The Relationship between Creative Thinking, Collaboration, and Communication Skills in High School Level Biology Learning

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Abstract

Background: To succeed in biology learning, creative thinking, collaboration, and communication skills are required. Theoretically, there is a relationship between creative thinking, collaboration, and communication skills in biology learning, but empirical testing is required.

Objectives: The goal of this study was to look at the relationship between students' creative thinking, collaboration, and communication skills in biology learning.

Methods: This study was included in the correlational study, with the study population consisting of Kerinci Regency tenth-grade high school students. The research sample consisted of 488 students. Simple random sampling is used in the sampling technique. The data analysis techniques used the Spearman correlation test to test the relationship between the two variables and the multiple correlation test to test the relationship between the three variables.

Results: According to the findings of the study, there is a relationship between creative thinking skills, collaboration, and communication in learning. The conclusion is that creative thinking, collaboration, and communication skills are a form of association of various interconnected elements. In biology learning, one skill will later be used to build other skills.

***Keywords**:* creative thinking, collaboration, communication, biology learning

1. Introduction

Students in the twenty-first century require a variety of skills in order to compete at both the local and global levels. In an increasingly complex era of life, skills can be a beneficial provision (Sari, 2012). Skills can be taught and acquired (Tomer, 1981). Regular practice and organized repetition can help to develop skills (Guevara-Villalobos, 2014). Today's students must be proficient in several abilities, including communication, collaboration, and creative thinking (Akyeampong, 2014; Stanley, 2016).

Creative thinking, collaboration, and communication skills are required in all fields, particularly education and biology learning. Students studying biology are frequently confronted with problems that exist around them. This is why biology is essential and should be taught to students. According to German education standards from 2004, four main competency areas must be mastered when learning biology: content knowledge, communication, scientific inquiry, and decision-making (Schönborn & Bögeholz, 2009). Students in Indonesia must master three competencies: cognitive, affective, and psychomotor (Amrianto et al., 2020). Mastering these competencies is unquestionably possible with the assistance of appropriate skills such as creative thinking, collaboration, and communication skills.

Creative thinking skills are an important strategy for dealing with current and future challenges (Nikkola et al., 2020). More and more, it is understood that creative thinking is crucial to biology learning and students' success, both inside and outside of the classroom. The need for problem-solving solutions in today's increasingly complex society drives the importance of creative thinking skills (Reynolds et al., 2013). As a result, it is critical for educators to develop students' creative thinking skills, as this is the key ingredient for current innovation and future progress (Sun et al., 2020).

Creative thinking does not necessarily come from one's thoughts, but rather through the impact of others (Kim & Kim, 2019). The majority of the time, collaborative problem-solving is more effective than individual performance while working individually (Cole et al., 2018). Collaboration abilities can have an impact on a student's creative thinking (Kim & Kim, 2019). Students must be taught how to collaborate. In everyday life, students will be required to collaborate. Later on, students will work and collaborate with others (Stanley, 2016). As a result, it is critical to developing students' collaboration skills.

Collaboration skills are intimately connected to communication activities. Oral communication is the foundation for fostering student collaborative abilities (Spies & Xu, 2018). Humans' most significant element for adapting to their surroundings is communication. Through communication activities, students may express, exchange, and evaluate thoughts and ideas (Ozkan et al., 2014). According to Laar et al. (2020), research on collaboration and communication skills is urgently needed in the current era.

In June 2022, preliminary research on the issue of creative thinking skills, collaboration, and communication in biology learning was undertaken to utilize bibliometric analysis. According to early research employing bibliometric analysis on the Google Scholar database, it is known that 1) a lot of research has been conducted on creative thinking skills in biology learning, as seen by the enormous circle on the term "creative thinking skills" and the presence of a connecting line with the keyword "biology learning."; 2) The circle for the keywords "collaboration skills" and "communication skills" is smaller than the circle for the keywords "creative thinking skills," indicating that research on collaboration and communication skills in biology learning is still less common than research on creative thinking skills (Appendix 1). According to bibliometric research, prior research relating two variables is still very uncommon, confined to the relationship between collaboration and communication skills, and even for three variables at once it has never been done.

2. Objectives

The previously discussed theoretical evidence suggests that creative thinking, collaboration, and communication skills are mutually beneficial and important to learn (Kim & Kim, 2019; Spies & Xu, 2018), particularly in biology learning. However, relevant articles that explain empirical evidence and demonstrate that the three abilities are connected in biology learning are still required. As a result, the purpose of this research was to look at the association between creative thinking, collaboration, and communication skills in biology learning as actual proof that these three variables are related.

