Developing the lesson plan of the manufacturing fish drying
STEM Education

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Abstract. The paper will clarify STEM education learning activity of the designing of the manufacturing fish drying. The STEM education learning activity was developed based on Sutaphan and Yuenyong [17] the context-based STEM education learning approach. The activity will start from context of Indonesian favourite dry fish. Then, the issue of manufacturing the drying fish will be raised in order to motivate students to practice knowledge for designing the fish dryers and process of fish drying. Through their designing, the lesson plan will provide students chance to practice integration of knowledge. These knowledge include nutrients in dry fish, fish species, measuring sizes of fish, energy sources, chemistry in preparing fish for drying, capitals analysis, marketing functions (e.g. buying and selling, pricing, grading, weighing, storage, transportation, financing and market information). And, students could learn to practice not only STEM knowledge and skills but also entrepreneurship education. This paper may have implications for designing STEM education learning activities.

Keywords. STEM education, nutrition, fish, dryer, manufacturing, entrepreneurship

1. Introduction

STEM Education is an educational approach that integrates science, technology, engineering, and mathematics. STEM education focuses on the problems in real life to enhance the experience; creative life skills and preparing students for globalization that require advanced knowledge and science process skills. Math and technology could be applied to the creation of innovations in the future. The full educational of STEM learning process is learning through activities or projects that integrate learning in science, mathematics, technology combined with engineering design concepts. Moreover, engaging students will participate in activities to develop knowledge and understanding as well as practice science skills to design outcomes or methods that bring innovation. The product of the design process STEM education does not mean strengthening the educational practice in the fields of STEM separately, but it aims to explicate an educational approach that integrates science, technology, engineering, and mathematics focusing on educational processes of problem-solving in daily life and
professional life [1]. Previous studies showed that STEM approach improves students' understanding of integrated STEM learning and students' power of imagination in project-based activity [2]. Furthermore, project-based learning integrated with STEM in class enhances students' science literacy [3]. It can be said that, faced with the needs or solve problems related to daily life by project-based learning give a direct meaningful science learning.

STEM approach in Indonesia is looking for real-life and prepare equipment as well as materials of practice on technology. To solve these obstacles, the things done by the teacher are to seek information from various sources such as books from within and outside the country and the internet then developed and modified to fit the conditions in Indonesia [4], [5], [6], [7], [8], [9]. The aspects of STEM approach in Indonesia is focused on Interdisciplinary integration, it is a learning approach in which students can combine the content of other fields with science and technology. Furthermore, students practice skills at least 2 subjects together, with activities linking all subjects. For students to see the consistency in the type of learning approach, besides teachers in related subjects must work together. The content or indicators is matched and designed learning activities in the courses by linking with other subjects through the content or indicators involved with science. After studying the subjects, students require more understanding of knowledge to the relationship among subject matter. Suprapto [10] reported that STEM provided available the new knowledge and technologies that are needed to address challenges. Moreover, Oktavia et.al. [11] revealed that STEM created the environment to build students' critical thinking, problem-solving, communication, and collaboration. For future study, it is important to take place the STEM education programs and to consider the 21st century skills as a foundation for STEM careers.

Fish gives a good balance of protein, vitamins and minerals thus constituting more than 60% of total protein consumption in adults in rural fishing areas [12]. It is a broadly known sensitivity that cuts across socio-economic, age, religious and educational barriers [13]. Fish products are the most vital source of animal proteins in Indonesia. Fish and fishery products are a significant food element for a large part of the world's population, particularly Indonesia. In tropical regions, conservation of fresh fish remains a problem because of the lack of suitable arrangements, and environmental and climatic conditions that subsidize to its spoilage within few hours [14]. To prevent fish damage and reduce postcapture losses, various preservation methods including frying, fermentation, drying, salting, and smoking are used [14], [15]. The issues of fish could be context of STEM education in school setting. This paper aim to integrated Project-based learning with STEM education through the natural resource in Indonesia also know ‘Dry fish’ to investigated learning process about implementation of subjects to design media or innovation outcomes on ikan asin.

