Enhancing Creative Thinking and Communication Skills Through Engineering Design Process (EDP) Learning Model: A Case Study

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Article Info	ABSTRACT
	The aim of this study is to determine the effect of the Engineering Design Process (EDP) learning model in improving 21st Century skills, students' creative thinking and communication skills on the subject of basic concept of genetics. Using a mixed-methods (qualitative and quantitative) approach, the authors aimed at identifying the effect of the EDP learning model implemented on Science Education undergraduate students, Manado State University. Our proposed learning model developed students' creative thinking and communication skills in one class with 20 participants who enrolled in a course in General Biology I. Data collection techniques were used to assess creative thinking and communication skills, using written test data and observation data, respectively. The effectiveness of the EDP learning model is confirmed by calculating the average overall score of students' creative thinking assessment of 88,44% with an excellent category. Similarly, the results of student collaboration skills showed a score of 82,19% also with an excellent category. Based on these results, it was revealed that students' creative thinking and communication skills could be increased by using the EDP learning model.
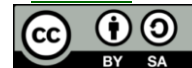
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1. INTRODUCTION

21st century skills are a well-accepted development in the world of international education, consisting of six headings: collaboration, communication, information and communication technology literacy, socio-cultural skills and citizenship, creativity, critical thinking, problem solving, and development of quality products good (Van Laar, Van Deursen, Van Dijk & De Haan, 2017). Characteristics of 21st century students include cognitive skills under the sub-themes of non-routine problem solving, critical thinking, and systems thinking; interpersonal skills under the sub-themes of complex communication, social skills, teamwork, cultural sensitivity, and dealing with diversity; and intrapersonal skills under self-management, time management, self-development, self-regulation, adaptability, and the executive function sub-themes.

How to develop 21st century learning skills arose with the question of how to organize the learning environment for 21st century individuals. This situation raises questions about the role of schools in developing students' skills. There is too much debate about how to teach these skills (Hakkinen et al., 2017). As a result of research by Zehra Onur (2020), it was concluded that there is a moderate, positive and significant relationship between the learning skills of 21st century students and educational technology competence. In addition, it was determined that students' educational technology competence was a significant predictor of their 21st century learning skills and could account for about a quarter (25.1%) of their 21st century learning skills. In teacher education and in-service training programs, teachers need to be well-educated so that they can contribute to the development of 21st century students and technology skills.

Science technology engineering and mathematics (STEM)-based learning is learning that is very suitable for improving students' 21st century skills. According to Atabey (2021) STEM-based learning has a positive correlation with students' 21st century skills. Likewise, the results of research by Zorluoglu (2021), show that teachers create limited metaphors for their knowledge of STEM and 21st century skills prior to STEM courses, while they create more comprehensive metaphors for STEM skills and 21st century as a result of awareness and

knowledge after a STEM course. Thus, STEM learning is needed to improve students' 21st century skills, so that students are able to adapt in everyday life.

This study uses the Engineering Design Process (EDP) learning model. The EDP learning model is based on several articles that have been analysed by Merve Arık (2020), the result is that some researchers use open questions and problem scenarios when presenting design summaries and use different teaching methods, mostly brainstorming, laboratory activities, and writing activities, while utilize the engineering design process. And also when creating design artifacts, researchers use four different steps, namely drawing, making, testing, redesigning. It is believed that this study will guide future science researchers and teachers in planning and implementing engineering design processes in classrooms K-12.

2. RESEARCH METHOD

This research was done at the Universitas Negeri Manado, Science Education Department. The respondents were 20 students taking a course in General Biology I. This study uses mixed methods, namely qualitative and quantitative. The data collection method used for communication skill assessment was an observation. The observer performed the observation by assessing each student's communication skills during group discussion. The data collection methods used were the assessment of creative thinking skills using tests. The test consisted of written questions that had been systematically planned by the teacher to measure the students' cognitive ability and learning achievement. The data from the results of this creative thinking skill test was obtained from students' worksheets in essay format. Student worksheets contained essay questions designed to improve students' creative thinking skills. The process of working on these problems was in the Create stage.

This study uses the EDP learning model. The application of the EDP learning model is carried out with steps namely Identify the need or problem, Research the need or problem, Draw/sketch possible ideas/solutions for the problem, Select the best possible solution(s), Design and construct a prototype, Test and evaluate the solution(s), and communicate the solution(s). In the first step, students will identify the problems given by the lecturer. The problem given in this research is "How are traits, such as the hair shape or skin colour of creature, transmitted from parents to offspring?". Based on these problems, they try to find the literature needed to find possible solutions that can be made. Furthermore, students will design the possible solutions they have found. Students will choose the best solution from several solutions found, which will then create a prototype based on the best solution. After testing and evaluating the solutions made, students presented their work in front of the class.

