STEM Learning Activity through Tempeh Making Process

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Abstract. The paper will clarify the STEM learning activity by tempeh making process, which provides through Sutaphan and Yuenyong context-based STEM education learning approach. This approach consists of 7 stages including (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage. The Learning Activity will bring students to practice integrated knowledge among chemistry, mathematics, biology, and economics to design their products. The activity may have implications for developing STEM learning activity in schools.

1. Introduction

Currently, many teachers have been persuaded using STEM (Science, Technology, Engineering, and Mathematics) Education to implement in their schools. Applying STEM is the answer for the 21 century challenging that demand the students' abilities to solve a problem and critical thinking. The idea of STEM is in line with today's curriculum in Indonesia, which is the curriculum 2013 [10], [16].

The primary purpose of the curriculum 2013 is to prepare Indonesians to have the competence to live as individuals and citizens who are loyal, productive, innovative, creative, and able to contribute to the life of the people, nation, country, and the world civilization. One of the philosophies in the 2013 curriculum is education to build a better experience now and in the future with a variety of intellectual abilities, communication skills, attitudes, and take part in developing a better society and nation life. With this philosophy, the curriculum 2013 intends to establish the potential of students into the ability to think reflective for solving social problems in society and building a better democratic society [1], [11], [16].

Using STEM in Science Education to address the current issue or phenomena is the best approach to achieve the learning output in the curriculum 2013. Science education research needs to pay more attention to the lifeworld contexts to bring up the connection among science, humans, and society [2], [19]. If the learning is fascinating the fruitful achievement will come up. It can be seen by students thinking, perseverance, and creativity [3], [17], [18]. Also, the integration makes meaningful learning for students. According to Novak [4], meaningful learning happens when integration concepts meaning are in our cognitive structure.

At present, engaging students in learning science through STEM is challenging. Some teachers at the secondary level consider that the integration of STEM curriculum a challenge [5]. The other teachers perceived that using STEM adds their workload and time. Besides, they also lack knowledge related to STEM topics and administrative support. [6]
Providing learning activity topics in STEM is one alternative way to encourage teachers to overcome the problem of lack of knowledge about STEM topics. By doing so, it can attract teachers to implement STEM in their classroom instead of using teacher-centered strategies. Using a problem related to their daily life can make a connection to their prior knowledge and become meaningful learning to achieve lesson aims.

The learning activity must in line with the competencies in the curriculum 2013. Therefore, science teachers need to concern with two main categories of skills, which are Main Competencies (Kompetensi Inti [KI]) and Basic Competencies (Kompetensi Dasar [KD]). Teachers are asked to integrate these two sets of competencies in their subject matter curriculum. [7] The success of STEM according to the teacher perception is that the availability of a quality curriculum. [8]

2. Developing STEM Education Learning Activities

One of the activities that can be developed is tempeh making process. Tempeh is one of the local fermentation foods in Indonesia. In Indonesia, tempeh is called “tempeh”. Most of the people in Indonesia get familiar with tempeh. Tempeh has many nutrients inside with cholesterol-free and low-sodium. To make tempeh, people use soybeans as raw material. Although in several places use other beans, soybeans tempeh is the dominant one. The ideas using tempeh as STEM sources based on the problem in society, which is most of the tempeh makers rely on soybeans. Even though there are so many beans that can be developed or made into tempeh, students will be challenged by their thinking to solve the problem in society.

The content of making tempeh based on the main competency “Understanding and applying knowledge (factual, conceptual, and procedural) based on his curiosity about science, technology, art, culture related to phenomena and events seen in the eye” and basic competency “Present data and reports on the application of biotechnology to support human survival through food production”[1]

Based on the competency mentioned above, then conducting the purpose of the lesson plan as follows:
1. Explain the scientific principles about the fermentation process
2. Explain the factors affecting the fermentation
3. Identify the microbe in tempeh product
4. To design tempeh by using different kinds of beans or raw materials
5. Investigate the fermentation process
6. Explain the process of creating the prototype/product.

Sutaphan and Yuenyong [9] suggested the STEM education pedagogy that was widely adopted in southeast Asia [12], [13], [14], [15]. The tempeh STEM education learning activity was developed based on seven steps of Sutaphan and Yuenyong [9] which the context-based STEM, education learning approach, included (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage [9]. The lesson plan could be highlighted in table 1.

