How to practice creative thinking skills through scaffolding on biotech content?

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Abstract. Biotechnology content is a more applicable field of science, so learners should be able to have creative thinking skills in applying concepts to problem solving. In this research, Scaffolding learning has been conducted, which is student form of concept development based on constructivism learning paradigm and students build creative thinking skill through the creation of biotechnology product ideas. The research design was R & D method. The subject of this research is a semester V biology education student at Wiralodra University. The instruments used are biotechnology creative thinking tests and program implementation observations. The data of creative thinking test was analyzed using inferential statistic, while the observation sheet used descriptive analysis. The result of this research is the result of students' creative thinking skill as well as description of the recommended shape and characteristics of the program, with the following results. The scaffolding learning program has a significant influence on students' creative thinking skill, and the program that trains creative thinking skill is built through two phases, namely phase 1 in concept building where students build their own knowledge, and phase 2 where students build thinking skills creatively through the creation of biotechnology product ideas.

1. Introduction
Biotechnology in the broad sense are some techniques that use living organisms or processes to create or modify products [1], in order to increase the use of plants and animals or to develop microorganisms for special purposes. Seeing this understanding, it can be said that this field is more applicative, so that learners in addition must have ability to master the basic concept must also be able to have the skills to apply the concept to solve the problem through biotechnology products.

Creative thinking skill is one of the most necessary skills in solving a problem. Problems identified and solutions provided must have a variety of answers as a guide to think divergently (creatively). Through creative thinking learners expected to connect the concepts of biotechnology to the opportunity to create a product. It is important to develop biotechnology learning that can provide learning support that makes learners can build mastery of concepts and skills of creative thinking as well.

Scaffolding is one of the strategies that provide such learning support. Scaffolding provides the basic skills for solving problems independently, where structured learning
support provided through program design [2]. The program itself includes the phases, teaching materials, media and lecturers who teach a role to raise the Zone of Proximal Development (ZPD) of learners to reach a level of potential development.

Knowledge is one of support for the growth of creativity [3], where before students trained to think creatively students must first have sufficient knowledge. Building knowledge or cognitive structure is the first and most important thing that must give to the learner, before they give a treatment to improve the skill of creative thinking. Based on preliminary study, scaffolding learning developed in two phases. Phase 1 in the form of concept development based on constructivism learning paradigm, where students build their own knowledge. Phase 2 students build creative thinking skills through the creation of biotechnology product ideas. How Scaffolding learning programs can enhance creative thinking if built through a gradual learning system? Therefore in this study will be studied how to train creative thinking skills through scaffolding On Biotech Content.

The biotechnology concept taught is industrial biotechnology. Industrial biotechnology is the application of biotechnology to meet industrial activity objectives, including manufacturing, bioenergy, and biomaterials. Also includes the use of cell and cell components such as organelles and enzymes to produce products. Industrial biotechnology applies the concept of fermentation to convert substrates into products. Fermentation is the process of energy production in cells in anaerobic state (without oxygen). Respiration is a process is energy production in anaerobic environment with no external electron acceptor. Sugar is a common ingredient in fermentation. The fermentation reaction in varies depending on the type of sugar used and the resulting product. Briefly, glucose (C₆H₁₂O₆) which is the simplest sugar, through fermentation will produce ethanol (2C₂H₅OH). This fermentation reaction carried out by yeast. Making tempe and tape (either glutinous tape or cassava or peuyeum tape) is a fermentation process that is well known in Indonesia. The fermentation process produces very useful compounds, from food to medicine.

2. Methods
This research is an implementation stage of R & D research method (research and development) adapted from Borg and Gall et al. [4]. The subject of this research is a semester V biology education student at Wiralodra Indramayu University who contracts biotechnology courses. The instruments used are biotechnology creative thinking tests and program implementation observations. The creative thinking data were analyzed using inferential statistics, while the data of program implementation observation analyzed descriptively qualitatively.

3. Result and Discussion

3.1. Recapitulation score average normalized gain inquiry skills test
The results of the pre-test and post-test of student creative thinking skill were obtained by the normalized gain values shown in Table 1:

| Test   | Xideal | Xmin | Xmax | X   | Gain <g> | Category |
|--------|--------|------|------|-----|----------|----------|
| Pre-test | 100    | 31   | 69   | 54.6| 0.32     | Medium   |
| Post-Test | 100   | 41   | 86   | 69.2|          |          |

The Data in Table 1 shows that student creative thinking skill is medium category. The maximum score gained by student 86 in post-test and 69 in pre-test. This result indicates that the scaffolding learning program could increase this skill moderately. The observation results in the phase during learning activities and mental activity shown in Table 2.
3.2. Observation results: description of the recommended form and characteristics of the program

Phase 1. Concept Development:

