Students’ creative thinking skills in biology learning: fluency, flexibility, originality, and elaboration

S A Handayani1,2*, Y S Rahayu1 and R Agustini1
1Universitas Negeri Surabaya, Surabaya, Indonesia,
2SMPN 1 Blega, Bangkalan, Indonesia
Email*: sri17070966003@mhs.unesa.ac.id; chandraasri70@gmail.com

Abstract. This study aimed at analysing junior high school students’ creative thinking skills in biology learning. Creative thinking skills were measured by providing 5 open-ended essays with the indicators of fluency, flexibility, original thinking, and elaboration thinking. The present study used descriptive survey method to obtain quantitative data without special treatment. The research participants were 189 eight-grade students registered in nine public junior high schools in Bangkalan Regency. The results showed that the students’ creative thinking skills were still low at all indicators of creative thinking skills and included in an uncreative category, especially in detailing and producing innovations as well as troubleshooting problems using various approaches. However, their fluency got the best score compared to other indicators even though the classical passing grade was not achieved.

1. Introduction

The 21st century education requires students to ably compete in a global competition by developing survival skills and knowledge. The very rapid development of science is shown by the industrialization and global era that enforce people to perceive qualified skills to come along with science and technology development [1, 2]. Of many skills to survive during global competition, higher order thinking skills (HOTS) should be mastered by students regardless the education levels [3, 4]. HOTS refer to an ability to process current information or prior knowledge and change it to look for any possible solutions for today’s problems [5].

HOTS could be divided into several sub-skills namely critical thinking, creative thinking, and metacognitive. Those thinking skills focus on processes and student’s behaviour integrated to learn and understand the learning material [6]. Each of those skills conceives distinctive characteristics. According to [7], critical thinking is a thinking process that involves logical and reflective reasoning to produce decisions. Meanwhile, creative thinking can be trained by paying attention to intuition, animating imagination, revealing new possibilities, broadening perspectives, and generating unexpected ideas [8].

Creative thinking skills come to be part of learning process to help students reach better learning performances and become confident and responsible learners, therefore, student’s creative thinking skills should be habituated to develop creative solvency in overcoming problems [9]. The product of creative thinking skills is creativity, which is the result of cognitive skills and can be learned through teaching and learning processes [10]. Moreover, creativity is an important skill in solving problems and generating innovative ideas [11-13]. Successful creativity learning process requires a supportive learning environment that can encourage students to solve problems using a right concept [14].

Indonesian government has facilitated creative thinking skills in the national education. Based on the Law on National Education System Number 20 Year 2003, national education functions to develop abilities and shape the character and civilization of a nation with dignity to educate the nation's life, aiming to develop student’s potential to become human beings who believe and fear God Almighty,
have noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizen. Creative students are those who can think creatively so that they can produce creativity. Therefore, creative thinking skills should be a goal for all subjects including but not limited biology.

Recently, there have been those who still perceive Biology as a subject that needs more memorization [15], so that the typical learning is more into textbook-based method. This perspective should be elicited because biology is one of the sciences in which its characteristics have contributed to the development of technology. The objective of biology learning is related to real-world phenomena and life processes. Biology has four elements namely scientific processes, scientific products/knowledge, scientific attitudes, and technology [16]. Scientific process is defined as a scientific method or procedure to describe natural phenomena. Scientific product refers to facts, principles, laws, or theories. To make students understand both scientific process and product, the used learning methods and approaches must be adjusted to the objectives. The role of biology for future life is very strategic especially in preparing students to be critical, creative, and competitive. Moreover, students should be able to solve problems and dare to make decisions appropriately and immediately, thus, they can survive in a global era. Therefore, biology learning requires good understanding of biological concepts that emphasize creative thinking skills.

In facts, many students still answer numbers of questions based on the textbook or teacher’s explanation so that they are not habituated to give different answers. In addition, they are less invited to solve problems using various approaches. As a result, the learning atmosphere does not permeate creative thinking skills.

1.1 The essence of Biology learning
Biology is defined as the study of living things and life-related problems. It is a scientific discipline involved in the field of sciences (Physics, Chemistry, and Biology) that studies materials and energy related to living things and life processes. The essence of biology learning has in common with science learning. Science learning can be defined as a scientific process, attitude, and product [17] that should be carried out by scientific inquiry to foster thinking skills [18].

