

## IDEA TESTING AND ANALOGY PREDICT CREATIVITY OF BIOLOGY STUDENTS IN ONLINE LEARNING

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### Abstract

Identifying factors affecting students' success is important. This is a study on creativity of biology students to solve their learning problem. The participants are biology students at Universitas Terbuka (UT), the only single mode distance learning university in Indonesia. conducting online tutorial in introductory biology. Descriptive and bivariate correlation statistics data are collected, including one dependent variable about improvement of problem-solving skill and six independent variables. The six independent variables are problem identification, information searching, idea generation, analogy, integrating different concepts, and idea testing. Demographic data are age, gender, and length of daily online activities. There are 73 students returned the survey with 23.4% response rate. Most students (more than 60%) agree to some extent in all the variables. There are different levels of agreement about the use of online tutorial regarding gender, age and length of daily online activities. There are only two out of six independent variables that have significant correlation (0.05 significance level, two-tailed) with improvement of problem-solving skill, which are analogy and idea testing.

**Keywords:** creativity, biology, problem-solving, distance learning, online learning

## 1 INTRODUCTION

A problem in online learning is low persistence of students. One reason for the problem is that they do not have self-directed learning (Ratnaningsih, 2007). It means that the students do not have awareness about their own goal and method of learning in an online learning environment. While the online course requires independent learning skill, they fail to develop the skill.

There are limited face-to-face communication between students and instructors. According to Moore & Kearsley (2012), a psychological gap exists between students and teacher in online learning, which is called transactional distance. The transactional distance affects students learning success. Students have to study without depending on direct contact with instructors.

Online courses provide different opinions on certain topic. In an online discussion, students have opportunity to discuss both supporting and opposing a topic (Eryilmaz, 2011). Depending on the students' motivation and skill, they can take advantage of the discussion or not. Those who can synthesize an understanding of the topic and get feedback from the discussion will get the benefit of learning in the online course.

There is a need to provide learning skills for biology students in online learning. Creativity may play an important role in online learning, since it enables students to learn to overcome the problem of learning without immediate feedback from teachers (Mittu-Wimsat, 2007). Therefore, a research in the creativity within the learning process is important to study how the students use the creativity to learn biology better.

The research may reveal if the students use all components of creativity, and whether there is a correlation between components of creativity in learning biology. The creativity in this research is more about creativity to learn biology in an online course. Hence, the research provides more knowledge about creative process in learning activity. The students with higher level of creativity can solve their learning problem (Kaufman, Cole & Baer, 2009; Zhang & Barthol, 2010). Therefore, one research question is about whether there is an improvement of their problem-solving skill after the online tutorial.

Most studies about creativity are conducted in other field outside biology. Mumford (2010), Dunbar (1997) did study of creativity in biology. However, their research is conducted on graduate students and experts of biology. This research is conducted on undergraduate college students from different majors taking introductory biology.

Lastly, the study of the online learning is conducted in a distance education environment. The online activities are also one opportunity of students to communicate with their instructors and other students. Since they do not have regular face-to-face meeting, they have to take advantage of the online activities to study and find out solution for their learning problems.

A definition of creativity by Begheto & Kaufman (2007) is that it is "the novel and personally meaningful interpretation of experiences, actions, and events" p73. According to Begheto &

Kaufman, this definition of creativity is called “mini-c” creativity. Unlike other definitions of creativity by Gruner & Csikzentmihalyi (2021) the definition of creativity put emphasis on creativity as an intrapersonal process. The definition of creativity from Begheto and Kaufman has similarity with personal creativity (Runco, 2004), that is more connected with transformational capacity of an individual.

The mini-c creativity is considered the most relevant with the field of education. Moran & John-Steiner (2003) pointed out that learning is related to creativity. A person is learning by a reorganization and interpretation process of knowledge. In other words, people learn by filtering and interpreting information. Therefore, this definition is used in the research, as it can explain the creative activities in the online courses.

Generating ideas is an important creative technique in learning biology. Mumford (2010) showed that generating ideas is important skill for problem solving in biology. This idea is supported by the concept of field and domain by Gruner & Csikszentmihalyi (2021). The study of Mumford showed that problem definition is an important part of generating ideas.

One learning strategy that uses creativity is analogy. Dunbar (1997) described that analogy was important for learning biology, although his research is mostly conducted among experts of biology. The process of analogy is connecting two things, the first is a base and the other one is a target. For example, a target is an idea that one tries to elaborate. Meanwhile, the base is a different idea that one use to elaborate the first idea. In the activity of analogy, the base is used as an example for explaining the target.

