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Enhancing Students' Creative Thinking Skills through Biotechnology Module based Socio-Scientific Issues

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Abstract: This study aims to enhance students' creative thinking skills through the biotechnology module based on socio-scientific issues. This is pre-experimental research with a one-group pretest-posttest design. The learning is carried out online using the Zoom meeting application, which is familiar to the students. The instrument for collecting data is a valid creative thinking skill test sheet. The students' responses were analyzed using a questionnaire. The data analysis was done by descriptive quantitative and inferential. The result of the inferential statistical test shows that there is a significant effect of using SSI-based biotechnology modules on students' creative thinking skills. The SSI-based biotechnology module is effective to improve creative thinking skills, indicated by the N-Gain value is 0.63 in the moderate category. The learning implementation has an average value above 75%, indicating that the learning process is carried out very well. 87.50% of the students gave excellent responses to the use of the SSI-based module in learning. There is an increase in the N-Gain value in creative thinking skills, so we can conclude that the biotechnology module based on the socio-scientific issue is effective to improve creative thinking skills.

Keywords: Socio-scientific issues; Module; Biotechnology; Creative thinking skills.

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Introduction

In early 2020, there was a new virus outbreak in Wuhan, Hubei Province, which then spread rapidly to various countries (Cao et al., 2020; Mehta et al., 2020; Velavan & Meyer, 2020). The virus is a new type of coronavirus (SARS-CoV-2) called coronavirus disease 2019 or COVID-19 (Cao et al., 2020; Kraemer et al., n.d.; Legido-Quigley et al., 2020; Yuliana, 2020). The outbreak of the COVID-19 had a very significant impact on all fields. All life sectors change and force humans to adapt. These changes also occur in the education field. The government has implemented several policies, including "stay at home" and "physical and social distancing" to anticipate the impact of virus transmission so that it does not spread widely (Kissler et al., 2020; Quay et al., 2020; Ratu et al., 2020). This policy brought a massive change in the world of education. Students who were supposed to carry out learning at school became learning at home. Face-to-face learning turned into online learning. This condition makes it difficult for educators to carry out learning. However, regardless of the conditions, a lesson must continue even during the COVID-19 pandemic (Beitsch et al., 2020; Gupta & Agrawal, 2020).

Distance learning requires educators to deliver all learning material, and students must understand all the material that has been delivered by the educator. However, there are several obstacles to implementing online learning, such as internet networks, mobile data, and learning applications (Rigianti, 2020; Jariyah & Tyastirin, 2020). Many learning media to use in face-to-

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face learning activities, such as objects around the environment (Agusta & Noorhapizah, 2018), but online learning is different. All learning media turned into visual media. In online learning, it is necessary to prepare a study guide that helps students to learn independently so that it allows students to study anywhere and anytime (Sandars et al., 2020). The study guide can be in the form of a module because the module has components, consisting of material, assignments, and evaluations so that it becomes a study guide that can be used independently by students with minimal guidance and direction from the teacher (Hasibuan et al., 2018; Nallakukkala et al., 2018).

The use of learning methods aims to foster the independence of students in learning to improve learning outcomes. It does not rule out the improvement of other skills when implementing the module in distance learning, which requires students to learn independently. Module development with a specific approach is proven to help students in honing thinking skills, other 21st century skills (Heliawati et al., 2020; Putri & Aznam, 2020), as well as other skills according to the approach used. One of the approaches that can be used in module development is the socio-scientific issue (SSI) approach. The SSI approach is widely used in 21st-century learning because it can improve the skills needed in the 21st century. According to (Ismawati &Pertiwi, 2019), learning that is integrated with socio-scientific issues can improve students' higher-order thinking skills. Also, a teaching material developed with a socio-scientific issue approach can improve decision-making skills (Nurtamara et al., 2019; Siribunnam et al., 2019), argumentation skills (Dawson & Carson, 2020; Istiana & Herawati, 2019; Öztürk & Doğanay, 2019); reasoning abilities (Afifi & Setambah, 2018; Karpudewan & Roth, 2018), scientific literacy skills (Heliawati et al., 2020; Purwani et al., 2018), nature of science (NOS) skills (Herman, 2018; Leung, 2022), as well as increasing critical thinking skills (Santika et al., 2018; Yacoubian & Khishfe, 2018).

