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The Impact of STEM Education on Science Education Student's Creative Thinking Skills on The Concept of Genetic Engineering: Case Study

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A B S T R A C T

The concept of genetic engineering is one of the most difficult materials students can understand. It's because it's very abstract and its existence is microscopic, so it takes educator skills to make it easier for students to understand the concept of genetic engineering. Understanding is much easier when it comes to using the issues that are in society and corroborating the concept of genetic engineering in prototype form. STEM education is one of the approaches that can help educators in developing creative thinking skills of science education students. The purpose of this research is that STEM education has an impact on the creative thinking skills of science education students on the concept of genetic engineering. Using a quantitative method by taking the average of student sheets and creative prototype genetic engineering by science education students. The average is rated according to 4 creative thinking skills indicators. Research shows the average creative thinking skills is 85.2% with excellent categories. As a results, students can think creatively to solve the problem of genetic engineering that happens in society. And understanding the concept of genetic engineering is easier for students to understand by using prototypes so misconception can be avoided. The conclusion of this research is the impact of STEM education can grow the creative thinking skills of science education students on understanding the concept of genetic engineering.

1. Introduction

Genetic engineering is one of the topics in microbiology courses. Genetic engineering is closely related to biotechnology which is a science that utilizes living beings and their lives in the production process of producing goods and services to improve quality of life. One of the main themes in biotechnology is genetic engineering which is experiencing incredible development. Genetic engineering births a new revolution in various areas of human life because the application of genetic reuse can produce a variety of products that can directly improve well-being in the medical field, Agriculture, Food, Food, and renewable energy. According to (Vajo, 2001), the application of genetic engineering in life produces a variety of products that can enhance the well-being of humanity according to its needs and contribute to the solution of various problems in human life, for example, analog insulin production to help diabetics, Astaxanthin production as a high antioxidant producer (Sandman, 2014), transgenic soybean production (Sieradzki Zbigniew, 2021), transgenic cotton

(Bermawie., 2017), Prebiotic production of xyloligosaccharide (Salupi, 2015). The production of the anti-aging detergent, (Nurhasanah Ade Nena, 2020), parthenokarphic fruit induction for improved quality and fruit production (Rotino GL, 1997) and the government has also had genetically engineered crop products that are seven genetically engineered corn seed products belong to syngenta and three genetically engineered products of sugar cane have PT Perkebunan Nusantara (PTPN) XI.

The study of biotechnology in particular genetic engineering is the application learning activity of biological organisms systems and engineering processes in the industry of goods and services for human benefit. So it requires a proper method of learning so that it's easy to understand. The development of this science can be used as a study subject by bringing up problems contextually through problem-solving models. One of the lessons that can be used to support the student's critical thinking is the study of STEM (science, technology, engineering, and maths). According to (Research, 2011), the main goal of STEM learning is to demonstrate the holistic knowledge of the subject of STEM. Using the study course approach that requires knowledge that complexity is applied to the proteges to prepare apprentices can compete and be ready to work by each other's field of expertise. STEM education gives practical encouragement to education in separate fields of STEM, At the same time, it developed a more educational approach that integrates science., technology, engineering, and mathematics by focusing on the process of education on solving real problems in everyday life or professional life (Septiani, 2016).

STEM learning in education is intended to prepare the trainees to compete and be ready to work according to their expertise, The study conducted by the research institute Hannover Research (2011) shows that the primary purpose of steam learning is to demonstrate the holistic knowledge between the subject STEM. The purpose of learning using the STEM approach fits the course of high school vocational learning which subjects in learning require complex knowledge. STEM education is an integrated education., technology, Formal engineering, and mathematics based on curriculum (Aini, 2023). STEM education can also be carried on in a non-formal way through nonjury and nonjury activity. STEM education is expected to form a highly skilled human resource that can provide innovation. By (Becker, 2011) STEM definition is an approach to learning between two or more in the STEM component or between one STEM component and another discipline. STEM learning is a collaboration of the four ideal fields of science between the problems that occur in the real world of (Torlakson, 2014). The exposure can be summed up by STEM learning is the process of learning to solve a problem with systematic research., by doing both observation and Fiji try (science), using a field of mastered science (tech), and utilizing the tools available (tech).