2. Developing the manufacturing fish drying STEM Education learning activities
The developed lesson plan of the designing of the manufacturing fish drying STEM education learning activities were developed based on Sutaphan and Yuenyong [16] the context-based STEM education learning approach. The context of Indonesian favourite dry fish will be provided in order to enhance students to make the prototypes or products of manufacturing the drying fish. Regarding on Sutaphan and Yuenyong [16], 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.

The 7 stages of context based STEM education teaching approach, the activities may motivate students to practice knowledge for designing prototypes of the fish dryers and process of fish drying. The integration of knowledge could be provided; for examples, include nutrients in dry fish, fish species, measuring sizes of fish, energy sources, chemistry in preparing fish for drying, capitals analysis, marketing functions (e.g. buying and selling, pricing, grading, weighing, storage, transportation, financing and market information). And, students will have also chance to apply their scientific and other knowledge for problem solving in context of engineers, technology, or
entrepreneurship [16]. The highlight of the manufacturing drying fish STEM education learning activities could be viewed as showed in the table 1.

**Table 1:** highlight of designing the manufacturing fish drying STEM education learning activities

| Stage | Activity |
|-------|----------|
| 1. Identification of social issues | Fishes being one of our natural resources which easy to find in Indonesia. Especially in Sumatera, fish dominates as our daily food. Indonesian love eating and our favorite is Dry Fish. Does the student discuss which species of fish that will be best to process as Dry fish? Why Indonesians like dry fish, and what is their opinion when they eat dry fish? The teacher ask students to do manufacturing the drying fish. Students may design a small enterprise that manufactures the drying fish with the help of relatively smaller machines and a few workers and employees. Products/prototypes: the fish dryer and process of fish drying |
| 2. Identification of potential Solution | 1. Students and teachers share the cost analysis in the design of their “ikan asin” (dry fish) dryer product. 2. Students may discuss their possible design on the ikan asin regarding the five capitals: physical, financial, social/technology, human, and natural capitals. Physical – energy sources for drying fish Financial – Using good but affordable local ingredients and selling it with affordable prices and dry fish with long last saving period Social/Technology – appropriate materials, drying techics materials, find ways to solve the problem Human – The safety of food and its nutritional value Natural – The use of organic ingredients |
| 3. Need for knowledge | 1. Study nutrients in dry fish. The experiment of determination of protein content will be provided based on Lowry et al. [17] protein content of hydrolysate solutions. The protein concentration in the solution was quantified from the standard curve using bovine serum albumin (BSA). The hydrolysate solutions were diluted to different protein concentration for carrying out the bioactivity assays [18]. 2. Study kinds of fish in local areas. They need to clarify fish species, sizes of fish, and so on. 3. Study energy sources for drying fish. The following energy sources will be proposed (i) solar drying; (ii) firewood/ saw-dust drying and (iii) waste oil burner technology [19]. 4. Project-Based Learning (PBL) of reviewing the fish drying techniques and dryers. Each group will have 4 to 5 members to work for PBL. Then, students may do following activities: 4.1 Students may tap or ask help from traditional dry fish manufacturers on how to make an Ikan Asin. They could also interview food technologists on what ingredients to be used in order to produce a healthy Ikan Asin. 4.2 Students may review process of fish drying e.g. using salt of NaCl as natural preservatives in fish. |

**Table 1:** (Continued)
| Stage                        | Activity                                                                                                                                                                                                 |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4.3 Students may review the existing fish dryers. They may find the Hohenheim solar tunnel dryer as figure 1 [19], a hangar fish dryer as figure 2 [20], the microwave drying as figure 3 [21], or heat exchanger tube arrangement as figure 4 [22]. CHEMISTRY – using salt of NaCl as natural preservatives in fish PHYSICAL – radiation on spot sunlight as a tool for dry fish MATHEMATICS – the ratio of the ingredients ikan asin such as salt, fish, and solar sunlight ARTS – creative packaging of *Ikan Asin* ECONOMICS – to increase sale marketing in fish yet, but still can affordable for society and to increase income fisherman and dry fish maker The students develop Scientific and Technological Literacy is the aim of K to 12 Education. |
| 4. Decision making          | Students have to make decision on developing prototypes of the fish dryer regarding on following aspects.  
- Capitals analysis  
- Considering factors of choosing energy source technology (e.g. productivity, income generation, and availability of fish or its by-products in the surveyed areas). [18]  
- Marketing functions. Students may consider marketing functions of dry fish that has been broken down into various functions such as buying and selling, pricing, grading, weighing, storage, transportation, financing and market information etc. [23]. |
| 5. Development of prototype or product | 1. Students may design the process of fish drying. They may conduct it for two weeks and also make a video or picture for documentation for all steps in making dry fish. Students will be guided with the following questions during their activity:  
1.1 What are the ingredients you are using in your *Ikan Asin*?  
1.2 Cite the specific ratio of ingredients such as fish, salt, and how many days you need to make dry fish?  
1.3 what are health benefits inside dry fish?  
1.4 What step in your procedure where you can see the heating temperature in the process of dry fish?  
1.5 What is the story behind your packaging/branding?  
1.6 Did you enjoy the activity? Why or why not?  
1.7 What values have you learned from the activity? |
Table 1: (Continued)

