Integration of Learning Science, Technology, Engineering, and Mathematics (STEM) in The Wetland Environment Area to Increase Students’ Creativity

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Abstract. In the era of industrial revolution 4.0, creativity is a key factor to face the challenges and opportunities of the increasingly complex development of science and technology. This requires the world of education, especially those located in the wetland environment to develop student creativity in exploring and maximizing the potential of the surrounding wetland environment. This study aims to determine the effect of STEM-based learning on the level of scientific creativity of students in solving renewable energy problems in the wetland environment. This research has involved 45 students who have applied Physics courses. The research method used is qualitative and quantitative methods (mixed methods) to determine the level of student creativity based on creativity review as 4P (Person, Process, Product, and Press). The results showed that the level of student creativity was influenced by STEM-based learning; where creativity is a key factor in the integration of science, technology, engineering, and mathematics, and its application in solving problems in the wetland environment.

1. Introduction
The era of the industrial revolution 4.0 with 21st-century learning that has competencies in life and career skills, learning and innovation skills, information skills, media technology with a support system in the form of assessment standards, curriculum, professional development, and learning environment [1]. This can be seen in Figure 1 which demands the success of students in gaining skills, knowledge of all time. In this 21st century, skills and types of work change according to the demands of the times, the work that was originally done by humans was replaced by machines, but the need for communication and technology experts is higher [2].
Figure 1. 21st Century Learning

The innovation skills needed in learning include creativity, collaboration, communication and critical thinking [3,4]. The education curriculum in Indonesia seeks to realize students who have the competencies needed in the 21st century in the era of the industrial revolution 4.0 through the development of creative education towards "Creative Indonesia 2045". However, this has not been supported by learning in Indonesia which is still memorized by conventional teaching [5,6]. This makes students' creativity cannot develop according to the demands of the times.

The integration of Knowledge Science, Technology, Engineering, and Mathematics needs to be done in the learning process in the wetland environment area [7,8]. The teacher designs a learning plan that integrates STEM knowledge to improve problem-solving and decision making abilities in the wetland environment area [9]. STEM can develop students' creativity in solving problems of daily life. Students can understand and apply STEM meaningfully following the development of ideas in solving problems faced, especially in the topic of renewable energy in the wetland environment.

Much research has been done on STEM, however there is not much to discuss about STEM in the wetland environment. This study aims to determine the dimensions of student creativity through the integration of STEM knowledge in the wetland environment area with the topic of renewable energy. The Project-Based Learning model is used to explore creative products as a result of students working on projects. This study answers research questions consisting of: (1) How is student creativity through the integration of STEM knowledge in wetland environments ?, (2) How is the level of student creativity viewed from the dimension of creativity ?.

2. Method
Creativity is one of the keys to success in life. Creativity can be trained and developed to explore the potential of students through the learning process [10]. This study involved 45 prospective physics teachers who programed Applied Physics in one of the LPTKs in Banjarmasin. This course weighs 2 credits during 14 meetings through six stages of learning as shown in Table 1.

Table 1. Stages of learning

| Stages | Activity                      |
|--------|-------------------------------|
| 1      | Identifying the Problem       |
| 2      | Exploring Problems            |
| 3      | Formulate and Analyze Ideas   |
| 4      | Designing Project             |
| 5      | Creating and Testing a Project|
| 6      | Report Project Results        |
Students are guided in recognizing the state of the energy crisis that occurred in Indonesia in particular by exploring the energy problems that occur in the wetland environment and directed to solve these problems through the empowerment of renewable energy. Through this activity, students participate actively and contribute through the theme of renewable energy in the wetland environment by making creative products through the integration of STEM. Students are divided into 9 groups with different projects. The projects are chosen by each group based on the identification and exploration of problems that occur in the surrounding environment with the theme of renewable energy. The projects undertaken include solar cell, wind, water, and soil energy in the wetland environment.

The research method used is a mixed method (qualitative and quantitative) as shown in Figure 2 [11].

Quantitative data were obtained from tests of creativity, tests of concepts about energy, and assessment of creative products. Qualitative data were collected through interviews, questionnaires, responses, and student journals. The instruments were validated by analyzing the Content Validity Ratio (CVR) [12]. Then a paired t-test was conducted to determine the effectiveness of the integration of STEM knowledge on the dimensions of student creativity in the wetland environment.

3. Results and Discussion
The research results are divided into two parts that answer the research questions. The first part explains how the creativity of students through the integration of STEM knowledge in the wetland environment. The second part explains how the level of student creativity is viewed from the dimension of creativity.

3.1 Student creativity through the integration of STEM knowledge in the wetland environment.

The creative thinking ability test is conducted before and after learning (initial and final tests) to find out whether the integration of STEM knowledge in the wetland environment can increase student creativity. Students' creative thinking skills consist of four indicators namely fluency, flexibility, originality, and elaboration [13,14]. Paired t-test results of the dimensions of student creativity for each indicator consisting of components of fluency, flexibility, originality, and elaboration can be seen in Table 2.
Table 2. Results of paired t-test on the dimensions of student creativity

| Subject  | Pre-test/Pos-test | Paired Differences M (SD) | t    |
|----------|------------------|--------------------------|------|
| Fluency  | Pair 1           | 4.258 (2.764)            | 7.631*** |
| Flu-pFlu |                  |                          |      |
| Flexibility | Pair 2          | 4.722 (2.174)            | 11.279*** |
| Fle-pFle |                  |                          |      |
| Originality | Pair 3           | 3.391 (2.534)            | 6.662*** |
| Ori-Pori |                  |                          |      |
| Elaboration | Pair 4          | 2.714 (2.771)            | 5.632*** |
| Ela-pEla |                  |                          |      |

*p<0.05, **p<0.01, ***p<0.001

In Figure 3 states the average increase in the percentage of indicators of students' creative thinking abilities during pre-test and post-test.

