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Instrument Test Design of Scientific Creativity in Ecosystem Topics based on Hu & Adey

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Abstract. The test instrument for measuring creativity has been widely developed but is still often found difficulty in terms of its preparation. The purpose of this research is to develop an instrument of test that use for scientific creativity assessment for senior high school student in ecosystem material. The instrument of test are developed by analyzing, adapting, and modifying from instrument of test that developed by Hu & Adey (2002). The research method use method of instructional research and development with 4D model restricted on 2D stage (define and design). Seven questions are developed by modifying and inserting ecosystem material generally and the coastal ecosystem specifically. The questions are developed into semi-open question that allows students to give answers as much as possible but still directed. Through the define and design stage, a scientific creativity test instrument for high school students has been developed in the ecosystem material based on instrument of scientific creativity test by Hu & Adey.

Keywords: creativity, scientific creativity, instrument test by Hu & Adey, ecosystem

INTRODUCTION

Creativity is one of the human capabilities that must have in facing the globalization era and evolutionary changes in all aspects of life nowadays [1]. Creativity is one of the aspects that can determine the development and progress of a nation in the future [2]. The creative individual is someone who is able to develop ideas in an original, useful and different from others or something new and unusual [3]. Creativity related to innovation, because creativity is the basis for innovative thinking that is used to create useful solutions to solve problem in the future [4].

Indonesia is one of the countries that have included creative ability as one of the aspects that must be owned by every citizen arranged in the learning curriculum. This means that, creative humans are one of the things that must be prepared from as early as possible to face the flow of globalization [5] and

> "….various issues related to environmental issues, advances in technology and information, the rise of creative and cultural industries, and the development of education at the international level" [6].

Creativity has 3 important aspects that become the main characteristic of creative itself. Aspects of creativity according to [7] include flexibility, fluency, and originality. Flexibility is an ability to exit or be different from previous "attitudes". Fluency is the ability to generate some number of original ideas, and then the originality can be interpreted to something new or rare and unheard of [8].

The scope of creativity (according to Rhodes's approach) is divided into four categories that include creative people, creative products, creative processes, and creative environments [1]. Those, the components related to the creativity that is owned by someone. Each individual has a different level of creativity and one of the tasks of a teacher is to be able to create creative learning to encourage the creativity of the students to become a more creative individual [9, 10]. Therefore, it is necessary to develop a measuring tool that is able to measure the creativity possessed by each different individual and in this study focused on the scientific measurement of scientific creativity.

The test instrument for measuring creativity has been widely developed so far, but the instruments developed still often have difficulty in its use. Some of the test instruments used to measure creativity in some domains are like the Creative Think-Divergent Production (TCT-DP) Test, Torrance Test of Creative Thinking (TTCT), Creative Reasoning Test (CRT), Creativity Style Questionnaire (CSQ), Creativity Checklist (CCL) [11, 17]. The test instrument measures the different domain of creativity. This research will be focused on the development of test instruments to measure the domain of scientific creativity.

.Scientific creativity is a different kind of creativity with creativity in general. Scientific creativity combines interconnected science and creativity with one another. Scientific creativity is the ability to use knowledge and skills (creative people) to produce an original creative product that has an individual or social value through the creative process [8]. In line with Liu & Lin [9] that scientific creativity according to Torrance's elaboration focused on aspects of knowledge, intellectual ability, personality and motivation, and environment. This notion of scientific creativity can be supported by several hypotheses that illustrate the structure of scientific creativity itself: "…...

a. Scientific creativity is different from other creativity since it is concerned with creative science experiments, creative scientific problem finding and solving, and creative science activity
b. Scientific creativity is a kind of ability. The structure of scientific creativity itself does not include non-intellectual factors, although non-intellectual factors may influence scientific creativity
c. Scientific creativity must depend on scientific knowledge and skills
d. Scientific creativity should be a combination of static structure and developmental structure. The adolescent and the mature scientist have the same basic mental structure of scientific creativity but that of the latter is more developed
e. Creativity and analytical intelligence are two different factors of a singular function originating from mental ability [8]".

The correlation between creative and science are two interrelated things because when students want to solve problems and create new knowledge in science, this can be done in a creative way, so it appears the term of scientific creativity [11].