The skills carried out in 21st-century learning include 4'C (communication, collaboration, critical thinking, and creativity) as described in the US-based Partnership for 21st Century Skills (Muhammad et al., 2020; Eryandi & Nuryanto, 2020). The 21st-century skills must be trained to students in learning at school as a provision for skills that will be used in daily life. It can help students to respond to the challenges of changing times, such as during the COVID-19 pandemic. Students are expected to be able to think critically and creatively in dealing with developing issues in society. Creative thinking can be trained through a variety of innovative learning (Yang et al., 2018), for example, online learning using a module based on socio-scientific issues. According to Herman (2018) and Zeidler et al., (2019), learning that is integrated with socio-scientific issues can improve thinking skills.

Based on the preliminary study, the data obtained from the questionnaire about the use of teaching materials for 27 science teachers in West Java Province showed only 18.5% of teachers use a module in learning. Most teachers still use textbooks provided by the government. The preliminary test results of 129 students in a junior high school in Majalengka showed that the average creative thinking ability of students was 38.32% in a low category. The low creative thinking skills of students are caused by several factors, including inadequate learning facilities, varied characteristics of students, lack of student motivation to learn, and the lack of teaching materials and innovative application of learning. Therefore, this socio-scientific issue-based module can be used as an alternative to innovative teaching materials for use in online learning. Several science materials can be applied using socio-cultural issues, including in biology learning (Owens et al., 2021; Subiantoro & Treagust, 2021); climate change (Dawson & Carson, 2020); biotechnology studies (Borgerding & Dagistan, 2018; Hancock et al., 2019); as well as the field of chemistry, namely acid-base matter (Kusumaningtyas et al., 2020); and solutions (Pandela et al., 2019),

Socio-scientific issues are suitable for use in biotechnology learning. Biotechnology is a concept that consists of the basics of modern and conventional techniques based on science (Rukayah et al., 2020). Biotechnology is one of the fields of biology that has grown for both scientific purposes and the development of science in society (Qalbina & Ahda, 2019; Shimasaki, 2014). For example, biotechnology in industry and entrepreneurship can answer the challenges that will be faced in the future (Fröhling & Hiete, 2020). Biotechnology learning is closely related to daily life because it causes problems that are close to students' life. These problems can be used as a source of contextual learning. As stated by Natadiwijaya et al., (2018) and (Straathof et al., 2019) that biotechnology is a more relevant field of science, so students need to have creative thinking skills in understanding the concept of biotechnology.

Based on the explanation, research is needed to integrate the approach to socio-scientific issues into a module as a learning solution during the pandemic. The purpose of this study is to measure the effectiveness of the biotechnology module based on socio-scientific issues in science learning biotechnology materials to train creative thinking skills through online learning during the pandemic. The effectiveness in question is that the biotechnology module based on

socio-scientific issues can improve creative thinking skills with the N-Gain value in the medium or high category. The biotechnology module used contains biotechnology introduction material which consists of sub-materials on the understanding of biotechnology, types of biotechnology, biotechnology applications, and the impact of biotechnology on life. The approach to socio-scientific issues as the basis for module development consists of seven aspects, including the problems faced are real, not artificial, events; contemporary relevance; controversial; describe the nature and process of science; problems are complex and open; combine science, technology, and social problems; and consider the ethical dimensions (Arbid & Tairab, 2020; Lee & Yang, 2019; Subiantoro & Treagust, 2021). Aspects of creative thinking skills measured in the study consist of fluency, flexibility, originality, and elaboration.

Method

This study used a pre-experimental method to measure the effectiveness of the product, which is a biotechnology module based on social scientific issues (SSI). The pre-experimental method is used because it provides treatment and can measure the results of the treatment without random sampling. The pre-experimental method identifies differences after being treated with particular results, then explains why the differences can occur. The test questions were tested with a one-group pretest-posttest research design (Fraenkel. et al., 2012), which measures creative thinking skills before and after learning. The pretest-posttest design avoids the main group boundaries as differences would be difficult to interpret the conclusions if using a comparison group. The research design is presented in Figure 1.

Pretest	Treatment	Posttest
O_1	X	O_2

Figure 1. One-group pretest-posttest design

Figure 1 showed that O_1 as a pretest was given to students before treatment; X as a treatment was given by learning using a biotechnology module based on socio-scientific issues; O_2 as a posttest was given to students after treatment.

Participants

The samples in this study were 129 ninth-grade students of MTSN 6 Majalengka consisting of 54 male students and 75 female students. All samples had not received material about biotechnology and had similar learning outcomes. The sampling was done using the purposive sampling technique. The specified sample is students who can access and operate the Zoom Meeting application properly.