Integration of different ideas is a creative technique in biology. DeHaan (2009) suggested students need guidance about creativity. The creativity guidance includes how to become creative, how to integrate materials across different subjects, inquire of assumption, and reflect viewpoints and possibilities. In addition, DeHaan found out that divergent and convergent thinking are components of creativity. Creative students can catch different ideas and perspectives.

A different creative technique is idea testing. Lawson (2001) studied on how a curriculum was designed to improve students’ learning strategy. He used a method of testing ideas that have been generated by students. Any ideas are tested using different alternatives of implications. For example, in a genetic course, students were assigned to do a calculation of certain Mendelian Law of genetics. Then, they had to relate their ideas with various possibilities that

may take place. They have to answer with their arguments about how to apply their suggested idea into different alternative of situations. The result of the study showed that there was an increase in student's thinking skill.

Student creativity in biology is important, since the subject is difficult to learn. The causes of the difficulty are misconception, interrelation of various subjects, and the nature of the topic. For instance, the structure of chromosome in a cell nucleus and its role in genetic activities are not understood by students (Cimer, 2012; Kubika-Sebitosi, 2007). Many students do not have the skill that makes it difficult for them to learn genetics. Besides the topic, there are many other topics in biology that is difficult to learn. There are five topics that are the most difficult in Cimer (2012); those topics are matter cycles, endocrine system and hormone, aerobic respiration, cell division, and genetics.

Another reason of the difficulty to learn biology is misconception. Kubika-Sebitosi (2007) found that misconception in previous level of education is the cause of the difficulty. For example, some students do not know the role of gene in inheritance process. The students do not understand which traits that are inherited, and what traits that are not inherited.

Previous study shows a benefit of online learning toward student academic achievement. Porter, McKee, Adams, & Costello (2007) shows that there is a relationship between online learning and examination result. Therefore, the use of online learning may help students learn better in distance education, since the students in distance education do not have regular meeting with instructors and other students. The advancement of information technology bring about the more use of internet as a learning media. Nowadays, online learning becomes important part of distance education (Moore, 2010). In this paper, the focus of study is about online learning within distance education system.

Distance education is popular in many countries for its flexibility. Distance education allows people to study despite some obstacles like geographic barrier. People who have already job or family responsibility can still get a degree. Therefore, distance education is established in Indonesia, an archipelagic country with 14,000 islands and 250 million populations.

However, despite the flexibility of distance education and the use of online learning, there is still a problem of student retention in Indonesia. Students at UT have a low rate of retention. There are 86.4% students who could not finish their study. Even compared to other open universities, the rate is lower (Diki, 2015). Some reasons for the low retention in online learning

are unaware of learning goals and lack of understanding about method of online learning (Ratnaningsih,et.al, 2007).

The focus of the research is on biology students at Universitas Terbuka. The subject has been taught through distance education since 2001. According to Diki, (20107), there are different media for teaching biology in the distance education system. The media includes printed textbook, computer simulation, and online tutorial. In addition, some face-to-face learning activities are included in the course, which includes classroom tutorial and laboratory practices.

## **2 RESEARCH METHOD**

The research question is to find out whether students use creativity in solving their learning problem (Kaufman, Cole & Baer, 2009; Mittu-Wimsat, 2007). In this study, creativity consists of problem identification, information searching, idea generation, analogy, integrating different concepts, and idea testing (Dunbar, 1997: De Han, 2009, Mumford et. al., 2010; Lawson, 2001: Zhang & Bhartol, 2010). The effect of students using creativity is that they can solve problem better. Therefore, the students who use the six criteria of creativity feel that they can solve the problem after their participation in the online tutorial.

The hypothesis is that students use the six steps of creativity to study in the online tutorial. Meanwhile, the null hypothesis is that there is no significant use of creativity for online learning.

The research questions are:

- a. What is the descriptive statistics of biology students in the online course.
- b. What key variables are the most significantly correlated with students' ability to solve problem.

In addition to the questions about the students' perception about creativity, there are questions about demographic data of the students. The demographic data are age, gender, and frequency of daily online activities.

The participants of the research are students of introductory biology course in a distance learning university in Indonesia. As a part of the course, they take online tutorial. There are 312 students who were included in the survey. The reason to include all students is to gain as many students as possible, considering that they live in Indonesia and not easily contacted in person. The survey is sent through electronic survey and email. The response rate is 23.4 %.