3. Methods

Type of Research

This is known as correlational research. The research took place in Kerinci Regency, Jambi, Indonesia, from January to March 2022.

Population and Research Sample

The research population consisted of class ten of high school students from 14 public high schools in Kerinci Regency, for a total of 1557 participants (data from the Jambi Provincial Education Office as of December 25, 2021). Simple random sampling was utilized as the sampling approach. The total number of student samples is 488 (31.34% of the population). According to Gay et al. (2012), because the population reaches 1500, the minimal sample number is 20% of the population. Table 1 shows the sample distribution.

Table 1. Distribution of Research Samples

No	School	Students
1	Senior High School 1 Kerinci	30
2	Senior High School 2 Kerinci	28
3	Senior High School 3 Kerinci	41
4	Senior High School 4 Kerinci	87
5	Senior High School 5 Kerinci	22
6	Senior High School 6 Kerinci	47
7	Senior High School 7 Kerinci	91
8	Senior High School 8 Kerinci	24
9	Senior High School 9 Kerinci	19
10	Senior High School 10 Kerinci	41
11	Senior High School 11 Kerinci	13
12	Senior High School 12 Kerinci	19
13	Senior High School 13 Kerinci	21
14	Senior High School 14 Kerinci	5
Total		**488**

Research Instruments

This study's instrument was a closed questionnaire with a five-point scale. The survey was distributed to 107 Kerinci Regency high school students. The study findings produced a valid and reliable questionnaire with the following outcomes: 1) a modified Greenstein (2012) questionnaire measuring creative thinking skills comprises 46 items with an average validity value of 0.40 (valid) and a reliability value of 0.89 (very high); 2) The 44 items on the Self-Assessed Collaboration Skills (SACS) questionnaire, which was modified from Hinyard et al. (2019), evaluate collaboration skills and have an average validity value of 0.53 (valid) and a reliability value of 0.94.

(very high); 3) with 40 items to assess communication skills, the Interpersonal Communication Competence Scale (ICCS) questionnaire, which was modified from Rubin & Martin (1994), has an average validity value of 0.50 (valid) and a reliability value of 0.93 (very high).

Data Analysis Technique

The Spearman correlation test is used in data analysis to analyze the connection between these two variables. The Spearman correlation test was used since the data is known to be non-normally distributed based on the prerequisite test. Using the multiple correlation test, data analytic techniques were used to examine the correlation between the three variables.

The IBM SPSS Statistics 25.0 program is used to process data. If the sig. < 0.05 and the correlation coefficient value are used to determine the degree of strength of the variable relationship, the variable is considered to have a relationship (H0 is rejected). The correlation coefficient value is evaluated using the correlation coefficient level criterion in Table 2.

Table 2. Correlation Level Interpretation Criteria

Interval Nilai Coefficient Correlation	**Correlation Coefficient Criteria**
0.85 – 1.00	Very High
0.65 – 0.85	High
0.35 – 0.65	Moderate
0.20 - 0.35	Low

(Source: adapted from Cohen et al. (2018))

The following is the research hypothesis:

1) Correlation between creative thinking skills and collaboration skills in biology learning

   H0: there is no relationship between creative thinking skills and collaboration skills in biology learning.

   H1: there is a relationship between creative thinking skills and collaboration skills in biology learning.

2) Correlation between creative thinking skills and communication skills in biology learning

   H0: there is no relationship between creative thinking skills and communication skills in biology learning.

   H2: there is a relationship between creative thinking skills and communication skills in biology learning.

3) Correlation between collaboration skills and communication skills in biology learning

   H0: there is no relationship between collaboration skills and communication skills in biology learning

   H3: there is a relationship between collaboration skills and communication skills in biology learning

4) Correlation between creative thinking skills and collaboration on communication in biology learning

   H0: there is no relationship between creative thinking skills and collaboration on communication in biology learning.

   H4: there is a relationship between creative thinking skills and collaboration on communication in biology learning.

5) Correlation between creative thinking and communication skills on collaboration in biology learning

   H0: there is no relationship between creative thinking and communication skills on collaboration in biology learning.

   H5: there is a relationship between creative thinking and communication skills on collaboration in biology learning.