STEM has been widely applied in improving learning comprehension, According to (Fathoni A., 2020) STEM learning has been successfully applied both outside and domestically, STEM learning has proven can increase students' creativity and critical thinking ability, STEM learning can be integrated with some learning models such as project-based learning, problem-based learning or cooperative learning model, STEM learning makes learners more confident towards future careers in the field of STEM, STEM learning is very suitable to be used in 21st-century learning.STEM learning applications have shown an increase in comprehension, especially among the teachers of Madiun City by 26.35 %. Teachers have a good involvement in drafting STEM-based learning plans to be applied in each participant's school (Setiawan Nur Candra Eka, 2020). The results of studying with the STEM model are excellent. This approach can create a cohesive learning system and an active learning system because all four aspects are needed simultaneously to solve the problem (Riyanto, 2021). Based on a survey the growth of STEM jobs is projected higher than non-sySTEM jobs. Other than that., In terms of appreciation., STEM work will also provide a higher income than the non-sySTEM employment field (Suwardi., 2021). Interesting. The goal of this research is to figure out the impact of STEM's approach on the creative thinking skills of the student education IPA particularly on the concept of genetic engineering material.

2. Research Methods

The method of study used is the quantitative research method by taking from the project worksheets students and the creativity prototype genetic engineering. The data by granting worksheets to students when learning STEM. The research was done in a student of 25 students in Semester 4. Quantitative data analysis by taking the worksheets students by 4 indicators of creative thinking skills (fluency, flexibility, originality, and elaboration). The rubric creative thinking skills assessment is shown in Table 1.

Table 1. The rubric creative thinking skills assessment

Indicator	The students' responeses to the questions of problems	Score
fluency	Do not answer or provide an idea which is irrelevant to the problem	0
	Provide an idea which is irrelevant to the problem solving	1
	Provide 2 irrelevant ideas but the answer is incorrect	2
	Provide 3 irrelevant ideas but the answer is incorrect	3
	Provide 3 relevent ideas and the completioan is correct and clear	4
Flexibility	Do not answer and give an answerin one or more methods but they are incorrect	0
	Give an answer in one method and it is correct	1
	Give an answer in 2 method and they are correct	2
	Give an answer in 3 method (various), the process and result are correct	3
	Give an answer in 3 method (various), the process and result are correct	4
Originality	Do not answer or gave an incorrect answer	0
	Give 1 answer on his own but it is not understandable	1
	Give 2 answer on his own, the process is directed but unfinished	2
	Give 3 answer on his own, but there is a mistake during the process and make the result incorrect	3
	Give 3 answers on his own, the process and result are correct	4
Elaboration	Do not answer or give the incorrect answer	0
	Give one answer and there ia a mistake while answering and the answer has no details	1
	Give two answers and there are some a mistake while answer, but it has less-detailed description	2
	Give three answer and three are some mistake while answering, but the description is detail	3
	Give more than three correct and detailed answers	4

Adapted to the rubric assessments and judgment to analysis using the following formula:

$$Score \frac{The\ score\ obtained}{The\ maximum\ score}\ x\ 100$$

Analysis was converted using the creative thinking skills category in Table 2.

Table 2. The rubric creative thinking skills assessment

Criteria	Value range
excellent	81-100
good	61-80
fair	41-60
less	21-40
poor	0-20

3. Results and Discussion

The research was conducted on students of science education in semester 4 with 25 students. Results of the research were obtained from the average value of the worksheet of education students according to 4 indicators of creative thinking skills. Creative thinking skills results are presented in Table 3.

Table 3. The result of creative thinking skill

Indicator	∑ Students	Average (%)	Category
Fluency	25	77,6	Good
Flexibility		84,8	Excellent
Originality		87,2	Excellent
Elaboration		91,2	Excellent
Overall score		85,2	Excellent

Based on table 3. It can be seen that the indicator of having average score of 77,6 % with good category. This is because they refer to something, these ideas, and alternative answers during creative thinking (Handayani, 2021). And presented the learning process capable of producing STEM students with ideas to solve the problems given on the student worksheet. Flexibility has average score of excellent % 84,8 categories, this is apparent from students who can adapt to resolve new ideas and can see from different points of view (Handayani, 2021). In question is, students can provide various new ideas capable of supporting the role of genetic engineering in the food sector in the community.

