The implementation of skill of disruptive innovators to improve creativity through science learning on green biotechnology conceptions

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Abstract. The purpose of this study is to identify the development of creativity in the concept of green biotechnology. To simplify the learning process, this concept can be divided into two sub-concepts: 1) fermentation and 2) preservation. This research was conducted using pre-experimental method with the design of one pretest-posttest group. The respondents involved in this study were 82 Pre-service Elementary Teachers (PETs) of 5th graders at Universitas Sebelas Maret. The process of improving the PETs’ creativity was examined based on a normalized gain analysis of the pre-test and post-test values for all sub-concepts. The results showed that the creativity dramatically increased by 77% (high) in fluency; 57% (moderate) on flexibility, 46% (high) on originality and 40% (moderate) on elaboration. This result confirms that the implementation of SDI in science learning can improve the overall creativity at a moderate level.

1. Introduction

The 21st century demands a range of skills that PETs must master, so it is expected that education can prepare students to master these skills in order to become successful and professional teachers. The essential skills in the 21st century that need to be empowered in learning activities are for example critical thinking skills, problem solving, meta-cognition, communication skills, collaboration, information literacy and innovation, and creativity [1][2]. The achievement of 21st century skills can be done by updating the quality of learning, helping students develop participation, tailoring learning personalities, emphasizing project-based or problem-based learning, encouraging cooperation and communication, increasing student involvement and motivation, using appropriate learning tools, designing learning activities which are relevant to the real world, empowering meta-cognition, developing student-centred learning, and cultivating innovation and creativity [3][4][5].

Creativity is the skill PETs need to have [5][6]. Creativity allows PETs to express thoughts, feelings and aspirations, helps keep pace with the times and rapid technological advancement, and supports science and technological development [7][8][9]. Creative thinking skill is influenced by many factors, such as intelligence[10], influenced by social or environmental factors [11][12] so that the ability to think creatively can be trained [13][7]. Creativity can be both process and product [14]. From the description, it can be defined that the creative thinking skill is a person's ability to produce solutions to problems encountered in everyday life. There are four domains of creative thinking skills, namely fluency, flexibility, originality and elaboration [9][15].
Fluency is the ability to generate a number of ideas related to the task. It is related to the number of ideas obtained[16]. Flexibility is the ability to process information or objects in different ways. Being given the same stimulus leads to the production of different ideas and alternative considerations [16][17]. Originality is the ability to generate and to combine unusual or completely new thoughts or ideas [16][7]. Elaboration includes the ability to expand ideas and to organize ideas as well as to clarify and to articulate them. The four domains of creativity are affected by 25-30% as genetic factors, and the remainder is determined during life or environmental processes [18]. One of life processes or environments that can affect creativity is the learning process that can facilitate creative thinking and prepare for the 21st century [4].

In short, 21st century science learning has a central principle that student-centred, collaborative, contextual learning can facilitate critical, innovative and creative thinking skills integrated with society, one of which is science learning [16][19]. One of the concepts in Science learning that has characteristics integrated with the community and important to learn in the disruptive is the concept of green biotechnology. Biotechnology is one of the concepts included in the basic-science-concept course taught in PETs. Biotechnology is a field of bioscience applications and technologies relating to the practical application of living organisms or their sub-cellular components to the service and manufacturing industries as well as to environmental management [20][21][22]. Biotechnology also uses biological systems (biological processes) to obtain useful goods and services for human well-being. Green biotechnology is studied with sub focus using the concept of fermentation and food preservation [23]. Disruptive Era requires Science learning that can facilitate 21st century skills such as learning stages that implement SDI.

SDI is the ability to find something innovative and is a part of the behavior of the creative entrepreneur. The results of Dyer et al's study of 5500 entrepreneurs in 75 countries indicate that there are five skills that can be implemented in science learning so as to produce creative PETs: association, questioning, observation, experimenting and networking. The five SDIs are expected to enhance the creativity components (a) elaboration, (b) flexibility, (c) fluency and (d) originality. In Figure 1 we can see the relationship between the creativity components and SDI based on the definition and characteristics of the indicators and SDI.

Table 1. The roles the components of skill of disruptive innovators (SDI) to improve creativity indicators.

| SDI       | Creativity |
|-----------|------------|
| 1. Association | (a)(b)(c)  |
| 2. Asking    | (b)(c)     |
| 3. Observation| (a)(b)    |
| 4. Experiment | (a)(d)    |
| 5. Networking| (a)(b)(c) |

2. Method
The method utilized in this study is a pre-experimental research. The research design is one group pretest-posttest. In this study, PETs were given a pre-test in the form of questions adjusted based on the concepts of green biotechnology and creativity indicators. After that, they learnt using skill of disruptive innovators, and did the final test. The research design is shown in the Figure 1.

