



## THE SENIOR HIGH SCHOOL STUDENTS' CRITICAL THINKING SKILL THROUGH THE DEVELOPMENT OF POPULAR SCIENTIFIC BOOKS

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### Abstract:

Competition, in this globalization era, requires human resources who master knowledge, with complex thinking skills, critical thinking skills, problem-solving, creativity, and metacognition. The development of critical thinking skills can involve students' interaction with the environment. This study aims to describe the critical thinking skills of high school students through the development of popular scientific books that have been developed. This research is development research that refers to educational design research (EDR) with the stages of preliminary research, prototyping phase, and assessment phase. The research took place in September 2018 to June 2019 at SMAN 2 Muara, North Barito Regency. Critical thinking skills data were obtained at the small group and field test stages by calculating the percentage of students' worksheet answers in popular scientific books, quantitative descriptive data analysis. The results showed students' critical thinking skills the indicators of interpretation, assumptions, deductions, and inferences reach very good categories.

**Keywords:** critical thinking skill, development research, popular scientific book

### 1. Introduction

Competition, in this globalization era, not only requires human resources who master knowledge, but also requires human resources who have complex thinking skills, critical thinking skills, problem-solving, creativity, and metacognition. Critical thinking skills are one of the competencies that students must-have in the 21st century. Critical thinking is thinking that focuses on what is believed or done for reasons that are reflective and reasonable (Ennis, 2011). Critical thinking skills are useful for students for the preparation of post-secondary education and the workforce (Lai, 2011).

The learning process in schools must facilitate students to learn to think. Teachers can use learning methods that invite students to think, stimulate questions and find facts to solve a problem or theme. Critical thinking skills of students can be raised through the question and answer process that stimulates the thought process (Afcariono, 2008). Students should be encouraged to answer questions related to determining the consequences of a decision or an event, identifying assumptions used in a statement, formulating the main points of the problem, finding bias based on different points of view, expressing the cause of an event, and choosing factors that support a decision (Langrehr, 2006).

The quality of learning can be influenced by several aspects, including professional instructors, the use of teaching methods, which are interesting and varied, positive student learning behavior and an atmosphere conducive to learning, and the use of appropriate learning media in supporting the learning process (Nurjanah et al. , 2016). The learning process in each educational unit must be interactive, inspiring, fun, challenging, and motivating students to participate actively (Kemendikbud, 2013). Through quality learning, students are involved in the learning process that encourages them to think critically in developing their knowledge and skills (Ristiasari et al., 2012).

The development of critical thinking skills can involve students' interaction with the environment. Utilization of the environment can develop skills to observe (with all the senses), take notes, formulate questions, hypothesize, classify, make writing, and make pictures or diagrams (Yamin, 2013). Environment-based learning can build ethics, care, and be cultured towards environmental problems (Mulyana & Dermawan, 2009). The environment-based learning process aims to make it easier for students to learn to use concrete media in daily life and introduce the surrounding natural environment as learning media, as well as instilling a love of nature for students (Purnamawati, 2016). Some important meanings of learning outside the classroom are students will be able to adapt to the environment, the natural surroundings, and with people's lives (Vera, 2012). Students can know the importance of life skills and life experiences in the environment and the natural surroundings, and have an appreciation of the environment and surrounding nature.

Environment-based learning leads to meaningful learning to find concepts and relate them to real life, so students more easily understand the material because it is directly related to daily life (Mumpuni, 2013). Meaningful learning can improve students' critical thinking skills. Environment-based learning is believed to be one of the lessons that can improve students' critical thinking skills (OECD, 2015). Thus, the existence of natural surroundings is a potential that can be used to support student activities in the learning process (Brahim, 2007). By engaging directly in the environment, students can easily understand the material because students make observations in concrete situations (Setiyoningsih, 2017).

The teacher must plan, strive for, create and arrange teaching materials in the learning environment so that learning is truly following the conditions around students. Development research emphasizes on formative evaluation so that the development

model used aims to produce a prototype (Tessmer, 1998). Therefore, the development of learning resources in the form of popular scientific books based on local potential is an effort to improve students' critical thinking skills.