The originality indicator has an average score of 87.2 % with excellent categories, this is shown by students to be able to give you unique new ideas., By giving his opinion on the superiority of society's genetic engineering product. It's reinforced by the many ideas that come from students to explain and develop their thinking skills about the excellence of the GMO plant which is the product of genetic engineering. Elaboration indicators have a score of 91.2% with excellent categories. This is shown by the focus of the student's answer in giving his opinion in a case of problems in society about genetically engineered products. Based on the opinion that students should be able to give the right answer and certainly not just one correct answer or in the sense that students give three correct answers to the problem presented. Based on the overall result of the creative thinking skills of science education students 85.2 % with excellent categories. This shows that STEM learning has an impact on the creative thinking skills of science education students. This is supported by experts who argue that STEM learning can have a significant impact on student's creative thinking skills. And STEM learning also gives students experience in collaborating between technological sciences., engineering, and math to optimize learning (Iskandar., 2020). This is also supported by another opinion, which states that learning STEM in Indonesia, can improve the creative thinking skills of students., This increase was intended to improve the performance of students (Rana, 2023). Creative thinking skills are needed for students to compete globally. This is because creativity is one of the keys to the competitiveness and development of national talent for the future. Skills were among the ten great skills that are required for the success of the future (Ho., 2024).

STEM learning gives an interesting impression because it helps students to understand the concept of genetic engineering that is too abstract, so misconceptions can be avoided. Interesting learning provides intrinsic motivation for students so that it increases student involvement in creativity (Mou., 2024). Genetic engineering talks about a technique in engineering the genes of a living creature to produce a new organism with superior quality. To be able to address society's problems or in other ways to make people's lives easier (Alemayehu, 2019). The fascination of STEM learning can be felt with the enthusiasm of students in putting together recombinant DNA which will be made from the fusion of bacteria plasmid with Bt genes and GFP genes, which can be seen in the following 1 Figure,

Figure 1. Students ordered DNA recombinant

Based on the Figure 1. It can be seen that students are required to be creative in cutting a plasmid and gene targets by the use of one of 3 restriction enzymes already provided the Ecor1, HindIII pst1, and sticky ends with a cut. Students have to be creative and know the criteria of any restriction enzymes. This is because the enzymes that cut 3 the same sticky ends but code nitrogenous bases can be cut off any difference a restriction enzyme. A restriction enzyme is an enzyme that acts to cut a DNA sequence to fragments DNA. Cutting a restriction enzyme depending on the characteristics of a restriction enzyme recognizes a DNA sequence will be cut (Ramya, 2023). Types of restriction enzymes are very many but the ones used in this prototype are only 3 to facilitate students. Of these differences, the student must be able to solve the problem to be able to strengthen the concept of genetic engineering. Many terms to understand and some techniques in genetic engineering. With tool limitations and the need to understand the idea of genetic engineering for science education students, Then the DNA test is done to determine the pathway to the resurrection. This is in line with the expert opinion that DNA modeling will make it easier for students to understand abstract genetic concepts. Modeling or a prototype will provide enthusiasm to students in learning the concept and actively involve students in the learning process (Julia, 2020). The active students in the learning process will provide meaningful learning and understanding of the concept of good genetic engineering. So, misconceptions can be avoided and creative thinking skills students can also increase and be able to compete globally later in society.

4. Conclusion

This study concludes that the impact of STEM learning can grow the creative thinking skills of students in science education in understanding the concept of genetic engineering. The overall average of the intellectual skills of the students in science education is 85.2 % with excellent categories. This shows the learning of STEM being able to develop students' creative thinking skills., In addition to avoiding misconceptions of the concept of genetic engineering by drafting the prototype DNA recombinant by students.

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