![Figure 1. One Group Pretest-Posttest Research Design.](image-url)
The data obtained in this study is a quantitative data of pre-test and post-test results in the form of students’ essay test scores. The population in this study were the PETs from elementary school education program in Universitas Sebelas Maret, consisting of twelve classes. The average number of students in each class was 40, while the sample was one of 5th grade students in the department with 120 PETs. However, the test results that could be analysed were only 82. The data processing in this research began by calculating pre-test and post-test score. Subsequently, the effect of implementing SDI on PETs’ creativity was determined by using normalized gain analysis. The development before and after SDI implementation was calculated by computing normalized gain equation \( <g> \) as follows.

\[
<g> = \frac{\text{Post-test score – Pre-test score}}{\text{Ideal score – Pre-test score}}
\]

Normalized gain criteria proposed by Hake [24] can be seen in Table 2.

| \(<g>\) | Criteria     |
|-------|-------------|
| ≥ 0.7 | High        |
| 0.3 < \(<g>\) < 0.7 | Moderate |
| < 0.3 | Low         |

3. Result and Discussion
Science learning using SDI was implemented in two sub-concepts that should be discussed: (1) the fermentation and (2) preservation. The results of the normalized gain analysis of each topic are presented in Table 3.

| Sub-concepts | Average scores | \(<g>\) | Criteria |
|--------------|----------------|--------|----------|
|              | Pre-test | Post-test |        |
| 1            | 1.30     | 3.52    | 0.60    | Moderate |
| 2            | 1.65     | 3.83    | 0.65    | Moderate |
| Overall      | 2.95     | 7.35    | 0.37    | Moderate |

Based on Table 3, there is a gradual increase in students’ creativity at each sub-concept with similar normalized gain scores that can be included in the moderate category. As found in the previous studies [18], learning using SDI can enhance students’ creativity. This is because the learning process using SDI can facilitate and stimulate creative thinking skills, so that the students will be more active during the learning process. The significant improvement occurred in a second sub-concept with N-Gain score is at 0.65. On one hand, the lowest increase occurred in the first sub-concept with N-Gain score is only 0.60. However, it is still in the moderate category [23].

In the first sub-concept, the improvement was relatively low because the students still adapted to the learning process employing SDI. Besides, they were not familiar with the types of questions given to measure the level of students’ creativity in the learning process.

The aspects of creativity observed in this research include four indicators; they are elaboration, flexibility, fluency, and originality. The development of each creativity indicator is presented in Table 4.
Table 4. Normalized gain recapitulation in each creativity indicator

| Indicators | Average scores | <g> | Criteria |
|------------|----------------|-----|----------|
|            | Pre-test       | Post-test |     |
| Elaboration| 0.95           | 1.77   | 0.40    | Moderate |
| Flexibility| 0.89           | 2.10   | 0.57    | Moderate |
| Fluency    | 1.11           | 2.56   | 0.77    | High     |
| Originality| 0.67           | 1.73   | 0.46    | Moderate |

The development of PETs' creativity was the same for every indicator except for the fluency indicator which scored the most significant increase with the N-Gain score (<g>) at 0.77. The lowest increase occurred in the elaboration indicator (0.4) and the originality (0.46) although the questions for both of these aspects (each of 3 questions) were in an easy and moderate difficulty level. However, based on the random interviews to some PETs and observations made during the learning process, PETs do not fully understand how to elaborate knowledge and generate new ideas in accordance with original ideas as the outcome of thinking itself as a part of creativity. The students mastered the skills of flexibility and fluency thinking to describe and provide ideas well. Thus, naturally the result of developing fluency is higher than that of other indicators. The average of the N-Gain of each indicator of creativity is presented in figure 2.

![Figure 2. The development of each creativity indicator](image)

4. Conclusion

Based on the research that has been done, it is concluded that the implementation of Skill of Disruptive Innovators (SDI) is able to increase PETs' creativity with normal gain score on every sub-concept on green biotechnology material. The development of creativity was also found in each indicator of creativity with the highest increase in fluency and flexibility indicators, while the lowest scores were on the indicators of originality and elaboration.

In practical terms, SDI can be used as an alternative to enhance PETs' creativity, but it is not able yet to improve the indicators of elaboration and originality well shown by the low gain score. Hence, to improve creativity, SDI can only be used as a method that supports the learning process. For further research, it would be better if the test is done by using an essay test to access more detailed information from the process of creativity in answering questions. In addition, modifications are required from SDI in order to further enhance creativity.

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