The questionnaire is based on Zhang & Bhartol (2010) about creative process engagement, Dunbar (1997), Mumford (2010) and Lawson (2001). The key variables are grouped into seven criteria, which are problem solving, problem identification, information searching, idea generation, analogy, integrating different concepts, and idea testing. The survey is translated from English into Bahasa Indonesia, before it is sent to the participants.

There are two ways of sending the survey. The first is using electronics survey from Qualtrics. However, some participants prefer using the Word and/or PDF file that is sent by email. The participants are given reminder email once a week for a month after delivery of the questionnaire.

This study also includes inferential statistics about creativity. The bivariate correlation is calculated with Pearson  $r$ , level of significance of 0.05 and two-tailed. The aim of gathering the inferential statistics is to find out what factors that affect student's problem-solving skill.

#### Dependent variable

The dependent variable is the student's perception about whether they can solve problem better after the online tutorial. The variable is identified and coded as "I can solve problem better after the online tutorial". There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

#### Independent variables.

The independent variables are identified and coded as follows:

Problem identification (I consider the problem from multiple perspectives.): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Information searching (I search for information from various sources.): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Idea generation (I consider diverse sources of information in generating new ideas.): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Analogy (I connect new topic with previous topic that I know already): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Integrating different concepts (The online tutorial allows me to combine the concepts that I learn from textbook, classroom tutorial, and laboratory): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Idea testing (The online tutorial challenges my understanding of concepts): There are four Likert scales ranging from 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

In addition to the Likert scale multiple choices question, there are two open ended questions about student's description of creativity. The first open-ended question is “. Explain how creativity is needed in the online tutorial “. The second open-ended question is “Explain how the online tutorial support you to increase your creativity”.

### **3 RESULTS AND DISCUSSION**

The descriptive statistics are provided in table 1. Most students (44.8 %) spend 2-3 hours per day for online learning, while 37.9 % spends between 1 – 2 hours per day. The percentage of male students is 66.7 %, while female students are 33.3 %. Most students (38.6%) are between 21- 25 years. Meanwhile, 31.4% of the students are more than 30 years of age.

The statistics of key variables shows that 69.4 % of students agree to some extent that they can solve problem better after the online tutorial. There are 94.4% students who agree to some degree that they think about the problem from multiple perspectives. There are 97.2% students who agree that they consider diverse sources to generate new ideas. There are 76.3% of students who agree to some degree that they connect new topic with previous topic that they learn. There are 97.1% students who agree to some degree about searching information from multiple sources. There are 77.7% students who agree and strongly agree that the online tutorial allows them to combine the concepts that they learn from textbook, classroom tutorial, and laboratory. There are 87.3% of students who agree and strongly agree that the online activities challenge their understanding of concepts.

Table 1. Descriptive statistics for biology students (n= 69)

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
I can solve problem better after the online tutorial	72	1.00	4.00	2.7778	.67599
I consider the problem from multiple perspectives.	71	1.00	4.00	3.0704	.48768
I search for information from various sources	71	1.00	4.00	3.3521	.58794
I consider diverse sources of information in generating new ideas.	71	1.00	4.00	3.2254	.53977
I connect new topic with previous topic that I know already	72	2.00	4.00	2.8333	.53074
The online tutorial allows me to combine the concepts that I learn from textbook, classroom tutorial, and laboratory.	72	1.00	4.00	2.8333	.60514
The online tutorial challenges my understanding of concepts	71	2.00	4.00	3.0704	.56881
Valid N (listwise)	69				

In a comparison between male students and female students, 95.8% male students agree and strongly agree that the online tutorial challenges their understanding of concepts. However, 30% female students disagree to the statement, while 69.5% female students agree to some extent.

There is a different perception between male and female students about “The online tutorial allows me to combine the concepts that I learn from textbook, classroom tutorial, and laboratory”, 89.6% male students agree and strongly agree. Meanwhile, 30.4% female students disagree.

Another difference between students of different gender is in their perception about improvement in problem solving as a result of the online tutorial. Among the male students, 72% agree and strongly agree that they can solve problem better after the online tutorial. However, only 60.85 of female students agree and strongly agree.

Another comparison is conducted between students whose age is 21-25, and those whose age is > 30. There is a different level of whether they agree or disagree with the statement “I can solve problem better after the online tutorial. There are 60.8% students who agree and strongly agree among students who are between 21 and 25 years of age. However, there are 70.3% who agree in the group of student 30 years old.

