in the form of multiple choice which has various variants as a result of the adaptation by Watson and Glaser. For example, in the basic clarification aspect, the indicator is to focus the question. Students are measured how to think critically when asking related questions in a statement. In the strategic and tactical aspects, the indicator is to decide on an action. Students are presented with various experimental designs and decide which one to do. Thus, students can measure their critical thinking skills in using strategies when conducting experiments.

The theme of light interaction with organisms is a theme created in integrated science learning with the connected type which combines several basic competencies and all fields of science, such as biology (photosynthesis and adaptation of living things to sunlight), physics (optical tools), chemistry (vitamin D), and IPBA (weather). With a theme that is in accordance with basic competencies, the assessment instrument is also adjusted to the level of student cognitive development, and the depth of the material. This critical thinking skills assessment instrument can measure some of the basic competencies involved in the theme of light interactions with organisms.

Conclusion

Based on the objectives, research results, and discussion, it can be concluded that the instrument for assessing critical thinking skills developed is valid and reliable so that it can be used to measure the critical thinking skills of junior high school students on the theme of light interaction with organisms.

This critical thinking skill assessment instrument is not limited to the theme of light interaction with organisms, critical thinking skills in science learning in various themes can be measured by adapting the form of the instrument that has been developed.

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