Data Collection

Data collection was carried out through tests to measure creative thinking skills, student response questionnaires to biotechnology modules based on social scientific issues (SSI), and observation sheets for the implementation of online learning. The instrument for testing creative thinking skills is in the form of description questions consisting of four pretest questions and four posttest questions, adjusted to the number of aspects of creative thinking skills used. Each question represents one aspect of creative thinking skills, as shown in Table 1.

Table 1. The aspect of creative thinking skills

Aspect	Description
Fluency	Students can provide ideas for solving problems
Flexibility	Students can provide various answers
Originality	Students can provide ideas or answers in their way and language
Elaboration	Students can provide detailed answers

(Fauziah et al., 2019; Huang et al., 2020).

The student response questionnaire instrument consisted of 12 question statements derived from two aspects of assessment, which are presented and graphics. The presentation aspect consists of seven statement questions, and the graphics aspect consists of five statement questions. Students filled the questionnaire by answering "Yes" or "No" on the Guttman scale to get clear and consistent answers to the problem (Aini et al., 2018). The learning implementation instrument is in the form of an observation sheet consisting of four aspects of assessment, which are the suitability of the lesson plan material, group management (if learning online, online class management), task management, and awards. The aspect of the suitability of the lesson plan material consists of two statements. The online classroom management aspect consists of three statements. The task management aspect consists of two statements. The aspect of awarding consists of one statement. Students filled the observation sheet by answering "Yes" or "No".

Validity

The validity of the test instrument was carried out through expert judgment by two experts in their field.

Data Analysis

Data analysis of the results of creative thinking skills was carried out by giving scores on students' answers. The scores are 0, 1, 2, 3, and 4 according to the scoring rubric per assessment indicator. The score for

creative thinking skills is obtained by dividing the score by the maximum score, which is 100.

Whether or not there is an effect of using the biotechnology module based on socio-scientific issues (SSI) on creative thinking skills is analyzed by looking at the significant difference between the pretest and posttest scores. Samples were processed using SPSS version 23. Test for differences using non-parametric statistics, Wilcoxon Signed Ranks. The basis for making research decisions is if the Sig. (2-tailed) p <0.05, so there is a significant difference between the pretest and posttest scores for creative thinking skills. Conversely, if Sig. (2-tailed) p> 0.05, so there is no significant difference between the pretest and posttest scores for creative thinking skills. If there is an effect of using a biotechnology module based on socio-scientific issues (SSI) on creative thinking skills, then the N-Gain value is calculated to determine the increase in creative thinking skills after using the module. The interpretation of N-Gain values is in the low, medium, and high categories.

The student response questionnaire to the module was analyzed by calculating the acquisition of students' response scores. This analysis is seen from the students' scores on the questionnaire sheets after implementing the learning using the SSI-based biotechnology module. The score is converted into a percentage and classified into the categories of bad (≤20%), not good (21-40)%, quite good (41-60)%, good (61-80)%, and very good (81-100)%.

Two science teachers observed the implementation of the learning process through the Zoom Meeting application. The analysis of the learning implementation was seen from the score of the observation sheet by the observer. Then it is calculated based on the Inter-judges Agreement (IJA) by dividing the scores of the activities carried out by the number of the scores of the activities carried out and the scores of the not being multiplied by 100%. RPP criteria are suitable for use in learning if the implementation is more than 75%.

Procedure

The learning process is carried out online using the Zoom Meeting. Before and after the learning process, creative thinking skills tests were carried out using the google form application. During learning, students not only attend meetings but also work on projects in the module.

Result and Discussion

The biotechnology module is structured with an approach to socio-scientific issues. Therefore, aspects of socio-scientific issues are integrated into the module in the form of biotechnology issues or news. The aspects of socio-scientific issues consist of seven aspects which are presented in Table 2.

Table 2. Aspects of Socio-scientific Issues in the Biotechnology Module

Aspects of Socio Scientific Issues	Characteristics	Location On Module
Real	The problems faced are real, not artificial	Issues entitled "Indonesia Punya Industri Bioteknologi Pertama di Asia Tenggara" (page 2).
Contemporary Relevance	The material in the module is modern and still exists today	Issues entitled "Profesor di Universitas Airlangga Temukan Vaksin Virus Corona" (page 6).
Controversial	The problems in the module are in the form of problems that can trigger conflict.	Issue entitled "Kontroversi Produk Hasil Rekayasa Genetika" (page 36).
Nature and Process of Science	Science demands proof; use the foundation of critical thinking; the scientific explanation is temporary; irrelevant to tradition; secular.	Issue entitled "Segera Dipasarkan, Buah dan Sayuran Hasil Genetic Editing" (Page 26)
Complex and Open	The problems presented in the module are interconnected and interdependent between fields of science, complex, and open to answers.	Issue entitled "Segera Dipasarkan, Buah dan Sayuran Hasil Genetic Editing" (page 17)
Combination of Technology, Science, and Social	The problems presented are a combination of science, technology, and social problems.	Issues 4 and 6 entitled " Saatnya Pemerintah Menerapkan Bioteknologi di Bidang Pangan" and " Sapi Bulgarian Blue Siap Dikembangkan di Indonesia" (pages 23 and 31)
Ethical Dimensions	The problems presented raise problems regarding the assessment of good and bad behavior	Issue entitled "China Susun Aturan Soal Pengeditan Gen Bayi" (page 42)