In science learning, students must carry out thinking activities and a set of processes to find new facts, concepts, and knowledge [19]. When will science learning contributes to the development of thinking skills? Learning natural phenomena begins from the cause-effect thinking relationship. Students must observe carefully the patterns of the relationships occurred from the learned subject and practice to determine what the cause and effect of the initial phenomenon. Learning science begins with the competence of observing both direct and indirect experience. Observing natural phenomena from experience directly affects somebody’s curiosity in which this activity can train students to formulate problems including what, why, and how the phenomena occur. Meanwhile, natural phenomena observed from indirect experience will train students' ability to predict the consequences of certain natural phenomena. Therefore, student still needs thinking skills in elevating individual’s science learning quality. Science process skills such as observing, interpreting, making hypotheses can be mastered accompanied by critical and creative thinking skills. Students are expected to critically find problems in life and seek the solutions creatively.

1.2. Creative Thinking Skills
Creative thinking is defined as one’s cognitive process to generate effective ideas in solving problems under certain aims and conditions [20 - 22]. It also can be meant as a positive action in stimulating brain function that can create proper learning style [23]. Lipman argues that the valuable characteristics of creative thinking skills include imagination description, independence, experimentation, holism, expression, self-transcendence, surprise, and creativity. Thus, creative thinking skills are essential cognitive aspects that must be included in the science teaching and learning process [24].

Creative thinking skills have four characteristics namely fluency, flexibility, originality, and elaboration. Fluency refers to one’s ability to produce many ideas, ways, suggestions, questions, ideas,
and alternative answers. Flexibility is an ability to generate ideas, answers, and questions that are varied from different perspectives. Originality is an ability to generate ideas to solve problems and create unique and distinctive thoughts. At last, elaboration refers to one’s ability to develop ideas along with the details [25][26].

Furthermore, Hu & Adey recommend a learning model to practice creative thinking skills that emphasizes several points such as: (a) determining an object for scientific purposes (unusual uses); (b) sensitivity level to scientific problems (problem finding) where students make as many problem formulations as possible to be investigated; (c) improving technical usage of a product (product improvement); (d) scientific imagination, (e) creative science problem solving; and (f) creatively experiment designing. This study will only measure the usefulness of an object, measure the level of sensitivity to scientific problems, increase the usefulness of a product, and convey scientific imagination.

Student activities that can produce creative thinking skills include those where there are: (1) exploration for the widest range of learning materials in accordance with the student’s will; (2) discovery student’s invented theories or their ways to solve problems; (3) making student groups to share opinions and knowledge; and (4) projects that must be completed along with conducting the problem solving activities [27].

Creativity and innovation will remain developed once students are given opportunities to think divergently. Students should be triggered to think out of the box, use new thinking ways, get the opportunity to present innovative ideas and solutions, ask unusual questions, and try to pose presumptive answers [28].

2. Method
This study used descriptive survey research design to obtain quantitative data because the researchers did not give treatment to the participants of the study. This study only revealed the measured variable and did not connect it with other variables. The survey was conducted on 189 eight-grade students registered at nine junior high schools in Bangkalan Regency in the 2018/2019 academic year.

The observed variables were creative thinking skills with four indicators. The data were collected using creative thinking skills test (CTST) in the form of five open-ended questions. Table 1 shows the five open-ended questions used in CTST.

| No. | Indicators                                                                 | Questions                                                                 | Creativity |
|-----|--------------------------------------------------------------------------|---------------------------------------------------------------------------|------------|
| 1   | Through observing the images of several leaf shapes, students could explain the benefits of the leaves with their own ideas (originality) in details (elaboration) from various aspects (flexibility) as much as possible (fluency). | Look at the following various plant leaves! Please describe the benefits of the leaves as much as possible from various aspects in details! | Unusual uses. |
| No. | Indicators                                                                 | Questions                                                                                                                                                                                                 | Creativity                                                                 |
|-----|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 2   | Through exploration of the natural phenomenon of rising groundwater to the stems of a cut banana plant, students could propose problem formulations from various aspects (*flexibility*) with their own ideas (*originality*) in detail (*elaboration*) as much as possible (*fluency*). | In afternoon, Mr. Amran went to the banana garden behind his house. He cut down banana tree trunks to get bananas that were ready for harvest. The next morning Pak Amran's son, Budi, was astonished because suddenly a large amount of clear water is found in the cut tree trunk. Write down the problem with your own ideas as much as possible from the event from various aspects and provide reasons beyond the answers! | Formulating Problems. (*problem finding*).                               |
| 3   | Through observing the image of the photosynthetic process in plants, students could explain the efforts or actions that could be undertaken so that the glucose produced increased in details from various aspects with their own ideas. | Look at the following picture of the photosynthesis process! The results of photosynthesis are starch and oxygen which are needed by other living things. Describe in detail with your own ideas various aspects of the efforts or actions you can take to increase the substances produced from the photosynthesis process! | Product improvement.                                                     |
| 4   | By observing the pictures of plant conditions during the dry season, students could predict in details the impact that will be experienced by plants and other living things as much as possible from various aspects. | Look at the following picture! Water is an important substance for living things, including plants. The picture above shows the condition of plants that lack water. If the situation lasts for a long time, predict with your own ideas what various aspects might occur because of the event? Describe your answer in details! | Scientific imagination.                                                 |
| 5   | By observing the pictures of transportation experiments on water henna plants, students could predict themselves and explain in detail the various aspects of events that will occur in the experiment as much as possible. | Look at the following pictures of water transportation experiments in plants. | Scientific imagination.                                                 |
Table 1 explains the five open-ended questions used in CTST. The numbers of questions were decided based on the times given to teach creative thinking skills questions (e.g. 80 minutes). The questions had been validated by three science subject teachers with good results. Creative thinking skills were measured from four indicators namely fluency, flexibility, originality, and elaboration.