Table 2. Scaffolding in phase 1

| Observation Results: Activity During Learning |
|------------------------------------------------|
| 1. Reminding the term by The lecturer / concept Fermentation by microbes |
| 2. Determining Zone of Proximal Development (ZPD) | Pre-test, assess the initial knowledge, Grouping students according to their ZPD |
| 3. Giving Task Learning in the form of tiered problems related to learning materials |
| 4. Each group presenting the application of biotechnology in the industrial field along with the concept contained. Lecturers distribute Task book, after you review the articles, discuss the answers to the following questions: |
| a. Why food that fermented by microbes can increase its quality? |
| b. What substrate criteria are feasible for fermentation? |
| c. What is the criterion of environmental conditions for fermentation to run? |
| d. What are the characteristics of good raw materials for: bioethanol, biodiesel, biogas? |
| 5. Directing students with high ZPD to help students with low ZPD | answer the questions: Is there a potential SDL to be applied to biotechnology products? Write down your answer on task book. What product of biotechnology can be generating from microbial fermentation? |

Phase 2. Creative Thinking

Table 3. Scaffolding in phase 2

| Observation Results: Activity During Learning |
|------------------------------------------------|
| Students reunited with their group in a circle of discussions, elected discussion chairman and student preparing with Task book in his hands |
| 6. Encouraging Students to work and learn to solve problems independently in groups |
| • Students share their answers written in task book I during the first phase of the opportunity of local resources related to what biotechnology is in their environment. Students take turns expressing opportunities according to them, so they collect a lot of information about biotechnology opportunities that may be created |
| • Students select 3-5 biotechnology product ideas that may be created and are eligible to be sold through a collection of opportunities and information gathered from all group members, 3-5 biotechnology opportunities written on their own task book sheet |
| 7. Providing guidance, motivation, giving examples, keywords or other things that can provoke students towards self-reliance learning |
| • Students listen to the lecturer explanation for out-of-school assignments, i. e the students rethink about the most likely opportunities to work out of the 3-5 opportunities that have been written, then further what is the most likely product they can create from the opportunity (written in the task book II) |
| • Beyond the hours of learning, can through further discussions evaluate with others or think independently about which ideas are most likely to work with and which biotechnology products they can create and sell worth |
| 8. Summing up lessons and assigning tasks. |
| • Students write down the improved Idea and then elaborated in the form of design (task book III). |
| • Students listen to the lecturers’ explanation of the next task. The task is to prepare all the necessary tools and materials for the production of their biotechnology product. |
The example of product that have been made is as follows:

![Image](image_url)

**Figure 1.** Biotechnology Product: (a) Soyeah : Nata de coco from tofu waste, (b) Dawing Yoghurt, (c) Jellyfish oil, and (d) Poultry antibiotic

This scaffolding learning is to provide basic skills to solve a problem independently. It is provided by structured learning support through program design. The program itself includes the phases, teaching materials, media and lecturers who teach a role to raise the Zone of Proximal Development (ZPD) of learners to reach a level of potential development.

The preliminary study yielded data that some approaches proved to increasing knowledge and understanding a biotechnology such as the "service-learning" approach. That is learning by doing a project task related to biotechnology [5], the use of the GAME model or the Genomic Analogy Model for Educator [6] then assigned a group research project such as by assigning observations on the manufacture of biotechnology products [7], the use of the University Master class & School visit. Two approaches aimed at further improving students' motivation and activity in the search for a variety of learning resources [8], the use of student debate [9], the use of seminar methods (consisting of lectures from experts, reading related articles and hands-on demonstrations) [10], and scenario-based discussion[11].

Learning Phase 1 and 2 implemented for biotechnology lectures. Learning activities built on the paradigm of constructivism. Local resources selected as raw material for application of concept to product. This program provides an opportunity for learners to develop their motivation in building knowledge in accordance with their cognitive structure and using local resources in solving problems. Problem solving activities give student chance to use their imagination and try to realize their ideas [3]. This motivation is important to be developed [12]. A motivation or enthusiasm during learning has a positive effect on creativity. Problems solving activities make ideas until evaluate them assigned in a limited time. According [13] creative people will be able to create something in a very limited time.

The explanation above has explained how creative ideas formed, as for simple explanation and the link between phase, purpose, and scaffolding can be seen in Figure 2.
Vygotsky's constructivism emphasizes that cognitive change occurs only when understood conceptions processed through a process of imbalance in an attempt to use new information. The students given a large amount of help at an early stage of learning, then the student takes on an increasing responsibility as soon as he or she can do so. The assistance can be guidance, warning, encouragement, outlining problems into learning steps, giving examples or others so that children become independent. Children need scaffolding to go to the level of potential development (level of potential development). The implementation of scaffolding as part of the constructivism learning process needs to be well recognized. That scaffolding does not need to turn into interference that would eliminate the child learning opportunities to master the problem-solving process. Curriculum design, instructional instruction, and educational assessment process are the factors that have a great influence on the learning process of constructivism.

4. Conclusion
Based on the analysis of research data, it found that student creative thinking skill included medium category. There is a real impact of the scaffolding program on students' creative thinking skills. Scaffolding learning programs that train creative thinking skills is built through two phases, namely phase 1 in the form of concept building where students build their own knowledge, and phase 2 where students build creative thinking skills through the creation of biotechnology product ideas. In Phase 1 students or learners adaptation in learning through the process of assimilation and accommodation so that the formation of knowledge and new cognitive structure. In Phase 2 after students have new knowledge and cognitive structure, they apply the concept to a creative idea. Namely applying the formed cognitive scheme into an idea, and designing a biotechnology products made from local resources.

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