Another difference between two different age groups is about the statement “I connect new topic with previous topic that I know already”. There are 83.3% students who agree to some extent with the statement in the group of the age between 21 and 25. However, there are 74.1% who agree and strongly agree in the group of those who are older than 30 years old.

There is a comparison of descriptive statistics between those who spend less than 1 hour per day and those who spend between 3 and 4 hour per day. One obvious difference is that the percentage of those who feel that they can solve problem better after the tutorial online is 50% among those who spend less than 1 hour a day. On the other hand, all students who spend between 3 and 4 hours a day feel that they can solve problem after the tutorial.

Lastly, the calculation of correlation between dependent and independent variables shows that there is a significant correlation between the variable “I connect new topic with previous topic that I know already” and “the online tutorial challenges my understanding of concepts”. The former statement that represents analogy is significant at .247 Pearson correlations at 0.05 levels, two-tailed. Meanwhile, the later statement that represents idea testing is significant at .374 Pearson correlations at 0.01 levels, two-tailed.

Table 2. Correlations of variables

		<b>Correlations</b>						
		I can solve problem better after the online tutorial	I consider the problem from multiple perspectives.	I search for information from various sources	I consider diverse sources of information in generating new ideas.	I connect new topic with previous topic that I know already	The online tutorial allows me to combine the concepts	The online tutorial challenges my understandi ng of concepts
I can solve problem better after the online tutorial	Pearson Correlation	1	-.038	.130	.140	.247*	.218	.374**
	Sig. (2- tailed)		.756	.281	.243	.038	.066	.001
	N	72	71	71	71	71	72	71
I consider the problem from multiple perspectiv es.	Pearson Correlation	-.038	1	.062	.536**	.321**	-.104	.033
	Sig. (2- tailed)	.756		.609	.000	.007	.390	.786
	N	71	71	71	71	70	71	70
I search for informatio n from various sources	Pearson Correlation	.130	.062	1	.242*	.373**	.328**	.395**
	Sig. (2- tailed)	.281	.609		.042	.001	.005	.001
	N	71	71	71	71	70	71	70
I consider diverse sources of informatio n in generating new ideas.	Pearson Correlation	.140	.536**	.242*	1	.230	-.013	.180
	Sig. (2- tailed)	.243	.000	.042		.055	.915	.137
	N	71	71	71	71	70	71	70
I connect new topic	Pearson Correlation	.247*	.321**	.373**	.230	1	.307**	.323**

with previous topic	Sig. (2-tailed)	.038	.007	.001	.055		.009	.006
	N	71	70	70	70	72	71	70
The online tutorial allows me to combine the concepts.	Pearson Correlation	.218	-.104	.328**	-.013	.307**	1	.293*
	Sig. (2-tailed)	.066	.390	.005	.915	.009		.013
	N	72	71	71	71	71	72	71
The online tutorial challenges my understanding of concepts	Pearson Correlation	.374**	.033	.395**	.180	.323**	.293*	1
	Sig. (2-tailed)	.001	.786	.001	.137	.006	.013	
	N	71	70	70	70	70	71	71

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

There are more than two third of students (69.4%) feel that the participation in online tutorial increases their problem-solving skill. The result shows that students can utilize the online tutorial to overcome their problem of learning the distance learning situation. As Ratnaningsih (2008) explained that students in the Indonesian distance learning university lack skills to study independently, the online tutorial can help them to learn better. It means that the online tutorial achieved the intended aim to support students.

The improvement of their problem-solving skill is part of the creativity. According to the definition of creativity from Beghetto & Kaufmann (2007) and Gruner & Csikzentmihalyi (2021), the improvement of students' problem-solving skill is parallel with their creativity. The problem solving skill allows the biology students to solve their learning problem (Kaufman, Cole, Baer, 2009; Mittu-Wimsat, 2007). Since the students of distance education do not have regular face-to-face meeting with the instructor, the creativity to take advantage of online tutorial is important for their learning success.

The improvement of students' problem-solving skill is a benefit of online tutorial as a part of online learning activities. This is supported by previous study of Pearce (2013) and Porter, McKee, Adams, & Costello (2007). It can help students to solve the difficulties of learning biology (Cimer, 2012; Kubika-Sebitosi, 2007).

The use of online tutorial broadens students' perspectives. There are 94.4% students who agree to some degree that they consider the problem from multiple perspectives. The benefit of broadening students' perspectives is that students will have richer resources to solve their learning problem. Guilford (1960) suggested divergent thinking as component of creativity.