In this research, the researcher used four indicators in the assessment process. The four indicators along with their items can be seen in Table 1.

Table 1. Indicators and items of creative thinking questions

No.	Aspect	Indicator	Question
1	Fluency	Giving more than one relevant idea and correct and clear solution	You are given a mysterious pea plant with tall stems and red flowers, and asked to determine its genotype correctly. You know the allele for tall stems (T) is dominant to stunted stems (t) and that red flowers (M) are dominant to white flowers (m). Write down all the possible genotypes of the pea plant!
2	Flexibility	Give answers with more than one way (various way)	You are given a mysterious pea plant with tall stems and red flowers, and asked to determine its genotype correctly. You know the allele for tall stems (T) is dominant to stunted stems (t) and that red flowers (M) are dominant to white flowers (m). List all possible genotypes of pea plants. Cross one of the genotypes you wrote down. Include the cross table!
3	Originality	Giving answer with their own way	You are given a mysterious organism that has the following genotypes. You are asked to determine the gametes in each individual a. AaBBCcDd b. KkLLMmNnOOPp
4	Elaboration	Focusing answers	Charles and Elaine are a married couple with heterozygous AB and B blood types. Describe using the table the percentage of possible blood groups in their offspring!

Indicators of creative thinking skills according to Munandar (1999) with modifications. In assessing each indicator of creative thinking skill, an assessment rubric was used. This rubric to assess creative thinking skills is provided in Table 2.

Table 2. Assessment rubric of creative thinking

Indicator	The students' responses 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

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	Provide 2 irrelevant ideas but the answer is incorrect	2
	Provide 3 irrelevant ideas but the answer is incorrect	3
	Provide 3 relevant ideas and the completion is correct and clear	4
Flexibility	Do not answer and give an answer in 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 methods and they are correct	2
	Give an answer in 3 methods (various), the process and result are correct	3
	Give an answer in more 3 methods (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 answers on his own, the process is directed but unfinished	2
	Give 3 answers 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 is a mistake while answering and the answer has no details	1
	Give two answers and there are some mistakes while answer, but it has less-detailed description	2
	Give three answers and there are some mistakes while answering, but the description is detailed	3
	Give more than three correct and detailed answers	4

Meanwhile, to analyse students' oral communication skills, researchers used qualitative data, by way of observation. This rubric to assess oral communication skills is provided in Table 3.

Table 3. Indicator of communication skill

Score	Criteria Element	4	3	2	0
/4	Student group demonstrates presentation delivery techniques (e.g., posture, hand gesture, eye contact, and vocal expressiveness).	All group members demonstrate professional delivery techniques that enhance the cohesion of the presentation including: confident tone voice and projection, purposeful pace and enthusiasm.	All group members demonstrate professional delivery techniques, yet delivery techniques may be ridged or unnatural which compromised the cohesion of the presentation.	A majority of group members demonstrate some professional delivery techniques yet inconsistencies compromise the cohesion of the presentation.	Delivery techniques of all group members detract from the cohesion of the presentation.
/4	Student group demonstrates use of language by using clinical terminology which avoids slang and layman's terms.	All group members demonstrate authentic use clinical term authentic use term without slang and layman's terms.	All group members demonstrate authentic use clinical terminology throughout most of the presentation, with minimal slang and layman's terms	A majority of group members attempt fluency of terminology, yet elements of layman terminology exist throughout the presentation.	Most group members do not use clinical instead use slang and layman's terms.
/4	Student group demonstrates interaction with supporting material by using demonstrations, illustrations, and models.	All group members demonstrate Interaction with supporting materials by using a variety of demonstrations, illustrations, models which enhances the credibility of the presentation.	All group members demonstrate Interaction with supporting materials by using limited variety of demonstrations, illustrations and models which enhances the	A majority of group members attempt interaction with supporting materials to enhance the credibility of the presentation by using one of the following	All group members do not use supporting materials which diminishes the

