

Development of Creative Thinking Instruments for Environmental Change

¹Woro Tien Asrini Putri, ²Suci Kusuma Wardini, ³Mieke Miarsyah, ⁴Rizhal Hendi Ristanto

^{1,2,3,4}Pendidikan Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Jakarta, Jl. Rawa Mangun Muka Raya, Jakarta Timur, 13320, DKI Jakarta, Indonesia

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ABSTRACT

One of the skills that must be developed in the 21st century is creative thinking skills. Creative thinking skill that need to be developed because creative thinking skills are the ability to bring up new ideas and interesting thoughts in different situations. There are four aspects of creative thinking skills used in this study, namely: (1) fluency, (2) flexibility, (3) originality, (4) elaboration. The purpose of this research is to develop creative thinking instruments that are used to determine the level of student's creative thinking abilities. The method used in this research is R and D with the ADDIE model (Analyze, Design, Development, Implementation and Evaluation). The instrument consisted of 11 essay questions which were validated by 2 expert validators and validated on 31 class X high school students empirically who were selected by cluster random sampling and tested on 2 expert validators. In this study, the results obtained 10 valid questions and 1 invalid question with a reliability value of 0.86. Therefore, this creative thinking question instrument can be used as a measuring tool for student creativity. It is hoped that this research can be further developed through implementation by students.

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INTRODUCTION

In the 21st century, the development of science and technology occurs very rapidly and commences in various aspects of human life. This development creates challenges, both directly and indirectly, for human resources. Quality human resources can be obtained through quality education. Therefore,

improving the quality of education is an important factor in determining the success and progress of nation building (Istiyono, *et al.*, 2020). The Partnership for 21st Century Skill Trilling & Fadel (2009) states that 21st century skills focus on critical learning and innovation skills: critical thinking and problem solving, communication and collaboration, creativity and innovation. Thus, 21st century

education aims to provide students with provisions so that they can master all the skills needed in the development of this era. Creative thinking skills are therefore one of the skills that must be developed in students.

Creativity is the ability to think in new and unusual ways and produce unique problem solving (Marwiyah, *et al.*, 2015). Creative thinking is an important basis for empowering students' thinking skills (Songkram, 2015). Creativity, like problem solving, is a form of transfer because it involves applying known knowledge and skills in completely new situations (Ormrod, 2009). The quality of thinking and problem solving of each student is different in generating new ideas from different perspectives (Santi, 2019).

Learning activities which refer to problem solving are one of the effective methods to increase students' creativity (Silver, 1997), which provides a comprehensive picture that students' creative thinking abilities can be developed and utilized by using an activity-based and real-life problem-solving approach. By presenting problems in real life, there will be a more realistic picture of students' ability to respond to problems presented in a creative way. The more real the condition described, the more serious the students' efforts to solve the problem. Thus, real environmental problems that students want to solve become important (Joanna, *et al.*, 1994).

There are 4 characteristics of creative thinking that can be developed into 14 more specific characteristics, namely: 1) developing humor, (2) fluency, (3) flexibility, 4) originality, (5) elaboration, (6) self-concept, (7) experimenting and testing ideas, (8) learning from mistakes, (9) tolerance for ambiguity, (10) resourcefulness, 11) sensitive to problems, (12) synergy, (13) imagination, (14) synetic. Brookhart explained that there are several activities that can be done by students to increase creativity, including: (1) deeply recognizing basic knowledge and learning something new, (2) opening new

ideas, (3) and looking for material sources to develop new ideas (Istiyono, 2020).

Aspects of creative thinking can be used to assess a product of creativity and one's creative thinking ability. Product creativity is used to help assess creative thinking scientifically. The creativity of this product consists of 4 categories, among others: (1) fluency, namely the ability to generate many ideas and complete relevant answers and current thoughts smoothly; (2) flexibility, namely the ability to produce ideas or answers that are uniform but with different directions of thinking and able to change ways or approaches; (3) originality, namely the ability to provide answers that are unusual, different from others and rarely given to most people in general; (4) detail (elaboration), namely the ability to develop, add, enrich an idea or answer, detail the details and expand an idea or answer (Istiyono, *et al.*, 2020).