The obtained quantitative data were analyzed descriptively. The students' creative thinking skills on each indicator would be calculated as follows: (1) fluency skills would be scored 1 for each appropriate response / idea / answer / response; (2) flexibility skill would be scored 1 for each answer from different aspects; (3) the ability to think originally would be scored 3 if the similar answers were less than 5%, 2 if the similarity was smaller than 15%, 1 if the similarity was less than 50%, and 0 if the similarity was greater than 50%; (4) elaboration would be scored 1 if each response was broken down into categories and 2 if the categories were broken down into sub-categories [25].

The obtained data were then calculated and categorized to figure out the level of each indicator. By adapting to [29], Table 2 shows the category of each indicator of creative thinking skills.

| Category   | fluency                          | flexibility                      | originality                    | elaboration                      |
|------------|----------------------------------|----------------------------------|--------------------------------|----------------------------------|
| High       | Writing down the answers appropriately with the total score of > 6 | Writing down answers from different aspects with > 3 answers | Having an original with score of > 4 | Having an elaboration with score > 4 |
| Moderate   | Writing down the answers appropriately with the total score of 3-6 | Writing down answers from different aspects with 2-3 answers | Having an original answer with score of 3-4 | Having an elaboration with score of 3-4 |
| Low        | Writing the answers appropriately with total score of < 3 | Writing down answers from different aspects with < 2 answers | Having an original answer with score of < 3 | Having an elaboration with score of < 3 |

Students were classically considered to be able to think creatively if they got the total scores of > 50% in moderate category. Afterwards, Table 3 shows the rating scale used to measure the level of creative thinking skills. This further helped the researchers figure out the level of students’ creative thinking skills.
Table 3. Students’ Creative Thinking Skills

| Level        | Characteristics                                                                 |
|--------------|----------------------------------------------------------------------------------|
| Level 4      | Students were able to demonstrate fluency, flexibility, originality and elaboration in solving problems. |
| (Very Creative) |                                                                                   |
| Level 3      | Students were able to show 3 out of 4 indicators of creative thinking skills (fluency, flexibility, originality, elaboration) in solving problems. |
| (Creative)   |                                                                                   |
| Level 2      | Students were able to show 2 out of 4 indicators of creative thinking skills (fluency, flexibility, originality, elaboration) in solving problems. |
| (Creative Enough) |                                                                                   |
| Level 1      | Students were able to show 1 of 4 indicators of creative thinking skills (fluency, flexibility, originality, elaboration) in solving problems. |
| (Less Creative) |                                                                                   |
| Level 0      | Students were not able to show the four indicators of creative thinking skills.     |
| (Not Creative) |                                                                                   |

3. Results and Discussion

Students’ creative thinking skills from nine public junior high schools in Bangkalan Regency were presented as follows:

Table 4. Junior High School Students’ Creative Thinking Skills Level in Biology Learning

| No. | Schools | VC\(^a\) | C\(^b\) | CE\(^c\) | LC\(^d\) | NC\(^e\) |
|-----|---------|----------|---------|----------|----------|----------|
| 1   | A       | 0.0      | 0.0     | 38.1     | 23.8     | 38.1     |
| 2   | B       | 0.0      | 14.3    | 28.6     | 38.1     | 33.3     |
| 3   | C       | 0.0      | 4.8     | 33.3     | 19.1     | 42.9     |
| 4   | D       | 0.0      | 0.0     | 14.3     | 19.1     | 66.67    |
| 5   | E       | 0.0      | 0.0     | 0.0      | 38.1     | 61.9     |
| 6   | F       | 0.0      | 0.0     | 33.3     | 42.86    | 23.8     |
| 7   | G       | 0.0      | 0.0     | 0.0      | 19.1     | 80.9     |
| 8   | H       | 0.0      | 0.0     | 0.0      | 28.6     | 71.4     |
| 9   | I       | 0.0      | 0.0     | 4.8      | 38.1     | 57.1     |

| Total |       | 0.0      | 0.0     | 152.4    | 266.7    | 476.2    |
| Average|       | 0.0      | 0.0     | 16.9     | 29.6     | 52.9     |

\(^a\)Very Creative  
\(^b\)Creative  
\(^c\)Creative Enough  
\(^d\)Less Creative  
\(^e\)Not Creative

In accordance with Table 4, the students’ creative thinking skills from nine public junior high schools in Bangkalan Regency were drawn as follows: 2 schools covering 4 levels of creative thinking skills (Creative, Creative Enough, Less Creative, Not Creative); 3 schools covering 3 levels of creative thinking skills (Creative Enough, Less Creative and Not Creative); and 4 Schools covering 2 levels of creative thinking skills (Less Creative and Not Creative). Figure 1 describes the level of creative thinking skills of junior high school students in biology learning.
Figure 1 shows the level of junior high school students’ creative thinking skills in biology learning. 51.91% of students were classified as not creative and 29.63% of them were less creative. 16.93% of them were creative enough and 2.12% of them were creative.

The level of students’ creative thinking skills was influenced by the achievement of creative thinking skills on each indicator. Table 5 conveys the results of students’ scores in each indicator of creative thinking skills.

Table 5. Scores of each indicator of students’ creative thinking skills.

| No | School | Fluency (%) | Flexibility (%) | Originality (%) | Elaboration (%) |
|----|--------|-------------|-----------------|-----------------|-----------------|
|    |        | L<sup>a</sup> M<sup>b</sup> H<sup>c</sup> | L<sup>a</sup> M<sup>b</sup> H<sup>c</sup> | L<sup>a</sup> M<sup>b</sup> H<sup>c</sup> | L<sup>a</sup> M<sup>b</sup> H<sup>c</sup> |
| 1  | A      | 38.1 61.9 0.0 | 71.4 28.6 0.0 | 90.5 9.5 0.0 | 100.0 0.0 0.0 |
| 2  | B      | 38.1 61.9 0.0 | 61.9 38.1 0.0 | 85.7 14.3 0.0 | 95.2 4.8 0.0 |
| 3  | C      | 42.9 57.1 0.0 | 85.7 4.8 0.0 | 95.2 4.8 0.0 | 66.7 33.3 0.0 |
| 4  | D      | 76.2 23.8 0.0 | 85.7 14.3 0.0 | 85.7 14.3 0.0 | 100.0 0.0 0.0 |
| 5  | E      | 71.4 28.6 0.0 | 100.0 0.0 0.0 | 100.0 0.0 0.0 | 90.5 9.5 0.0 |
| 6  | F      | 23.8 76.2 0.0 | 66.7 0.0 0.0 | 100.0 0.0 0.0 | 100.0 0.0 0.0 |
| 7  | G      | 90.5 9.5 0.0 | 100.0 0.0 0.0 | 90.5 9.5 0.0 | 100.0 0.0 0.0 |
| 8  | H      | 90.9 9.5 0.0 | 100.0 0.0 0.0 | 100.0 0.0 0.0 | 100.0 0.0 0.0 |
| 9  | I      | 71.4 28.6 0.0 | 100.0 0.0 0.0 | 85.7 14.3 0.0 | 100.0 0.0 0.0 |
| Total |     | 543 357 0.0 | 119 0.0 0.0 | 67 0.0 0.0 | 48 0.0 0.0 |
| Average |   | 60.3 39.7 0.0 | 13.2 0.0 0.0 | 7.4 0.0 0.0 | 5.3 0.0 0.0 |

<sup>a</sup>Low  
<sup>b</sup>Moderate  
<sup>c</sup>High

Table 5 shows that, out of 9 schools, only 3 schools reached the fluency indicator with score > 50% eventhough the other three indicators were not successfully achieved (flexibility, originality, and elaboration). Figure 2 shows the recapped data of students’ creative thinking skills.
Junior high school students' creative thinking skills in biology learning were still low. Some students only showed low and moderate level of creative thinking skills with different score ranges of each indicator and no students reached high level. In average, more than 50% of students were at low levels on all indicators of creative thinking skills, which meant that students had not been able to think fluently (fluency), overcome problems with various aspects / points of view (flexibility), think to produce new and unique things (originality), and think smoothly (fluency). However, the fluency indicator showed a better score of 39.7% compared to the three other indicators with the scores of 5.3% - 13.3%.