Popular scientific books are scientific books that are presented in a style that is popular or relaxed so that it is easily understood by ordinary people and interesting to read (Wardani, 2007). Popular scientific books contain ideas or ideas as outlined in scientific papers that discuss current issues by emphasizing the theoretical aspects, as well as summarizing relevant and up-to-date research results (LIPI, 2012). One of the advantages of popular scientific books is that they use popular languages, are not bound by the rules of scientific writing, so they are interesting to read and easily understood by lay people (Dalman, 2014). Previous studies regarding the making of BIP have been carried out. Irwandi (2018) explained the development of a popular scientific book about turtle species and its preservation to improve the critical thinking skills of high school students in coastal areas on Pulau Sembilan. Fitriansyah (2014) explains the development of popular scientific books about being able to develop critical thinking skills. The above research reports that popular scientific books that have been developed are suitable for use as reading material for both students and the community to practice critical thinking skills.

One of the high school lessons that can be taught using environment-based learning is biodiversity. One submatter of biodiversity is species diversity. Therefore the effect of environment-based learning on students' critical thinking skills needs to be assessed, so a riverbank in the Pendreh village was chosen to fulfill these learning activities, especially on the diversity of rattan species and their preservation. In connection with this reason, the research question raised how critical high school students' critical thinking skills through the development of popular scientific books?

## 2. Material and Methods

This type of research is development research that refers to educational design research (EDR) by Plomp & Nieveen (2007). Research steps include preliminary research, prototyping phase, and assessment phase. However, the research focused on preliminary research to produce an initial product (Rattan Popular Scientific Book on the Riverbanks of Pendreh), then continued formative evaluation (with the Tessmer 1998 model) to produce popular, valid, practical and effective popular scientific books to improve students' critical thinking skills.

Critical thinking skills are trained according to Watson's critical thinking indicator (1980), namely interpretation, assumptions, deduction, and inference. The learning process in practicing critical thinking skills is trained using popular scientific books. The links between popular scientific books and indicators of critical thinking skills are presented in Table 1.

**Tabel 1:** The relation of Popular Scientific Book with the Critical Thinking Skills Indicator

Critical Thinking Indicator	The Critical Thinking Explanation	Critical Thinking Development	Popular Scientific Book Elements
CT-1 Interpretation	Being able to interpret the information from the discourse then formulate questions the right problem following the discourse	Students can make questions about the characteristics that must be observed with the Arecaceae family	There are statements in the introduction that are marked with certain. Data is obtained from commands in the students' worksheet Procedures section
CT-2 Assumption	Being able to identify facts to determine the solution of the problem and provide assumptions precisely from the solution	Students can determine the characteristics that must be observed in the Arecaceae family	There is a statement in the material description section. Data is obtained from commands in the students' worksheet Procedures section
CT-3 Deduction	Able to formulate solutions to problems from general to specific precisely and sequentially	Students are able to make observations on the characteristics of the Arecaceae family	There is a statement in the part of the description of material that is marked with a certain mark. Data is obtained from orders in the Observation section of the students' worksheet
CT-4 Inference	Draw conclusions from problem solutions appropriately	Students are able to make a classification of the observed Arecaceae family	There is a statement in the part of the description of material that is marked with a certain mark. Data is obtained from commands in the Discussion section of observations on students' worksheet

The research was carried out for 9 months (September 2018 - June 2019) at SMAN 2 Muara Teweh, North Barito Regency. Research subjects in the field test stage were 28 students. The effectiveness data were obtained from the results of critical thinking skills at the small group and test stage. Analysis of students' critical thinking skills data that is calculating the score of the answers in doing students' worksheet when doing the practicum. The results of critical thinking skills are analysed descriptively.

The method for calculating the percentage value is as follows:

$$\text{Percentage score} = \frac{\text{achieved score}}{\text{maximum score}} \times 100\%$$

The percentage value of critical thinking skills obtained from the calculation is then categorized according to the following Table 2:

**Table 2:** Percentage Category Critical Thinking Skills

Percentage (%)	Category
$81,25 < X \leq 100$	Very High
$71,5 < X \leq 81,25$	High
$62,5 < X \leq 71,5$	Medium
$43,75 < X \leq 62,5$	Low
$0 < X \leq 43,75$	Very Low

Adapted from Karim (2015).

### 3. Results and Discussion

The effectiveness of expectations and actual effectiveness is based on four indicators of students' critical thinking skills, namely 1) interpretation, 2) assumptions, 3) deduction, and 4) inference in learning using the developed popular scientific book.

#### 3.1 Interpretation Indicator

The results of the use of popular scientific book research that were developed on critical thinking skills interpretation indicators are presented in Table 3.