The purpose of this study was to develop a creative thinking test instrument for high school students on the subject of Environmental Change. It is expected that students are able to improve their creative thinking skills in solving a problem that occurs in the environment.

METHOD

This type of research is research and development. The research used the ADDIE model development model developed by Branch (2009). In this method there are 5 stages, namely (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. The research flow of the ADDIE model can be seen in Figure 1.

Analyze

At this stage, a needs analysis is carried out. So at this stage what is done is to analyze Basic Competencies and learning indicators that can be developed for the preparation of creative thinking instruments. The basic competencies and learning indicators chosen must be in accordance with the aspects of

creative thinking that will be developed in the test instrument.

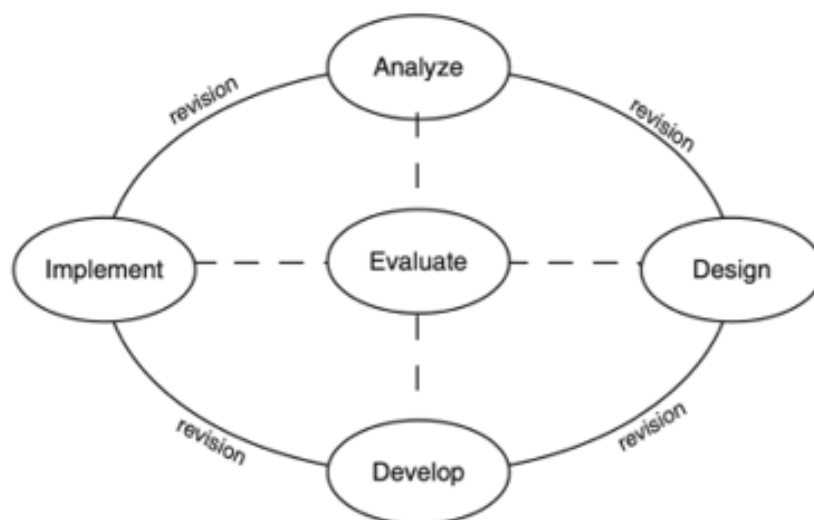


Figure 1. Development of the ADDIE model according to Branch (2009)

Design

At this stage, the desired performance verification process and appropriate testing methods are carried out. So what is done at this stage is to make a design for the development of creative thinking instruments. The designs made at this stage include: 1) compiling instrument grids, 2) compiling instrument assessment rubrics, 3) arranging student worksheet layouts. At this stage, the selection of testing methods on the creative thinking question instrument was also carried out. This instrument will be tested for validity, reliability test, discriminatory power test and level of difficulty test.

Development

At this stage, the product design realization process is carried out so that it becomes a development product and validates the product developed. So what is done at this stage is to compile a creative thinking test instrument in accordance with the design that has been made and then validated both construct validation and item validation. The instrument that has been developed is validated by 2 expert validators and tested on 31 students of class X IPA 2 SMAN 11 Bekasi.

Implementation

At this stage, the preparation of the learning environment is carried out and

involves students in the application of the instruments that have been developed. So what is done at this stage is to implement the creative thinking test instrument that has been developed for students.

Evaluation

At this stage, an assessment process of product quality and instructional processes is carried out, both before and after implementation. So what is done at this stage is to evaluate the product by testing the level of product effectiveness.

The data analysis techniques carried out in this research are:

1). Validity test

a. Expert Validity Test.

Calculating the validity score from the expert using the formula:

$$\text{Validity (V)} = \frac{\text{Total score 2 expert validation}}{\text{max total score}} \times 100 \%$$

(Fatmawati, 2016).

The results of the validity of the known percentage are then matched with the validity criteria as presented in Table 1.