Referring to Table 4 and 5, the junior high school students' creative thinking skills in Bangkalan Regency were still low on all indicators. The low score of each indicator of creative thinking skills caused the low level of students' creative thinking skills. Most of the students were at less creative and not creative levels. This showed that most eight-grade students in Bangkalan Regency still did not have the skills to think creatively (82.5%). Some studies showed the low thinking skills had by junior high school students, undergraduate students, even master students [30]. Therefore, an effort to practice creative thinking skills was necessary so that students could be successful in life.

Low creative thinking skills was possible to happen because such skills had not been handled properly during the learning process, therefore, it was very important to integrate creative thinking skills in every subject [30]. Moreover, it happened due to enforcements of understanding concepts, principles, and theories, and no encouragement toward students' creative thinking skills [31]. Teacher’s perspective on the fact that creative thinking skills was an individual process became another cause [32]. Teacher might also not understand the right way to increase student’s creativity in the teaching and learning process [33]. At last, the learning approach used to develop students’ creative thinking skills was too difficult for students who had limited creativity, knowledge, and skills [34].

Teacher center also contributed to the low level of students’ creative thinking skills since the students were less actively involved in learning activities. This typical teaching technique was unidirectional so that students always depended on the teacher, tended to be passive during the learning process, and only listened to the talks, took notes, and memorized the concepts taught. The learning autonomy given to the students was not enough to develop their independence and creative thinking skills in which it resulted on inhibited ideas [14].

Enabling students to think creatively requires teacher’s serious efforts and challenging work. According to [35], student’s learning outcome was most influenced by teacher’s working performance (30%), student’s characteristics (49%), and other factors covering home, school, and friends (7%). The role of teacher was important in leading student’s better learning outcomes, problem solving skills, concept mastery, and thinking skills. Therefore, creative thinking skills need to be trained from an early age through consistent habituation. The skills would develop well with a good train since childhood through exploration, inquiry, discovery, and problem solving [27]. Creative thinking skills were important to be developed because it was not given from birth, but something that was acquired.
built, and honed from learning and practicing. A teacher not only transferred knowledge, but also promoted a learning environment that facilitated the development of creative and collaborative thinking skills. Student-centered learning model would provide access to students in exploring all the competencies they had to solve a problem in several ways. The results showed that student-centered learning and the involvement of creativity would support the creative process [36-37]. This learning approach required persistence, personal discipline, and attention, involving mental activities such as asking questions, considering latest information and unusual ideas with an open mind, making connections of dissimilar things, applying imagination to every situation that generated new and different ideas, and paying attention to intuition [38].

A teacher acted as a facilitator and a counselor. Teachers could train students' creative thinking skills by providing a learning environment that facilitated the competencies inside. Activities such as observation, experiments, and field trips could make students able to learn autonomously, understand subject materials easily, have a positive attitude towards science, and develop their creative thinking skills [39]. Giving open-ended questions was also an activity that could facilitate creative thinking skills because students needed to carry out deep exploration to find solutions of the problems. Students were asked to develop creative thinking skills to create high creativity in science learning [40]. The purpose of giving open-ended questions was to stimulate students' creative thinking patterns that indirectly contributed to the formation of creative, innovative, and problem-solving thinking skills [41]. The scaffolding process was essential in helping creative thinking skills and must be done by asking students about things related to the problems they had without overly controlling the students [42].

Creative thinking skills could be developed in science learning through several methods or approaches, for instance an inquiry learning model [43-45]. Cheng further argued that a problem solving-based model could be used to develop creative thinking skills such as through the implementation of demonstration, discussion, or question and answer session [46]. Therefore, it was necessary to transform science education from learning-by-memorizing (superficial learning model) to learning-to-thinking superficial (complex learning model).

4. Conclusion
Based on the results of the present study, the profile of creative thinking skills and learning autonomy of eight-grade students in Bangkalan Regency is still low. Teacher intervention is required to train students' creative thinking skills in biology learning. Teacher must be able to facilitate the availability of an environment that can develop students' creative thinking skills.

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