The biotechnology issues that are presented are the main characteristics of the module. Besides that, there is a column of questions about creative thinking every time a biotechnology issue is presented. The question column aims to hone the creative thinking skills of students. The characteristics of the biotechnology module are Characteristics of biotechnology modules are loading biotechnology issues and facilitating students to think creatively.

Table 2 showed the socio-scientific issue (SSI) based biotechnology module integrates socio-scientific issues aspects into biotechnology material. Those aspects of SSI are real, not artificial; contemporary relevance; controversial; describe the nature and process of science; problems are complex and open; combine science, technology, and social problems; as well as considering the ethical dimension. These SSI aspects are integrated into the form of biotechnology issues that trigger the creative thinking skills of students in solving problems under the biotechnology issues in the module. This is a characteristic of the SSI-based biotechnology module compared to other biotechnology modules. The implementation of SSI, which is integrated into a teaching material, is still unfamiliar (Genisa et al., 2020; Wan & Bi, 2020). Online learning, as a result of the COVID-19 pandemic, has made educators act creatively in producing study guides for students to carry out learning independently.

The effect of the SSI-based biotechnology module on creative thinking skills can be seen after the statistical test. The results of the normality test for the ability to think creatively are presented in Table 3.

Table 3. Results of Normality Test for Creative Thinking Skills

	Test statistic	Asymp. Sig.
Pretest	0.167	0.044
Posttest	0.242	0.000

Based on the results of the normality test for the creative thinking skills in Table 3, both on the pretest and posttest data are at a significance level (α) < 0.05. It shows that the data are not normally distributed. The prerequisite test is not fulfilled, so the statistical test used is the non-parametric statistic test, namely the Wilcoxon Signed Ranks Test. Based on the results of the calculation of the statistical difference in the average value of the test results for the creative thinking skills using the Wilcoxon Signed Ranks Test, the data obtained a significance level of 0.000. With the significance level of 0.000 < 0.05, it can be concluded that "H_0 is rejected". It means that there is a significant increase in the creative thinking skills of students after using the module in learning. The results of this study are in line with the statements of Borgerding & Dagistan (2018), learning by integrating SSI can promote thinking skills, such as critical and creative thinking. Learning using the SSI approach can develop student competencies (Nida et al., 2020; Tsai, 2018), such as making scientific concepts and generating ideas for solutions proposed in solving a problem (Borgerding & Dagistan, 2018; Herman, 2018). The results of this study are reinforced by the findings of Hancock et al., (2019), SSI-based learning is effectively used to contextualize science learning in a complex social environment. A teacher must be able to choose the appropriate science learning to be applied using the SSI approach, including biotechnology (Borgerding & Dagistan, 2018; Hancock et al., 2019). The characteristics of rapidly developing biotechnology materials, such as the concepts of genetics and evolution, raise problems as material for discussion in learning (Anisa et al., 2020; Toman, 2019).

SSI-based biotechnology module is quite effective in improving creative thinking skills, seen from the N-Gain results, which are in the medium category. Increasing the creative thinking skill, which is still in the moderate category after students took biotechnology learning using the socio-scientific issue-based module, is because online learning has several obstacles, such as unstable internet networks, mobile data, uneven availability of facilities, and lack of parental supervision. The obstacles experienced during online learning significantly reduce the effectiveness of the learning process (Dhawan, 2020). It makes students not focus on learning and reduced motivation in practicing creative thinking skills during the learning process. It is following the results of research from Jamaluddin et al. (2020) that the biggest obstacle to online learning is an unstable internet network and limited mobile data. Other obstacles are learning applications more difficult learning management, barriers to learning assessment, and lack of supervision (Jariyah & Tyastirin, 2020).

Even though they face several obstacles during online learning, teachers can still train students' creative thinking skills optimally in various ways. One way to optimize students' creative thinking skills is by using innovative learning or the use of innovative teaching materials (Jebur, 2020; Nur et al., 2020). The SSI-based biotechnology module is an online learning solution that can optimize students' creative thinking skills training because this module is specially prepared with components designed to train students' creative thinking skills.