Table 1. Criteria for Validity of Learning Devices

No	Score	Criteria
1	85.01 - 100%	Very Valid
2	70.01 – 85.00%	Quite Valid
3	50.01 – 70.00%	Less Valid
4	01.00 – 50,00%	Invalid

b. Item validity test

Calculating the validity score of the test results to students using the Pearson Product Moment (PPM) formula.

$$r_{xy} = \frac{n \cdot \sum XY - (\sum X) \cdot \sum Y}{\sqrt{\{n(\sum x^2) - (\sum x)^2\} \{n(\sum y^2) - (\sum y)^2\}}}$$

From the results of the calculation of the value of r_{xy} then compared with r table. The number of samples in this study were 31 students, so the value of r table at significance level = 0.05 $df = n - 2$ is 0.355. The criterion is that if $r_{xy} > r_{table}$, the question item is said to be valid. The following are the validity criteria in Table 2.

Table 2. Criteria for item validity

Koefisien validitas	Keterangan
0.00-0.355	Tidak Valid
≥ 0.355	Valid

2). Reliability test

Calculating the reliability value for essay questions using Cronbach's Alpha correlation. After obtaining the instrument reliability value, it is interpreted using the Guilford criteria. The criteria for the degree of reliability can be seen in Table 3.

Table 3. Criteria for the Degree of Reliability

Reliability Coefficient	Information
$0.90 < r_{11} \leq 1.00$	Very high
$0.70 < r_{11} \leq 0.90$	High
$0.40 < r_{11} \leq 0.70$	Currently
$0.20 < r_{11} \leq 0.40$	Low
$0.00 < r_{11} \leq 0.20$	Very low

RESULTS AND DISCUSSION

Analysis Stage

At this stage, an analysis of the basic competencies that will be selected as material for developing creative thinking questions is carried out by referring to the concept that creative thinking can be developed and utilized with problem solving methods in real life. As the problem presented becomes even more real, the picture of students' ability to respond to the problem presented in a creative way will

also become more realistic (Kitto, 1994). Therefore, material on environmental change was chosen with KD 3.11 - Analyzing data on environmental changes, their causes, and impacts on life and KD 4.11 - Formulating ideas for solving problems of environmental changes that occur in the surrounding environment. Environmental material is one of the biological concepts that can support the emergence of problem-solving skills (Fatmawati, 2016).

Design Stage

The results of design stage are in the form of a creative thinking test instrument table of specification and creative thinking test scoring guidelines. The developed table of specification refers to 4 aspects of creative thinking by Mitchell, Stueckle, & Wilkens in the research of Istiyono, *et al.*, (2008). The four aspects of creative thinking include (1) fluency, (2) flexibility; (3) authenticity (originality); (4) details (elaboration). This aspect of creative thinking is paired with learning indicators on environmental change material so as to produce a table of specification for preparing questions for creative thinking test instruments. This table of specifications was used as a reference in developing test instruments. The table of specification for the preparation of creative thinking questions made can be seen in Table 4 below.

Table 4. Creative Thinking Test Instrument Development Table of Specification

Aspect	Learning Indicators
1. Fluency	Concluding the results of a literature study on the impact of environmental damage on the causes, prevention and aspects of overcoming them.
a. generating ideas and solving relevant answers	Finding data about endurance for one's own survival.
b. smooth recent thinking	Describing the causes of environmental imbalance.
2. Flexibility	Menginventarisir data-data tentang jenis-jenis limbah serta pengaruhnya terhadap kesehatan dan perubahan lingkungan.
a. generate ideas or answers that are uniform but with different directions of thinking	Menyimpulkan hasil studi literatur tentang dampak kerusakan lingkungan penyebab, pencegahan serta penanggulangannya
b. able to change the way or approach	
3. Originality	Summarizing the results of a literature study on the impact of environmental damage, its causes, prevention and mitigation
a. give an unusual answer, different from the others and rarely given to most people	Inventory of data on types of waste and their effects on health and environmental change
4. Elaboration	Inventory of data on global warming, depletion of the ozone layer and the greenhouse effect, what causes it and how to prevent and deal with it.
a. developing, adding, enriching an idea or answer, elaborating the details	
b. expanding an idea or answer	

The questions were developed by referring to the specification table made in the form of an essay with 15 questions consisting of 11 numbers. The description test used for the development of the instrument in the form of descriptive questions, explanations, reasons or

other forms by using their own answers (Almuharomah & Mayasari, 2018). The scoring of this creative thinking instrument refers to the assessment rubric in Table 5 below.