**Table 3:** Indicators of Expectation Interpretation and Actual Interpretation

No	Parameter	Expectation	Actual
1	Determining rattan habitus	16,7	16,7
2	Determining Characteristics of Rattan Flowers	10,0	13,4
3	Determining Characteristics of Rattan Fruits	13,3	15,0
4	Determining Characteristics of Rattan Leaves	16,7	15,0
5	Determining Characteristics of Rattan bars	16,7	16,7
6	Determining the Characteristics of Rattan Roots	16,7	16,7
<b>Total Score</b>		<b>90,0</b>	<b>96,7</b>

Source: Data processing results.

Table 3 shows the increase in critical thinking skills interpretation indicators. N-Gain achieved by 0.9 (high category).

#### 3.2 Assumption Indicator

The results of the use of popular scientific book research developed on critical thinking skills as an indicator of assumptions are presented in Table 4.

**Table 4:** Indicators of Expectation Assumptions & Actual Assumptions

No	Parameter	Expectation	Actual
1	Habitus	2,9	2,8
<b>Root :</b>			
2	Rooting system	2,9	3,0
3	Root color	2,9	3,0
<b>Bar :</b>			
4	Shape	2,7	2,9
5	Midrib	2,7	2,8
6	Segment length	2,3	2,5
7	Segmentation conditions	2,0	2,0
8	Internode cavity	2,3	2,6
9	Tendrill length	2,9	3,0
10	Lay down	1,4	2,6
11	Spread thorns	0,8	1,5
12	Thorn color	2,9	3,0
13	Thorn form	0,0	0,0
14	The color of the bar	3,0	3,0
<b>Leaves :</b>			
15	Type of leaves	2,9	3,0
16	Leaf's position	2,4	2,8
17	Leaf's form	2,4	2,4
18	Leaf's shape	2,1	2,3
19	The shape of the spines	2,1	2,8
20	The color of the spines	2,0	2,5
21	Leaf edge	2,7	2,8
22	P/L leaf	2,6	3,0
23	Leaf tip	2,6	2,7
24	Leaf texture	2,7	3,0
25	Leaf color	2,9	3,0
<b>Flower :</b>			
26	Flower's type	3,0	3,0
27	Flower's size	2,6	2,3
28	Flower's color	3,0	2,9
<b>Fruit :</b>			
29	The size of the fruit	2,6	2,4
30	Scale's size P/L	3,0	2,9
31	Fruit surface	3,0	2,7
32	Form	2,9	2,7
33	Color	3,0	3,0
<b>Total score</b>		<b>80,9</b>	<b>88,1</b>

**Source:** Data processing results.

Table 4 shows the increase in critical thinking skills as an indicator of assumptions. N-Gain achieved by 0.8 (high category).

### 3.3 Deduction Indicator

The results of the use of Popular Scientific Book research developed on critical thinking skills as an indicator of assumptions are presented in Table 5.

**Table 5:** Deduction Indicator Expectation & Actual Expectation

No	Parameter	Expectation	Actual
1	Kingdom	14,3	14,3
2	Phylum	13,3	14,3
3	Class	14,3	14,3
4	Order	11,3	14,3
5	Family	14,3	14,3
6	Genus	12,3	14,3
7	Species	14,3	14,3
<b>Total score</b>		<b>94,1</b>	<b>100,0</b>

**Source:** Data processing results.

Table 5 shows an increase in the critical thinking skills of indicators of deduction. N-Gain achieved by 1 (high category).

### 3.4 Inference Indicator

The results of the use of popular scientific book research developed on critical thinking skills as an indicator of assumptions are presented in Table 6.

**Table 6:** Inference Indicator Expectation & Actual Inference

No	Parameter	Expectation	Actual
1	Benefits	48,0	100,0
2	Threats	50,0	100,0
<b>Total score</b>		<b>98,0</b>	<b>100,0</b>

**Source:** Data processing results.

Table 6 shows the increase in critical thinking skills inference indicators. N-Gain achieved by 1 (high category).

The effectiveness of popular scientific book expectations and actual effectiveness in the four CBC indicators are presented in Table 7.