6) Correlation between collaboration and communication skills on creative thinking in biology learning

   H0: there is no relationship between collaboration and communication skills on creative thinking in biology learning

   H6: there is a relationship between collaboration and communication skills on creative thinking in biology learning

The research hypothesis can be briefly seen in Fig 1.

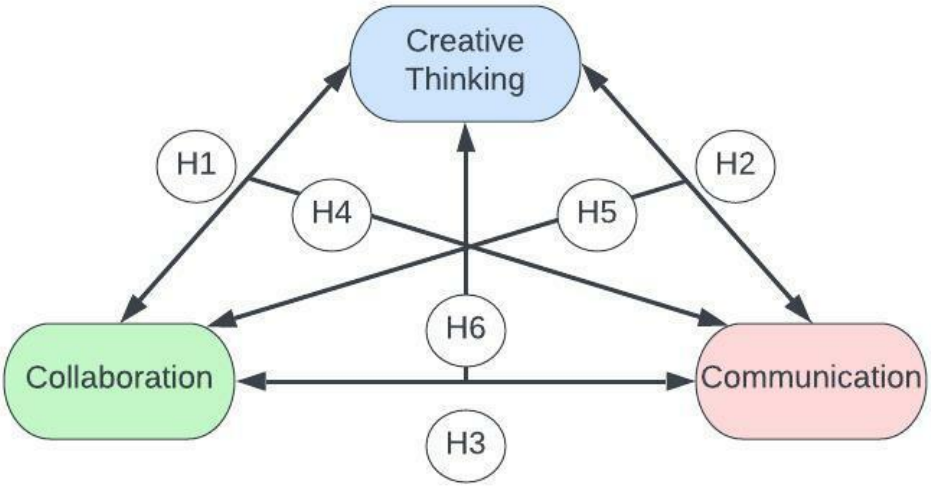

Fig 1. Research Hypothesis Diagram

4. Results

Based on the correlational analysis of two variables and three variables, it is known that there is a relationship between variables, either two variables or between three variables. Table 5 shows the findings of the correlational analysis.

Table 5. Results of Two- and Three-Variable Correlation Analysis

Hypothesis	Sig. Value	Relationship Strength Levels	Description
1. First Hypothesis	0.000	0.416 (Moderate)	H0 is rejected
2. Second Hypothesis	0.000	0.299 (Low)	H0 is rejected
3. Third Hypothesis	0.000	0.615 (Moderate)	H0 is rejected
4. Fourth Hypothesis	0.000	0.563 (Moderate)	H0 is rejected
5. Fifth Hypothesis	0.000	0.610 (Moderate)	H0 is rejected
6. Sixth Hypothesis	0.000	0.410 (Moderate)	H0 is rejected

5. Discussion

The distribution of mastery of collaboration and communication skills, as well as creative thinking skills, in biology learning, is known to vary for each student based on the findings of data analysis. The findings of the correlation study are consistent with the hypothesis that the development of creative thinking, collaboration, and communication skills is correlated with learning biology. This is consistent with Tang et al. (2020) assertion that these three abilities are interrelated and support student achievement.

However, the second hypothesis discovered a low-category association between creative thinking skills and communication skills. The poor correlation is due to the fact that it is impacted by several factors. Gender disparities are one of the aspects that frequently impact the outcomes of studies on creative thinking and communication skills (Piaw, 2014; Wiskin et al., 2004). According to Ulger & Morsunbul (2016), women have a better degree of creative thinking than men, while according to Rusdi et al. (2020), women can explain things more structured than men. Furthermore, other elements might impact students' skill mastery, such as learning styles, ethnicity, and critical thinking skills (Piaw, 2014).

The mastery of the three skills is typically interrelated and mutually beneficial. Creative thinking skills cannot exist apart from communication and collaboration skills, and vice versa. Creative thinking involves and generates something new or original (Lai & Hunt, 2006) that may be used to solve difficulties in biology. When evaluated closely, Greenstein (2012) markers of creative thinking skills show a relation with collaboration and communication skills.

Greenstein (2012) indicator of creative thinking skills, "with others," reveals that more ideas emerge while working with others (collaboration). Furthermore, additional markers of Greenstein (2012) creative thinking skills, such as indicators of curiosity, fluency, originality, and divergence, show that ideas can arise through verbal and nonverbal communication. Rodríguez et al. (2019) and Tang et al. (2020) define creative thinking as a social and collaborative phenomenon that emerges through interactions between individuals.