The study shows evidence that information searching is a part of biology students learning. In addition, most students search for information from multiple sources. This information searching is supported by internet that provides students with almost unlimited information.

Idea generation is also conducted by students when they learn biology. There are more than ninety percent of students who agree that they consider diverse sources to generate new ideas. Mumford (2010) study showed similar result with this study.

The students use analogy as predicted by Dunbar (1997). More than three quarter of students agree or disagree with using analogy. They connect new topic with previous topic that they know already. Since one of the difficulties in learning biology is caused by interrelation of various topics in biology (Cimer, 2002), the creative technique is important.

Integration of different concept is one of the biology students' activities. Ninety five percent students agree or strongly agree with the idea that online tutorial allows them to combine the concepts that they learn from textbook, classroom tutorial, and laboratory. Integration of different concepts is suggested by Moran & John-Steiner (2003) as an example of creativity. Besides, the skill of integrating different concept is one of the required skills to overcome difficulty in learning biology (Cimer, 2012; Kubika-Sebitosi, 2007). Therefore, the result shows that the skill is necessary for biology students.

In addition, idea testing is also another activity of the biology students. There are more than four fifth of students who agree and strongly agree that the online activities challenge their understanding of concepts. According to Lawson (2001), idea testing is one of the creative techniques in biology college student. It means that the creative technique applies both in online as well as in classroom situation.

Differences exist between male and female are regarding the statement that the online tutorial challenges their understanding, and the statement that the online tutorial allows them to combine different concept. The skill in combining different concept is important for solving problem (Dunbar, 1997). The lack of the skill can affect their success in dealing with difficult topic in biology.

Age difference shows different perception about creativity. The older students feel that they become more capable in problem solving as a result of the online tutorial. However, there is a rather subtle difference in the process of analogy between the older and the younger students. There are larger numbers of younger students who are using analogy in their learning process compared to the older students.

The more obvious difference is between students with less daily online activities and those with more daily online activities. Since students with at least 3 hours of daily online activities are twice more capable in solving their problems, it is likely that they have better skill in using online tutorial for improving their study skills. This is related to the finding of Mittu-Wimsat (2007), that creativity support students in online learning.

On the other hand, the bivariate correlation shows only two dependent variables that have significant relationship with independent variables. Therefore, analogy and idea testing are two variables that are identified as important creativity skill to increase problem solving. The result shows that the study of DeHaan (2009) and Dunbar (1997) about analogy, and Lawson (2001) are supported by this study.

#### **4 CONCLUSION**

All the key variables are mostly agreed by the students. There are around two third of students feel that they can solve the problem better after the online tutorial. It means that most students are using the techniques in their learning process. There are differences in the key variables depending on age, daily online activities, and age.

There are only two out of six independent variables that are significantly correlated with improvement of problem solving, which are analogy and idea testing. However, the percentages of students who agree with each of the six independent variables are higher than the percentage of the dependent variables. It is likely that students do not understand the advantage of creativity in solving their learning problems, although they already use the skill at some extent.

### **Recommendations**

Students need training in creativity for problem solving. They also need training about skill in online learning. Students need introductory learning skill orientation prior to begin their online tutorial (DeHaan, 2009; Mittu-Wimsat, 2007). The learning skills include creativity for solving their study problem.

### **Limitations of Study**

There is a low response rate in the study. There are only 23.4% students responded. It is possible that students who replied are those who are familiar with the online tutorial or general online activities. However, as suggested by Ratnaningsih (2007), some students are still not familiar with learning in distance education, especially the online learning, although they are already familiar with using internet.

The use of self-reporting survey of creativity. It is affected by students' perception about creativity. There is no question about their perception regarding creativity. It is possible that they have different perception and definition about creativity. As there is various definition of creativity in the literature (Beghetto & Kaufmann, 2007; Gruner & Csikzentmihalyi, 2021), the differences of students' perception about creativity may affect the correlation between the independent variables and dependent variable.

### **Future Research**

There should be a study on students learning styles, since the learning styles may affect their creativity. According to Faranda et.al (2020) there are three learning styles, which are surface learning, where students focus on memorizing information, strategic learning where students focus on selecting ways to gain high grade, and deep learning where students focus on understanding the learning content. It is the deep learning that requires skill in understanding the content that may include creativity. In the future, there should be a study about relationship of the learning styles and creativity.

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