Table 1. Lesson Plan on Tempeh Making Process

| Stage                      | Activity                                                                 |
|----------------------------|--------------------------------------------------------------------------|
| 1. Identification of social issues | 1. Teacher ask students to discuss about fermentation food in Indonesia (local food).<br>Teachers show small experiment related to fermentation process using small bag contained sugar and yeast.<br>Students observe the activity.<br>Teachers ask students why fermentation important?<br>Teacher provide problems related to tempeh production. |
Table 1 (Continued)

| Stage                          | Activity                                                                                                                                                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Identification of social issues | 2. “The raw material to make tempeh is soybeans. Hundreds of tempeh tofu makers currently rely on imported soybeans as raw material. As a result, they could not do much if the price of imported soybeans soared. Meanwhile, local soybean supply is only able to meet 30 percent of the needs of craftsmen. Actually local soybeans are quite good for tofu and tempeh, but the availability is not sustainable.  
3. Teacher asks student is it possible to make tempeh using a different type of beans or raw material?  

![Picture 1. Soybean Tempeh](source picture: health.detik.com)  

Picture 1. Soybean Tempeh  

| 2. Identification of potential solution | Students discussing their possible designing based on Sciences (chemistry, biology), Technology, Engineering, and Mathematics. For examples, students may come up with some ideas of capitals as following:  
- Biology: Observing what kinds of microorganism involve in tempeh fermentation  
- Chemistry: what types of fermentation, what the results of the fermentation  
- Technology and Engineering: Making tempeh with different raw material and Designing a package/using different types of packages  
- Mathematics: Measure the time of fermentation  
- Financial: How to make an efficient tempeh with a cheap cost |
| 3. Need for knowledge | Students discuss and searching on the internet or literature about the things of fermentation, the microorganism that will be used and kinds of beans, packages and how to sell the product. Besides, they can ask directly to the local tempeh manufactures.  
Students do activity to identify microbe in soybeans tempeh. |
Table 1 (Continued)

| Stage                      | Activity                                                                                                                                 |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 4. Decision-making        | After students have the knowledge about all of capitals and learning activity                                                                 |
|                            | 1. Students, which work in group of 4-5 people, will present their idea in front of the class and explain what beans that they will choose and what kind of modification they will do. |
|                            | 2. After class presentation session, each group will be needed to finalize their design before starting to develop their product.            |
| 5. Development of prototype or product | Steps to make tempeh as follows :                                                                                                           |
|                            | 1. Soak the beans                                                                                                                         |
|                            | 2. Rub the beans to remove the skins                                                                                                       |
|                            | 3. Cook the beans                                                                                                                         |
|                            | 4. Dry the beans and add tempeh starter                                                                                                    |
|                            | 5. Fill and flatten in the bags                                                                                                            |
|                            | 6. Incubate the tempeh                                                                                                                    |
|                            | Students develop their tempeh based on their design. Students make experiment using soybeans tempeh as control. Students must consider about the time for fermentation, color, aroma, texture, cohesiveness and package. |
|                            | Students observe the tempeh product and fill in the table.                                                                                  |

| No | Time fermentation | Color | Aroma | Texture | Cohesiveness |
|----|-------------------|-------|-------|---------|--------------|
| 1  | 24 hour           |       |       |         |              |
| 2  | 48 hour           |       |       |         |              |
| 3  | 72 hour           |       |       |         |              |

6. Test and evaluation of the solution | Students will be asked to develop some ideas how the quality of product. The member of the will take a look of the time of fermentation, taste, aroma and texture compare to the soybeans tempeh. They will conduct a small survey to determine consumer preferences, and product prices. Is the product profitable or not? The students also can test the nutrient content in the new product compared to soybean tempeh and identify the microorganism that they found. |

7. Socialization and completion decision stage | 1. Present and explain what their product are. How they develop their product, how they explain about biotechnology process in making tempeh. |
|                                               | 2. Share what they learn from the comment and what they will revise for the completion solutions. |
|                                               | 3. The last, convince audiences that their products are worth selling and profitable. |
3. Conclusion

This paper shared the learning activity in STEM education by tempeh making process. The STEM steps based on Sutaphan and Yuenyong which consist 7 steps namely (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage. The tempeh making process will provide students insight and experience to conduct small research, develop their product, and to sell the product. By solving problems and apply their scientific knowledge, students will learn meaningfully.

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