According to Kim & Kim (2019), creative thinking is not always created from one's thoughts, but rather requires the effect of cooperation (group activity). This shows that student-centered learning is critical to the success of biology learning. Gardner & Belland (2012) said the same thing: the lecture style, which is extensively employed in conventional learning, does not yield high-level biology learning. Teachers in traditional classrooms are generally unable to assist in the development of student's abilities since they are solely concerned with imparting knowledge to

students. Transferring knowledge to students entails the instructor just relaying facts to students without actively engaging them in the learning process (Fitriani et al., 2020a).

Individual performance when working individually is frequently superior to collaborative problem-solving (Cole et al., 2018). According to Kim & Kim (2019), collaborative skills can affect students' creative thinking. Mumford et al. (2012) support the premise that when people are encouraged to use associational knowledge, the quantity, and quality of ideas are created increase.

Teamwork, as it is commonly used by students in school, is a type of teamwork practiced by students. According to Hinyard et al. (2019), collaboration provides learning opportunities in social interaction. Hinyard et al. (2019) further said that the eleven suggested collaboration indicators are related to people's engagement in social interaction activities inside groups, such as group contributions, group support, group dynamics, and others.

Social interaction activities are inextricably linked to communication activities that might help students develop collaborative skills. Collaboration allows you to practice using dialogue and discussion while exploring diverse ideas and experiences (Resta & Lee, 2010). Students who are given the opportunity to participate in class discussions can propose solution to the problems discussed (Asyari et al., 2016).

Cho & Jonassen (2012) also stated that when studying biology, students would remember more effectively if they explain the things, they learn to others rather than repeating them aloud numerous times. This demonstrates the importance of communication skills in supporting the effectiveness of biology learning.

Communication skills are constantly used in tandem with collaboration skills (Slota et al., 2017; Spies & Xu, 2018). Collaboration among students will almost definitely never be separated from communication activities. Through communication activities, students may express, share, and evaluate thoughts and ideas (Ozkan et al., 2014). The most crucial aspect of human life is communication. Oral communication is the foundation for fostering student collaborative skills (Spies & Xu, 2018).

Rubin & Martin (1994) propose communication skill indicators that encourage the inclusion of communication in all social activities, both in and out of the classroom. Social interaction activities allow students to strengthen their collaboration and creative thinking skills. Furthermore, verbal communication activities might help students learn new concepts (Muhdhar et al., 2021).

Communication is essential in debating since it is a fundamental human endeavor (Hernawati et al., 2018). Students who participate in real-world debates can improve their conceptual knowledge in learning biology (Hasnunidah et al., 2019). Arguing about collaboration skills entails students participating in group activities. In other words, via arguments, students may improve group discussion and interaction activities, which in turn increases student collaboration.

Rubin & Martin (1994) identified one indicator of communication skills, namely self-disclosure, which is defined as the ability to open or express something to others, as being associated with students' mastery of creative thinking skills (King et al., 1996). This frequently occurs during student discussions. Peer discussions allow students to share their discoveries with their classmates and receive feedback from them (Fitriani et al., 2020b).

The relationship between creative thinking skills, collaboration, and communication in general can be described in Fig 2.

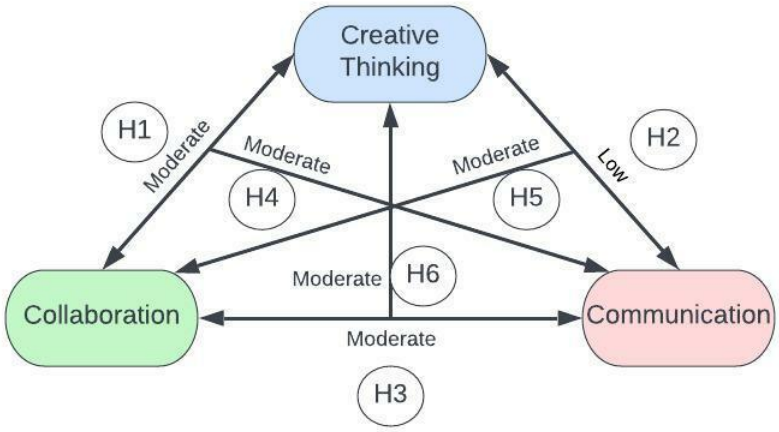

Fig 2. Relationship between Creative Thinking Skills, Collaboration, and Communication

Given the significance of creative thinking, collaboration, and communication skills in the growth of diverse disciplines of knowledge (Dunbar et al., 2006), an effective method for honing these skills is required. Schools, particularly high schools, should be able to provide students with these three abilities (Ibán et al., 2020; Tomer, 1981). Students can improve their creative thinking, collaboration, and communication abilities. Project-based task activities (Gencer & Gonen, 2015; Stanley, 2016), participatory learning (Bestelmeyer et al., 2015; Nikkola et al., 2020), and cooperative work (Rodríguez et al., 2019) can all be used to practice creative thinking, collaboration, and communication skills.