![Figure 3](image)

Figure 3. Average percentage of pretest and postest creative thinking abilities

Indicators of fluency in creative thinking skills increased by 16%, flexibility by 18%, originality by 15%, and elaboration by 18%. From the results data, it can be stated that learning through the integration of STEM knowledge in the wetland environment can increase the dimensions of student creativity. In the activity of identifying problems, exploring problems, formulating and analyzing ideas, dimensions of student creativity on flexibility (t=11.279; p<0.001), and fluency (t=7.631; p<0.001) showed good development. Students can identify problems in the energy crisis by offering creative solutions to the wetland environment.

The next stage, design, and design a project to apply the ideas that have been analyzed. Students learn to identify problems, offer alternative solutions, and design projects through the integration of STEM knowledge in wetland environments with a variety of creativity. During the project design activity, the group that designed the power plant using peatlands revised the project design that it had designed. At first, the use of peat soils only used one jar, but after testing it turned out that it could not yet turn on the LED lights as an indicator of the flow of electricity. Then the use of peat soil is propagated into two jars, apparently, the lights are unstable. Then 3 peat soil jars are used, the light is dim. After being propagated to 4 jars, the light can light up. This shows that students have collaborated to solve problems well. This success is a series of activities and experiences done by students learning from failure. Student learning activities through STEM integration can be explained as shown in Figure 4.
| Activity | Integration STEM knowledge |
|----------|-----------------------------|
| 1. Identifying the Problem | **Science**<br>Electrolysis is the measurement of an electrolyte by an electric current. In electrolysis cells, chemical reactions will occur if an electric current is passed through an electrolyte solution. |
| 2. Exploring Problems | **Technology**<br>Peat soil pH is the acidity of the peat soil. The pH of peat soils can be measured using a pH meter, the pH of peat soils is manipulated twice as much as 4.8 and 3.8. Strong current is the amount of electric charge that can flow in a conductor in one second. Current strength can be measured using an ammeter and expressed in Amperes (A). The type of positive electrode is the metal material used as a positive pole, the type of metal used for the positive electrode is copper (Cu). The type of negative electrode is the metal material used as the negative pole, the type of metal used for the negative electrode is zinc (Zn). Conducting cable is a conveyor wire from the electrode to the ammeters, in this experiment the type of cable used must be maintained that is using copper wires. The temperature of the room is the change in heat in the room. Room temperature can be measured using a thermometer and can be expressed in units of Celsius, Kelvin, Reamur, and Fahrenheit. The room temperature is maintained at 25 °C. |
| 3. Formulate and Analyze Ideas | **Engineering**<br>The prototype of a simple power plant used by the writer applies the electrochemical principle or often called Galvani Cell. Electrical energy can be generated because there is acid content in peat soil. According to the electrochemical principle, a solution that is strong acid or strong base can generate electrical energy. |
| 4. Designing Project | **Mathematics**<br>Mathematical calculations on the flow of electricity flowing on peat can be formulated as follows:<br>1. \( P = \frac{W}{t} \)<br>2. \( W = I^2 \cdot R / t \) |
| 5. Creating and Testing a Project | **Figure 4. Integrated learning activities STEM knowledge** |
The findings of the study explained that the dimensions of student creativity developed well through the integration of STEM knowledge in the wetland environment. Increased student creativity is a learning process activity to jointly solve problems that are following the four pillars of education, namely learning to know, learning to do, learning to be, and learning to live together [15,16].

3.2 The level of student creativity based on the dimensions of creativity

The dimensions of student creativity are grouped into four elements which are often called the 4P component consisting of Person, Process, Product, and Press [17,18]. Human characteristics as individuals must have a sense, work, creativity that involves personality, motivation, intelligence, thinking style, emotional intelligence, and knowledge [19].

| Subject | Pre-test/Pos-test | Paired Differences M (SD) | T     |
|---------|------------------|---------------------------|-------|
| Person  | Pair 1           | 8.14                      | 6.17***|
|         | Per-pPer         | (7.47)                    |       |
| Process | Pair 2           | 14.43                     | 10.23***|
|         | Pro-pPro         | (7.62)                    |       |
| Product | Pair 3           | 18.19                     | 23.63***|
|         | Prd-pPrd         | (4.23)                    |       |
| Press   | Pair 4           | 11.19                     | 7.15***|
|         | Pre-pPre         | (9.32)                    |       |

*p<0.05, **p<0.01, ***p<0.001

The results of data analysis stated that students experienced significant changes in all components of the 4P creativity dimension as seen in Table 3. Product Components (t = 23.63; p <0.001) experienced the biggest changes, then Process components (t = 10.23; p <0.001), the Press component (t = 7.15; p <0.001), and the smallest change lies in the Person component (t = 6.17; p <0.001).

Based on these results it can be stated that the learning process through the integration of STEM knowledge can increase the dimensions of student creativity effectively. Besides, the learning process through STEM integration can create a learning environment that encourages students to explore the dimensions of creativity to the fullest.

4. Conclusion

Creativity is one of the main keys that must be mastered by students in 21st century learning in the era of the industrial revolution 4.0 in the rapid development of science and technology. This study aims to determine the dimensions of student creativity through the integration of STEM knowledge in the wetland environment. Based on the results of the study, it can be concluded:
1. The learning process through the integration of STEM knowledge in the wetland environment can enhance student creativity in terms of creative thinking skills consisting of fluency, flexibility, originality, and elaboration.
2. The learning process through the integration of STEM knowledge in the wetland environment can increase the dimensions of student creativity components of the dimensions of creativity consisting of Person, Process, Product, and Press.

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