Existing test instruments cannot all be used to measure scientific creativity. Scientific creativity requires a special instrument that can be developed in accordance with the needs in terms of measurement of scientific creativity. Several test instruments have been developed such as the development of test instruments by Siew, Chong, and Chin [12], they developed a test instrument in measuring the scientific creativity of the Hu & Adey version for 5th graders with some modifications. Usta & Akkanat [13] developed an instrument to measure the scientific creativity of seventh grade students in Turkish elementary schools by combining the 3 other creative test instruments developed before. Karademir [14] developed an instrument to measure the correlation between scientific process skills and scientific creativity of gifted students in third and fifth grade

through project-based activity. Any process of activities to be performed to produce a product will be analyzed using size of scientific creativity suggested Hu & Adey.

Therefore, this study will be developed a test instrument that is expected to be used to measure the scientific creativity of high school students which will be inserted in ecosystem materials especially coastal ecosystems. Indicators on each number of questions to be developed will be tailored to the competencies to be achieved on the topic of the ecosystem in accordance with the existing curriculum of learning. The main design of the instrument development will be done in accordance with the design of scientific creativity test instrument by Hu & Adey.

METHODOLOGY

The method used in this research is adapted from the method of Research and Development of instructional 4D-model (define, design, development, and disseminate) to developing the instructional materials for training teachers by S. Thiagarajan [15]. The method is limited in 2D stage (define and design). In the *Define* stage an analysis is conducted to determine the learning objectives and the provision of material to be developed. In this study the material to be developed is about scientific creativity measured through instruments developed by Hu and Adey. The *Design* stage aims to design prototypes of learning tools that include the compilation of modified forms of questions, preparation of test standards and making initial designs in accordance with scientific creativity measurement instruments by Hu and Adey. Modifications of the questions are done by inserting the ecosystem material especially the coastal ecosystem as the problem used in the questions.

RESULT AND DISCUSSION

The test instrument for creativity has been done and studied for a long time, but the number examined, especially for secondary school level is still small. The initial activity is by conducting analysis and review of the creativity test instruments developed by Hu & Adey. The activity continues into the next stage in the form of development of test instruments in accordance with the adaptation and modification in accordance with the desired material. The following is the exposition of the development stage of scientific creativity test instrument on ecosystem material.

1. *Define* (Definition Stage)

   Hu & Adey [8] divides the criteria of scientific creativity into 3 major dimensions into the Scientific Creativity Structure Model (SCSM). These three dimensions are a major component of scientific creativity. The first dimension is the ***product dimension*** divided into 4 sub-dimensions namely *technical product*, *science knowledge*, *science phenomena*, *science problem*. The second dimension is the ***trait dimension*** that is divided into 3 sub-dimensions namely *fluency*, *flexibility* and *originality* that describe the main characteristics of creativity itself. The third dimension is the ***process dimension***. The process dimension describes how to go through to gain that creativity [12]. The process dimension is divided into two sub dimensions: *thinking* and *imagination*. The dimensions of scientific creativity developed by Hu and Adey can be seen in the following diagram:

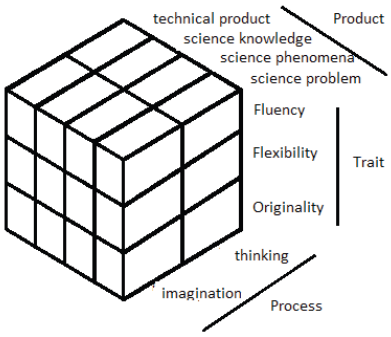

FIGURE 1. Three-Dimensional SCSM [12]

Each dimension will form a combination with a total of 24 cells. The total of 24 cells is a component of such scientific creativity. Each item will contain each dimension that is part of the scientific creativity. Not all dimensions can be included in the item, for example is the imagination with knowledge [8]. These two dimensions have contradictory meanings because the dimension of imagination is more inclined to the ability to think of something unreal or even impossible based on existing experience, while the dimension of knowledge rejects it [16]. In the beginning, Hu & Adey developed 9 items, but because of 2 items were considered difficult to be done, they were eliminated into 7 items, so that in this research will also be developed 7 kinds of questions [8].