To see how the increase in creative thinking skills is, an analysis of the N-Gain value is carried out. The result showed that the average N-gain is 0.63 (medium

category). The N-Gain value of creative thinking skills in terms of each indicator is shown in Table 4.

Table 4. N-Gain Value on Creative Thinking Indicators

Creative Thinking Indicator	Mean of pretest	Mean of posttest	N-Gain
Fluency	35.70	72.30	0.57
Flexibility	43.80	83.00	0.69
Originality	42.90	78.60	0.62
Elaboration	43.80	78.60	0.62

The creative thinking indicator that gets the highest N-Gain value is flexibility (Table 4). The reason is that the module contains exercises that guide students to explore the answers. Questions to practice creative thinking skills are presented in the question column for each biotechnological issue. In line with research conducted by Hoffmann et al. (2020), creativity is trained by finding problems and generating various ideas. Diverse ideas as evidence of creative thinking appear in individuals who are often trained compared to individuals who are not trained to think creatively (Morin et al., 2018; Puccio et al., 2020). Besides, Wartono et al., (2018) stated a lesson that trains students with problems is very effective for improving students' creative thinking skills. The lowest N-Gain gain is on the fluency indicator. The reason is that students have not been able to provide the correct answers to the questions. One of the contributing factors is the lack of students' initial knowledge of biotechnology material. Initial knowledge or previous knowledge is essential for students to have because it is related to curiosity (Schwarz, 2019; Wade & Kidd, 2019) and is useful for further learning (Subramaniam, 2020; Zhang et al., 2019) so that it has an impact on motivation and better learning outcomes (Lan et al., 2020; Lee & Yang, 2019). Zambrano R. et al. (2019) and Siegelman et al. (2018) stated that individuals who have prior knowledge are proven to be superior in learning compared to individuals without prior knowledge.

Online learning requires more attention from the teacher so that every learning takes place well. Two observers assessed the learning implementation at the three learning meetings. The results of the implementation of learning are shown in Table 5.

Table 5. Results of Learning Observation.

Learning	Observation results (%)	Mean (%)	Category
First	100.00 100.00	100.00	Very Good
Second	87.50 100.00	93.80	Very Good
Third	100.00 100.00	100.00	Very Good

The results of the learning implementation show that all indicators are well achieved. The teacher delivers the material according to the steps in the lesson plan. The teacher divides groups for assignments at home according to the students' skills. When learning takes place, the teacher delivers the material and assignments to students. The teacher also provides directions to students who experience difficulties during discussions and at the time of working on assignments. Before students do the task, the teacher conveys the rules of observation/work on the task so that there are no errors or miscommunication to students. Finally, the teacher gives gifts or praise to students who can answer questions or do assignments well.

The practicality of the product can be seen from the user's response to the products they have used. In this case, students, as users of the module, respond to the SSI-based biotechnology module after the learning. Responses are given by paying attention to the practicality of the presentation and the graphics aspects of the biotechnology module based on socio-scientific issues. The mean result of the student's response to the module in the graphics aspect got 81.4% in the very good category, and the presentation aspect got 91.8% in the very good category. The average result of students' responses to the biotechnology module based on socio-scientific issues was 87.5% in the very good category, which shows that the module is very good in practicality and suitable to use.

The response of students shows that the module used in learning is excellent in the practicality of use. The learning in the module is presented not only in terms of material, but also students can do simple practicum that can be done independently guided by practicum activities in the biotechnology module based on socio-scientific issues. It makes the module fun to learn by students. According to Pursitasari et al., (2019) and Suciyati & Adian (2018), a teaching material that is presented with a pleasant presentation can increase the competence of students. The real impact of the development of this SSI-based biotechnology module is beneficial in providing teaching materials during online learning, helping students learn independently without losing the goal of achieving 21st-century competencies that are included in the 2013 curriculum, which is creative thinking.

Conclusion

The characteristic of the socio-scientific issues-based module is that it integrates socio-scientific issues (SSI) aspects into biotechnology material. Those aspects of SSI are real, not artificial; contemporary relevance; controversial; describe the nature and process of

science; problems are complex and open; combine science, technology, and social problems; as well as considering the ethical dimension. The biotechnology module based on socio-scientific issues can enhance the creative thinking skills of students with medium category and students gave a positive response to the use of the SSI-based module in science learning. However, Biotechnology modules cannot be used for a long time because their material develops very rapidly. Therefore, teachers must have the skill to develop module content according to the latest research findings.

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