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Score	Criteria Element	4	3	2	0
			credibility of the presentation.	types: demonstrations, illustrations or models.	credibility of the presentation.
/4	All group members consistently demonstrate techniques to engage the audience and enhance the quality of the presentation: provocative questions using humour and other means to elicit a response from the audience.	All group members consistently demonstrate techniques to engage the audience and enhance the quality of the presentation: provocative questions using humour and other means to elicit a response from the audience. All group members consistently demonstrate techniques to engage the audience and enhance the quality of the presentation: provocative questions using humour and other means to elicit a response from the audience.	All group members demonstrate techniques to engage the audience by using a limited variety of the following that may not necessarily enhance the quality of the presentation: posing provocative questions, using humour, and using other means to elicit a response from the audience.	A majority of the group members use either some or only one of the following audience engagement techniques, but they may be used inappropriately or ineffectively: posing provocative questions, using humour, and/or using other means to elicit a response from the audience.	Most or all group members do not use audience engagement techniques.

The rubric of communication skills (Oral communication) is taken from David (2017).

Creative skills are measured using question sheets at LKM according to the indicators used. Meanwhile, communication skills were measured using an observation sheet when students discussed and presented the results of the discussion in front of the class. The results of student work and observations are assessed according to the assessment rubric, then analysed using the following formula.

$$Score = \frac{Obtained\ score}{Maximum\ score} \times 100$$

Then the values obtained are converted using the categories of creative thinking and communication skills in the Table 4

Table 4. Criteria on the value range of creative thinking and communication skills

Criteria	Value range
Excellent	81-100
Good	61-80
Fair	41-60
Less	21-40
Poor	0-20

The Criteria table on the value range of creative thinking and communication skills was adapted from Widoyo (2012).

3. RESULT AND DISCUSSION

As many as 20 students as respondents in this study. They are students who are taking General Biology I course. This study uses the EDP learning model to determine the increase in students' creative thinking and communication skills. The test method is used to assess students' creative thinking skills, which consists of 4 questions on the student worksheet (LKM). Each question represents an indicator in creative thinking skills.

Based on the results of the study, data on students' creative thinking skills were obtained in Table 5. And students' oral communication skills in Table 6.

Table 5. Data for creative thinking skills of natural sciences education students

Indicator	Students	Mean score (%)	Category
Fluence	20	88,75	Excellent
Flexibility		92,50	Excellent
Originality		86,25	Excellent
Elaboration		86,25	Excellent
Overall mean score		88,44	Excellent

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Table 6. Data for communication skills of natural sciences education students

Indicator	Students	Mean score (%)	Category
Groups of students demonstrate presentation layering techniques (eg, postures, hand gestures, eye contact, and vocal expressiveness).	20	78,75	Good
Student groups demonstrate use of language using clinical terminology avoiding slang and lay terms.		85,00	Excellent
Groups of students demonstrate interaction with supporting materials by using demonstrations, illustrations, and models.		86,25	Excellent
All group members consistently demonstrated techniques to engage the audience and improve presentation quality: provocative questions using humor and other means of eliciting a response from the audience.		78,75	Good
Overall mean score		82,19	Excellent

Based on table 4, the average score of the overall indicators is 88.44% with a very good category. In the analysis of students' thinking skills, it is obtained from the results of the answers given by students to each question that has been given on the student worksheet (LKM). Furthermore, in table 5, the average score for the overall indicator is 82.19% with a very good category. This data was obtained based on observations by observers when students made presentations in front of the class, by observing students' oral communication skills based on the communication skills assessment rubric.

In addition, documentation of student product results in solving a problem regarding the basic concept of genetics can be seen in the image below.
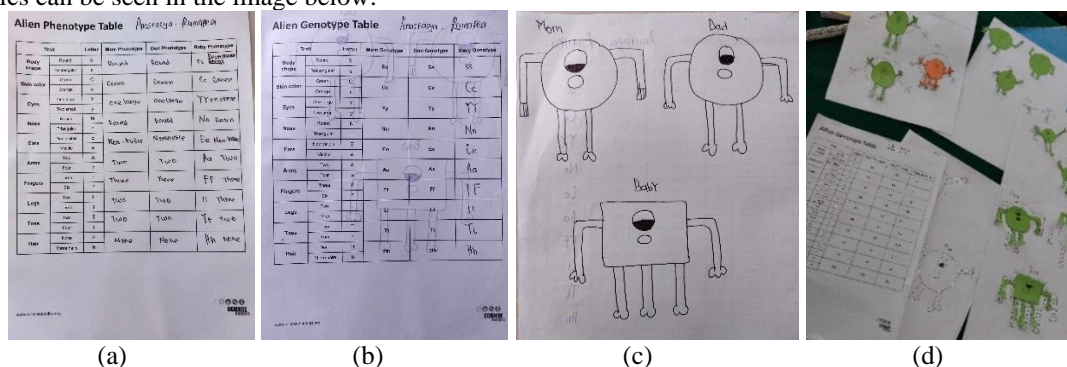

(a) (b) (c) (d)

Figure 1. Prototype and final product of problem solving by students. The picture above, (a) and (b) shows students worksheet. Picture (c) shows the prototype of their solution, and figure (d) shows final product of problem solving by students.