Each item will represent the three dimensions of SCSM's scientific creativity. The following is a composite of each scientific creativity dimension in the Hu & Adey version of SCSM model for each item that can be summarized in a table adapted from research of Setyadin [11].

TABLE 1. The Dimensions of Scientific Creativity on Each Item

Section 1				Section 2			
Creativity Aspects	Item Number	Creativity Aspects	Item Number	Creativity Aspects	Item Number	Creativity Aspects	Item Number
Imagination Fluency Technical Product	3	Thinking Fluency Technical Product	3	Imagination Fluency Science Knowledge		Thinking Fluency Science Knowledge	1
Imagination Flexibility Technical Product	3 & 7	Thinking Flexibility Technical Product	3 & 7	Imagination Flexibility Science Knowledge		Thinking Flexibility Science Knowledge	1
Imagination Originality Technical Product	3 & 7	Thinking Originality Technical Product	3 & 7	Imagination Originality Science Knowledge		Thinking Originality Science Knowledge	1
Section 3				Section 4			
Creativity Aspects	Item Number	Creativity Aspects	Item Number	Creativity Aspects	Item Number	Creativity Aspects	Item Number
Imagination Fluency Science Phenomena	4	Thinking Fluency Science Phenomena		Imagination Fluency Science Problem	2	Thinking Fluency Science Problem	2
Imagination Flexibility Science Phenomena	4	Thinking Flexibility Science Phenomena	6	Imagination Flexibility Science Problem	2 & 5	Thinking Flexibility Science Problem	2 & 5

Imagination Originality Science Phenomena	4	Thinking Originality Science Phenomena	6	Imagination Originality Science Problem	2 & 5	Thinking Originality Science Problem	2 & 5

A total of 7 questions developed by Hu & Adey will be adapted and modified according to the desired material. Here is an example of item number 1 of Hu & Adey's version of the scientific creativity test instrument:

"Please write down as many as possible scientific uses as you can for a piece of glass. For example, make a test tube."

The item will be adapted into Indonesian and modified according to the desired material. The questions presented in the item on Hu & Adey's version are open-ended questions. Students are given the opportunity to provide the widest possible answer in accordance with their ability to think so that will bring up a variety of answers and not fixated on one answer only [18]. Sometimes the problem with the open-ended question type has a difficulty in the analysis process compared to the closed-ended question type [19]

Fluency score is obtained by giving point 1 for each correct answer, so the more correct answer then the higher score obtained. The flexibility score has the same way as the fluency score by giving each answer with a different approach with 1 point. Originality score is obtained by grouping students' answers according to the similarity level and then presented in percentage. If the level of similarity of students' answers to the overall answer is less than 5% then it will earn 2 points. 1 Points for student answers within the range of 5% -10% of the overall answer and 0 points if the student's answer is at a frequency greater than 10% of the overall answer.

This test is well suited to measure the level of students' scientific creativity, but if applied to measure scientific creativity in a particular subject matter in a lesson will give students difficulties. In a certain material in a learning student must have knowledge in accordance with the material in order to be able to answer questions given in accordance with the hypothesis in the structure of scientific creativity according to Hu & Adey on the third point.

2. *Design* (Development Stage)

A total of 7 questions will be developed based on the existing material in the ecosystem, especially the coastal ecosystem with the semi-open question model. Semi-open questions give students the opportunity to answer questions freely but still focus and stick to the desired answers. This is because there are several choices of answers used as examples of answers so that answers given by students will still be directed although given the freedom in answering [20].

Semi-open question questions make it easy to analyze the correct answers. Students are given the opportunity to provide alternative answers other than the example given. After analyzing the 7 pieces of questions developed by Hu & Adey on the scientific creativity test instrument, the following forms of adaptation and modification are as follows:

Item 1

Item number 1 is used to measure *fluency*, *flexibility*, and *originality* to train students' *scientific knowledge* about their *thinking* processes. Sounds item number 1 is as follows:

"Write down as many as possible the function of mangrove plants around the coastal ecosystem! For example are Oxygen producer"

Item 2

Item number 2 develops possible *scientific problems* and impacts that will be generated later. Problems are developed through a process of combination between *imagination* and *thinking*. Item number 2 use for measure the *fluency, flexibility,* and *originality*. Students are asked to provide questions that may cross his mind when the sandy land on the beach is dominated by clay due to landslides. Sounds of item number 2 are as follows:

"*If within the coastal ecosystem there is a landslide so that the original sandy beach area changes and is dominated by clay, what scientific question comes to your mind? Write down as many scientific questions as they relate to that fact! (Example: what are the new plants that will emerge and can live in the coastal ecosystem?*)"

Item 3

Item number 3 measures the *fluency, flexibility,* and *originality* associated with improving the quality of a *technical product* in order to maximize the benefits produced through the *thinking* and *imagination* process.