6. Conclusion

According to the study's findings, the skills of creative thinking, collaboration, and communication in biology learning differ for each student. Biology learning is connected to creative thinking, collaboration, and communication skills. Creative thinking, collaboration, and communication abilities are indications of how multiple interrelated parts may be combined. One skill will help to create another.

This study's limitation is that it does not identify and assess aspects associated to students' skill mastery, such as gender, learning style, and others. This is necessary as a factor that may be employed to teach students' creative thinking, collaboration, and communication skills. Future study should be able to connect each skill indication when examining the relationship between creative thinking, collaboration, and communication skills, and it is critical to pay attention to aspects that might impact student mastery of abilities.

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Appendix 1

Bibliometric analysis using the Publish of Perish 8 application and visualization using the VOSviewer application. The keywords used are “creative thinking; biology learning”, “collaboration; biology learning”, and “communication; biology learning”. The criteria for the articles used are 1) in English; 2) is not a written work in book form; 3) it is obvious who published it (the journal is clear); 4) the publisher is clear. The Publish of Perish 8 program chose 2940 articles, which were subsequently selected using specified criteria, leaving just 2350 articles available for usage. The VOSviewer application was used to visualize 2350 articles. The VOSviewer application gathers 184 words that often appear in articles and then selects these words as needed, leaving just "communication skills," "collaboration skills," "biology learning," and "creative thinking skills" to be shown. Fig 3 shows the visualization results.

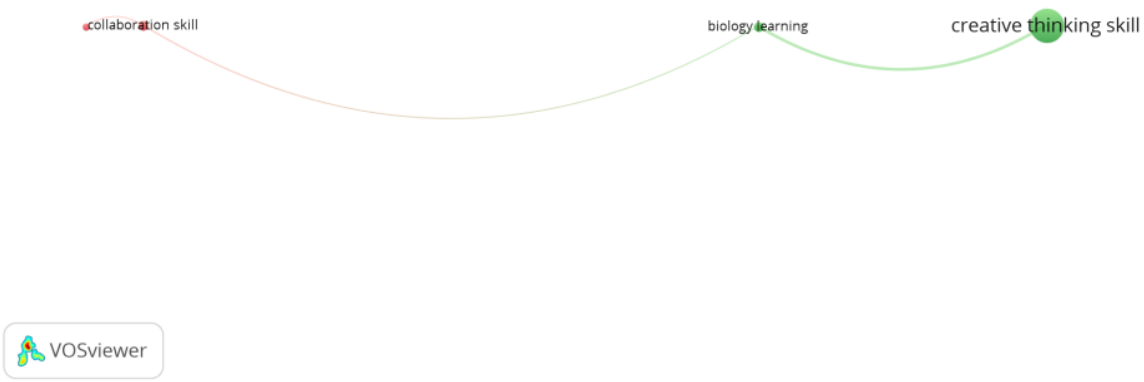

Fig 3. Bibliometric Analysis Visualization for Creative Thinking, Collaboration, and Communication Skills in Biology Learning

Note:

The keyword "communication skill" is not featured in the figure, but it is represented by the circle on the far left. Because this research is rarely conducted, there is a loss of writing the keyword "communication skills."

Based on Fig 3 it is known that 1) a lot of research has been conducted on creative thinking skills in biology learning, as seen by the enormous circle on the term "creative thinking skills" and the presence of a connecting line with the keyword "biology learning"; 2) in biology learning, research on collaboration and communication skills is still rare compared to research on creative thinking skills, as indicated by the circles for the keywords "collaboration skills" and "communication skills" being smaller than the circles for the keywords "creative thinking skills."

According to the bibliometric research, prior research linking two variables is still very rare, confined to the relationship between collaboration and communication skills, and it has never been done for three variables concurrently.