**Table 7:** The effectiveness of Popular Scientific Book in the Four Indicators of the CBC

No	CBC	Expectation		Actual	
		%	Category	%	Category
1	Interpretation	90,0	Very Good	96,7	Very Good
2	Assumption	80,9	Good	88,1	Very Good
3	Deduction	100,0	Very Good	100,0	Very Good
4	Inference	100,0	Very Good	100,0	Very Good

**Source:** Data processing results.

Based on the results of this study, inference can be made namely the critical thinking skills of students on the indicators of interpretation, assumptions, deduction, and inference reach very good categories using popular scientific book.

#### **4. Discussion**

The effectiveness of developed popular scientific book includes the effectiveness of expectations obtained from the Small Group and the actual effectiveness of the Field Test on four indicators of students' critical thinking skills, namely 1) interpretation, 2) assumptions, 3) deduction, and 4) inference in learning using the developed popular scientific book. Based on the results of the implementation, it can be stated briefly that the use of popular scientific book to study biodiversity, especially for rattan, tends to improve the critical thinking skills of high school students. The factors suspected of causing this are the characteristics of the popular scientific book developed as explained in the previous section. The role of popular scientific book in growing critical thinking skills of high school students in learning biodiversity, especially in rattan will be explained below.

##### **4.1 Interpretation Indicator**

The interpretation that is able to interpret information from the discourse and then formulate the right questions in accordance with the discourse. Interpretation indicators with high categories ( $N\text{-Gain} = 0.8$ ) prove that popular scientific book is effectively used to practice the critical thinking skills of interpretation indicators. The increase was caused by the characteristics of the developed popular scientific book, namely an attractive design, the complete presentation of the material in the popular scientific book accompanied by original pictures really helped students to find out information about the material being studied, so as to create an effective learning process. Popular scientific book with an attractive design causes students to pay attention to the message conveyed through the popular scientific book. This is what makes students wonder about what information can be obtained from the popular scientific book. These questions continue to grow until students read or study the material in popular scientific book. The emergence of questions caused by interesting designs that students can train and practice critical thinking skills. The material presented in full about the developed popular scientific book makes it easy for students to find the information needed when finding similar objects in their surroundings. In addition, popular scientific book is presented with colored illustrations. Color in the image is an important visual element to give the impression of an emphasis that can heighten the level of realism of the object or situation being described and create a certain emotional response to students. Learning through actual images will foster motivation to find out or study the plants that surround them (Hamalik, 1995). Therefore, color has the capacity to increase the chance of environmental stimulation to be properly coded, stored and retrieved.



## 4.2 Assumption Indicator

Assumptions are namely being able to identify facts to determine the solution of the problem and provide assumptions precisely from the solution. Indicator assumptions with high categories (N-Gain = 0.8) prove that popular scientific book is effectively used to improve the critical thinking skills of indicator assumptions. The increase was caused by the characteristics of popular scientific book that were developed, namely the presentation of complete material in the BIP accompanied by original pictures really helped students to dig up information about the material being studied. Presentation of complete material about rattan in the popular scientific book is a guide for students in conducting data collection with full accuracy. Accuracy of students in collecting data to answer the problems made previously will make accurate observations. The complete description of the material in the popular scientific book includes an explanation of concepts, definitions, procedures, examples, and exercises that can help students explore ideas or ideas, identify ideas, explain the characteristics of a concept and ideas, and can define. So, the completeness of the material can improve students' knowledge or cognitive when learning rattan material. This is supported by the opinion of Daryanto (2007) that understanding ability is based on the level of sensitivity and degree of absorption of the material.

Presentation of rattan native plants contained in popular scientific book will further enrich students' insights and knowledge, because students learn more accurately because it can optimize the potential of the five senses to communicate with these objects. So as to facilitate understanding, strengthen memory, can foster student interest and can provide a relationship between the content of subject matter with the real world. As stated by Hamalik (1995), that learning through actual images will foster regular and continuous thinking, to study more deeply the surrounding plants.

## 4.3 Deduction Indicator

The deduction is able to formulate solutions to problems from general to specific precisely and sequentially. Deduction indicators with high categories (N-Gain = 0.8) prove that popular scientific book is effectively used to improve the critical thinking skills of deduction indicators. The improvement was caused by the characteristics of popular scientific book that were developed, namely the complete description of the material in popular scientific book containing explanations of concepts, definitions, procedures, examples, and exercises that could help students explore ideas or ideas, identify ideas, explain the characteristics of a concept and ideas, and be able to define. So that the completeness of the material can improve students' knowledge or cognitive when learning rattan material. This is supported by the opinion of Daryanto (2007) that understanding ability is based on the level of sensitivity and degree of absorption of the material.