"Give as many inputs to the poster so that the message conveyed in the contents of the poster is really capable of supporting care to prevent abrasion!"

Students will be given an opportunity to show their creativity in the development of a product in the form of posters so that the message delivered in the poster is more fully communicated. Students will be asked to provide input to the contents of the poster creatively and as much as possible.

Item 4

To measure the dimensions of the students' *imagination* in terms of *scientific phenomena*, students are asked to write down the possibilities that would occur if on this earth the water cycle is interrupted or the number is reduced drastically. Students will imagine future possibilities about this phenomenon. *Fluency, flexibility* and *originality* scores will be calculated through a process of students' imagination of possible scientific phenomena in the future.

"What will happen if the water cycle process gets interrupted and even decreases in number on earth? Write the answer as much as possible!"

Item 5

To measure *fluency, flexibility,* and *originality* through the process of *thinking* and *imagination*, students are asked to provide solutions to overcome the problem of waste based on *scientific knowledge*. The more and more different from most of the solutions given, the fluency, flexibility, and originality scores are maximized.

"Write down as many ways or methods as possible so that the garbage that often accumulates on the beach can be overcome and does not disturb the balance of the coastal ecosystem itself!"

Item 6

The mmeasurement on item number 6 to be done is a measurement on the aspects of *flexibility* and *originality* in the ability to design an experimental method of existing *scientific phenomena* through the *thinking* process.

"How to know the water content on the beach is true salt water or contains salt? Write down as many ways, tools and procedures as it relates to the biotic components in the ecosystem!"

Item 7

To measure the dimensions of *technical product* through thinking and imagination, students are asked to provide their ideas in creating a waste processing tool design based on the *thinking* process and *imagination*. Students will describe the design of the tool simply by the name of the components and functions of the tool. In this item, the *originality* and *flexibility* aspect is emphasized in addition to the fluency aspects.

"Create a design of waste processing tools on the beach to make better condition in the coastal ecosystem!
Draw your design and write down the name and function of each component"

The calculation of scores on each item is done in accordance with the way of scoring done in the development of the instrument version of Hu & Adey. The fluency and flexibility score on each question is calculated by giving 1 point for each given answer. The originality score is given by giving 2 points for less than 5% answer similarity. 1 Points for student answers within the range of 5% -10% of the overall answer and 0 points if the student's answer is at a frequency greater than 10% of the overall answer.

At item number 6 & 7 has different scoring method. The flexibility score in item number 6 is obtained with a maximum score of 9 points for each way (3 points), tool (3 points), and procedure (3 points). The originality score is computed as before. If the answer is less than 5% it gets 4 points. 2 Points for student answers within the range of 5% -10% of the overall answer and 0 points if the student's answer is at a frequency greater than 10% of the overall answer The flexibility score at item number 7 is obtained by giving 3 points for each machine component and the correct function mentioned by the student. Originality score is obtained by giving 1-5 points according to the diversity and suitability of student answers in the form of pictures given [8].

CONCLUSION

Seven questions about ecosystem topics especially coastal ecosystems were developed based on the adaptation and modification of the scientific creativity test instrument developed by Hu & Adey. The developed question items refer to the SCSM model structure that contains all dimensions of scientific creativity such as product dimensions, trait dimensions, and process dimensions [8]. The question items are arranged in a semi-open question that allows students to give answers as much as possible but still directed [20].

This research is still limited to the ***design*** phase in the preparation of Hu & Adey based test instruments. Further research is expected to be continued into the ***development*** stage to validate by expert judgment, improved validation results, and small-scale trials to be continued in large-scale trials in ***disseminate*** stages. Researchers hope that the development of scientific creativity test instruments continue to be done in all branches of knowledge, especially in science in order to continue to have a correlation between the branches of science itself.

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