This study aims to improve several 21st century skills, namely students' creative thinking and communication skills in General Biology 1 learning. The learning process used by researchers uses the Science Technology Engineering and Mathematics (STEM) approach, with the Engineering Design Process (EDP) learning model.

STEM learning with mastery of multidisciplinary knowledge needs to be optimized in schools in Indonesia so that the expected learning objectives are in accordance with the demands of the 21st century. The application of STEM education can develop students' thinking and logic in various fields of knowledge, this is in accordance with the objectives contained in the Indonesian education curriculum (Nurhayati, 2020). STEM-based learning can create the necessary learning environment for 21st century skills, in this case and design, plan and solve problems in an organized way (Akcanca, 2020). Problem-based learning increases learning activities, motivates students to learn independently to find information themselves from various sources, such as the environment, media and the internet (Choiriya, 2019) and students can follow the learning well (Fattahillah, 2019). One of the problem-based learning is the EDP learning model.

The EDP learning model is a problem-based learning model, with steps namely Identify the need or problem, Research the need or problem, Draw/sketch possible ideas/solutions for the problem, Select the best possible solution(s), Design and construct a prototype, Test and evaluate the solution(s), and communicate the solution(s) (Siew, 2017). In the EDP learning model, there is the most important step, namely prototype construction. During this step, an idea can be further developed according to the features of the prototype, and the feasibility of some desired changes to the specifications of the prototype can also be assessed (Lin, K.Y., 2021).

Several steps in the EDP learning model, namely Draw/sketch possible ideas/solutions for the problem, Select the best possible solution(s), Design and construct a prototype, Test and evaluate the solution(s), are able to make students think creatively in solve a problem. At this stage students are required to produce the best solution in

solving the problems received. Yusnaeni (2017) said that creative activities improve 7 diverse thinking skills, even in the same problem. In this study, researchers provide a case regarding the basic concept of genetics. This case is packaged in a unique story form, which is about the genotypes and phenotypes of the alien pair. From the same genotype and phenotype, each student is required to calculate the possible genotypes and phenotypes of the alien offspring. The results obtained will be very different from one student to another.

Creative thinking skills are one of the 21st century skills that students need to develop so that they are able to adapt in everyday life. Creative thinking skills help students solve problems and find the right solutions (Gok, 2022). So, students must have a learning experience that is able to train their creative thinking skills in the classroom. This can make their creative thinking skills grow. One of the learning models that can be used is the EDP learning model with the STEM approach. Based on the results of the research described above, it can be seen that the use of the EDP learning model can improve students' creative thinking skills. Students made a prototype that contained the solutions to the problems and presented different prototype results. Furthermore, the prototype was chosen by the group to develop the right solution for a problem. This activity improved students' creative thinking skills (Aini, 2020).

In the final stage, namely Communicate the solution(s). Students are required to communicate the results of their discussions with the group in front of the class. At this stage, students are directly able to hone communication skills. Students will try to communicate their ideas correctly, and try to discuss with other friends about the problem. This activity is very effective in facilitating interaction between students and lecturers. This also allows interaction between students regarding how they should behave in front of the class and how they divide tasks among each member for presentations.

According to Cavanagh (2019), oral communication skills are very important for students' academic and professional success. This is because the experience of communicating in public, verbal persuasion, and coping mechanisms to deal with physiological arousal can increase the self-efficacy of students' oral communication. This self-efficacy will be associated with oral communication performance, and also positively influence overall academic performance.

4. CONCLUSION

EDP learning model improved students' creative thinking skills with an overall score of 88,44%. The students' communication skills increased with an overall mean score of 82,19%. The use of the EDP learning model can improve students' creative thinking skills. There is the most important step, namely prototype construction. Students made a prototype that contained the solutions to the problems and presented different prototype results. Furthermore, the prototype was chosen by the group to develop the right solution for a problem. This activity improved students' creative thinking skills. In the final stage, namely Communicate, that is able to make students to improve their communication skills in class.

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