Table 5. Rubric for Assessment of Creative Thinking Instruments

Aspect	Assessment criteria	Point
Fluency	Not answering or providing ideas that are not relevant to the problem	0
	Providing an idea that is not relevant to problem solving.	1
	Providing a relevant idea but the wrong answer.	2
	Providing more than one relevant idea but the wrong answer.	3
	Providing more than one relevant idea and correct and clear answer.	
	Providing more than one relevant idea but the answer is still wrong.	4
Flexibility	Providing more than one relevant idea and the answer is correct and clear.	
	Not answering or giving answers in one or more ways but all are wrong.	0
	Providing answer in only one way but wrong	1
	Providing answers in one way, the calculation process and the results are correct	2
	Providing answers in more than one way (various) but the results are wrong because there is an error in the calculation process	3
Originality	Providing answers in more than one way (various), the calculation process and the results are correct	4
	Not answering or giving the wrong answer.	0
	Providing answers in his own way but not understandable.	1
	Providing answers in his own way, the calculation process has been directed but not finished.	2
	Providing answers in his own way but there is an error in the calculation process so that the results are wrong.	3
Elaboration	Providing answers in their own way, the calculation process and the results are correct.	4
	Not answering or giving the wrong answer	0
	The answer is wrong and not accompanied by details.	1
	The answer is wrong, but it is accompanied by details in parentheses.	2
	The answer is wrong, but it is accompanied by details.	3
Providing correct and detailed answer.	4	

Development Stage

At this stage, the development of creative thinking questions instrument is carried out by referring to the table of specification. The

examples of questions that we developed can be seen in Table 6.

Table 6. Examples of Creative Thinking Test Instrument Development Questions

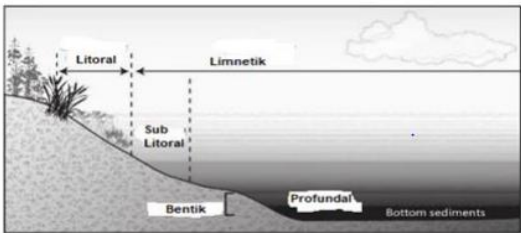
Aspects of Creative Thinking	Learning Indicators	Question Number	Example of Question
Flexibility <ul style="list-style-type: none"> produce ideas or answers that are uniform but the direction of thinking is different able to change the way or approach 	Inventory of data on types of waste and their effects on health and environmental change	2	Look at the picture below!  <p style="text-align: center;">Gambar Pembagian zona di ekosistem laut</p> <p>In the picture of the division of the lake ecosystem zone above, the limnetic zone is an area that is far from the edge of the lake where light can still penetrate. In this zone, phytoplanktons and photosynthetic plants provide food for zooplankton, fish, and other animals. However, as the population increases and the waste generated, this zone can also be polluted with various kinds of plastic waste. Predict what will happen if this plastic waste pollution is not addressed immediately!</p>

Table 7. Calculation Results of Instrument Validation and Reliability

Validity		Question Number	Reliability	
r_{xy}	Criteria		r_{11}	Level
0.694	Valid	1	0.87	Reliable
0.434	Valid	2		
0.839	Valid	3a		
0.399	Valid	3b		
0.614	Valid	4		
0.175	Invalid	5		
0.616	Valid	6		
0.533	valid	7a		
0.711	valid	7b		
0.842	valid	7c		
0.657	Valid	8a		
0.624	Valid	8b		
0.768	Valid	9		
0.410	Valid	10		
0.637	Valid	11		

Notes : r table (5%) = 0.3550, $dn = 31-2 = 29$

The questions that have been developed are 15 items arranged in 11 questions. These questions were then validated by 2 expert validators, who proceeded to give some suggestions and input regarding the instrument to be tested. The score of the expert validator is 91.67% with very valid criteria. Suggestions and inputs from expert validators can be seen in Table 7.