The increase was also thought to be caused by the characteristics of the developed popular scientific book, namely the existence of certain pages in the developed popular scientific book found statements to improve students' critical thinking skills and each

plant displayed presented the names of the regions, so that they were easily recognized and understood by students. The statements that must be made by students that are developed on certain pages in BIP will cause students to be involved in evaluating the information sources of information contained in the description of popular scientific book material that is developed to be explored more deeply. Students will tend to seek the truth by thinking openly and tolerant of new ideas they find in studying rattan. So that they can analyze the problem well and have a high curiosity. If critical thinking is developed, students will tend to seek the truth, think openly, be tolerant of new ideas, be able to analyze problems well and have high curiosity (Anderson, 2004).

Each plant displayed in the popular scientific book presented the names of the area that will foster students' desire to conduct interviews with the surrounding community found when students make observations in an area. This was confirmed by the results of researchers' interviews with students who received additional information not found in the popular scientific book about the benefits of these plants. Student activity to find out the true benefits and threats to rattan is an effort to improve the critical thinking skills of indicators of deduction. This is following the opinion of Kowiyah (2012) that efforts to improve critical thinking by increasing the quality of his thinking by handling skillfully the structures inherent in thought and applying intellectual standards to the results of data collection he did.

#### **4.4 Inference Indicator**

Inference is namely concluding solutions to problems precisely. Inference indicators with high categories ( $N\text{-Gain} = 0.8$ ) prove that popular scientific book is effectively used to improve the critical thinking skills of inference indicators. The increase was caused by the characteristics of the popular scientific book that was developed, namely a complete description of the material, examples, statements, questions or exercises by the material contained in the popular scientific book. The ability of students to practice critical thinking skills in making conclusions from the material is caused by the reasoning that sharpens the memory and the level of student understanding of the material that has been learned. The right way to train and develop critical thinking skills is assisted by a complete description of the material, examples, statements, questions or exercises by the material contained in the popular scientific book. This will direct students to use all the potential they have and direct them as decision making. The simplicity of popular scientific book presentation is made and with language that is not too standard makes it easy for students to remember and understand the material, thus helping students in concluding the material being studied. The right way to practice reasoning is the completeness of the material that encourages students to develop their concepts and knowledge as a whole (Darma, 2014).

Rattan plant classifications are presented coherently in the developed popular scientific book. This makes it easy for students to group the characteristics that lead to the making of classifications and be able to deduce accurately, clearly, and relevantly from what they know. Consistent with Wardoyo (2013), the formation of students'

thinking patterns can be done by incorporating rules that will determine orderly and compliant actions and behavior in various rules and regulations.

This was also revealed by several studies including Fitriansyah (2018) which stated that popular scientific books had been developed that had language that was easy to understand, had an attractive appearance, detailed material description, and could develop critical thinking skills that could train and develop students' critical thinking. Then it was reinforced by Utami (2017) that popular scientific books that use simple language that is easy to understand will facilitate students in understanding the contents of the material. Based on the overall N-Gain value, all of which are in the high category. After being converted as a whole, students' critical thinking skills have an average N-Gain value of 0.8 which includes high criteria, these results indicate that there is a high change in critical thinking skills between before and after learning by using popular scientific books developed. This illustrates the popular scientific book has been effectively implemented in learning. Increasing students' critical thinking skills is inseparable from the learning process. Therefore, it can be seen that differences in the final results of interpretation skills, assumptions, deductions, and student inference occur in accordance with the use of popular scientific books. Students' interpretations, assumptions, deductions and inference skills are high because during learning activities students make observations and answer students' worksheet very well.

Student involvement in the process of environmental education will enhance critical thinking skills so that the material is easily understood and recalled. That is, increasing critical thinking skills can improve students' cognitive abilities. Increasing students' cognitive abilities can improve Indonesia's educational rankings which are still low based on the mapping of The Learning Curve 2013. According to Ilaah & Yonata (2015), critical thinking can help students understand the material, and concepts can be remembered for a longer period because the concept was found by students.

## 5. Conclusion

Based on the findings it can be concluded that the popular scientific book developed was effectively used to improve critical thinking skills based on the results of expectations and actual effectiveness. Students' critical thinking skills on indicators of interpretation, assumptions, deduction, and inference reach very good categories using popular scientific book.

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