After the instrument is declared to meet content validity and advance validity, the questions will be revised according to the directions and suggestions of 2 validators, then tested on 31 class X students of SMAN 11 Bekasi City. From the test data of the test questions and the calculation of the validity using the Pearson Product Moment (PPM) formula and the reliability of the test, Cronbach Alpha analysis was used. The calculation results obtained that the test validity and test reliability are presented in Table 7.

From the experimental data, it can be seen that the value of r_{xy} for each item is greater than r_{tab} . This shows that 14 items of the creative thinking ability test are declared valid, and 1 question is declared invalid. Meanwhile, from the results of the reliability calculation, the reliability value is $r_{11} = 0.87$. This shows that the question instrument is said to be reliable.

The results of developing creative thinking instruments can be seen from the level of difficulty and differentiating power of the questions. The difficulty level of the questions is expressed through the difficulty index obtained from the calculation of the average score of the question items compared to the maximum score for each item of the question. It can be seen in Table 8 that of the 15 items developed, there is 1 easy question item and 14 difficult question items. After validation of the validity of the items, difficult questions can be used to train the abilities of students who have a good level of intelligence. Thus, of the 15 item questions, 14 items were declared feasible or usable, 1 was declared feasible or could be used but had to be corrected because it was invalid. Items with easy criteria must be

corrected and invalid, which is number 1 in the Fluency aspect (Susiningrum, 2018).

Table 8. Difficulty Level

No	Difficulty Level (P)	Criteria
1	0.78	Easy
2	0.06	Difficult
3	0.06	Difficult
4	0.06	Difficult
5	0.06	Difficult
6	0.06	Difficult
7	0.06	Difficult
8	0.03	Difficult
9	0.06	Difficult
10	0.04	Difficult
11	0.04	Difficult
12	0.04	Difficult
13	0.04	Difficult
14	0.04	Difficult
15	0.06	Difficult

The discriminating power of the question is determined by the differentiating power coefficient. Based on Table 9 of the test results, there is 1 item item with poor differentiating criteria and 14 item items with good criteria. Therefore, it can be said that the 15 item questions are acceptable and suitable for use. This is because the higher the differentiating power coefficient of a question item, the more capable the item is to distinguish between students who master competence and students who lack competence. Based on the explanation, a good question is one that has a fairly high differentiating coefficient. The assessment instrument developed was tested on thirty-one students, so that the number of students in the upper and lower class groups were eight students each. Appropriate item items are items that meet the empirical eligibility criteria, namely reliability, item validity, level of difficulty and discriminatory power. This is because the criteria influence each other, so if one of the criteria is not met by an item, then the item cannot be said to be feasible (Susiningrum, 2018).

Table 9. Different Power

No	Different Power (D)	Criteria
1	0.20	Revised
2	0.01	Accepted
3	0.02	Accepted
4	0.01	Accepted
5	0.01	Accepted
6	0.00	Accepted
7	0.01	Accepted
8	0.01	Accepted
9	0.02	Accepted
10	0.02	Accepted
11	0.02	Accepted
12	0.01	Accepted
13	0.02	Accepted
14	0.01	Accepted
15	0.02	Accepted

CONCLUSION

The ability to think creatively is supported by students' internal factors, because students who get high creative thinking test scores are also those who excel in learning biology well in their class. Creative achievement is supported by three prerequisites, namely adequate intellectual ability, motivation and intelligence. The product of this research is a table of specifications, questions and rubrics for the assessment test description. Of the 15 questions, 14 questions are valid and 1 question is invalid. In terms of difficulty level, there are 14 items that are difficult and 1 item that is easy, while in terms of differentiating power there are 1 question that must be corrected and 14 questions that are accepted. However, this research still needs to be developed and continued to the next stage.

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