| Stage                      | Activity                                                                                                                                 |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 5. Development of prototype or product | 2. Students may develop prototypes or products of the fish dryer. They may construct their ideas of prototypes regarding on literature review as the figure 1 – 4. Students will be guided with the following questions during their activity: 2.1 What materials will be used for each part of dryer? 2.2 What is the maximum amount of fish in the minimum time? 2.3 What is quality of the dried fish? For example, quality of the dried fish should be determined by direct sensory evaluation by consumers and their acceptance of the product, which was usually reduced to a maximum of 30% of its original weight [20] 2.4 What is appropriate temperature for drying? For example, solar tunnel dryer should provide temperature of 60°C inside the dryer in order to produce the optimum trade-off between minimising microbial growth and minimising deterioration (tanning as well as taste and smell alterations) [20]. 2.5 For solar dryer, students will be asked how much the velocity of the air delivered by the ventilator should be provided. [20] 2.6 For microwave dryer, students will be asked. How much microwave power levels should be provided to investigate the effects of microwave power on drying of fish? What is maximum weight of fish in a microwave drying? How long of microwave drying should be provided for moisture loss of fish was recorded until no detectable weight change? [21] |
| 6. Test and Evaluation of the solution | Students may test and evaluate their prototypes or products about the fish dryer and process of drying regarding on the following issues.  The teacher may ask this question: "Aside from Ikan Asin making activity, cite other examples where the concepts of heating temperature on the process of dry fish?"  How long to reach the appropriate dry fish based on temperature, maintaining nutrients, health and safety (minimising microbial growth), tasty and smell alterations, size of fish  Fish - maintaining nutrients, health and safety (minimising microbial growth), tasty and smell. The experiment of determination of protein content will be provided based on Lowry et al. (1951) protein content of hydrolysate solutions.  The appropriate temperature of dry fish based on maintaining nutrients, health and safety (minimising microbial growth), tasty and smell alterations, size of fish, time of drying  How many dry fish will be produced by the dryer a day?  the development of an efficient method for their use, comparison of the results with traditional drying techniques, and testing the ease of use and comprehension of the user and construction manuals (Heilporn et.al, 2010)  What and how marketing function about the dry fish was considered and evaluated? |
Table 1: (Continued)

| Stage                          | Activity                                                                                                                                                                                                 |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7. Socialization and completion| Each group will make a vlog on their final product and publish it on social media. They can also display their output in the school and sell it. In this way, they will also learn the value of entrepreneurship. An IKAN ASIN will commence, and there will be a distinguished panel of judges to be invited. An open forum will commence so that the students will use this information to improve their product better. The issues of aesthetic value/packaging/branding, texture, taste, cost, and nutritional value may be reflected in order to improve their prototypes or products. |

According to the table, some stage of teaching will be clarified more details. In need for knowledge and development of prototype or product stages, teachers may foster to review the fisher dryer in order to scaffold students to develop concepts of their prototypes or products about the fish dryers. The examples of dryers included the the Hohenheim solar tunnel dryer as figure 1 [19], a hangar fish dryer as figure 2 [20], the microwave drying as figure 3 [21], or heat exchanger tube arrangement as figure 4 [18].

![Figure 1: the Hohenheim solar tunnel dryer [19]](image1)

**Figure 1:** the Hohenheim solar tunnel dryer [19]

![Figure 2: a hangar fish dryer, the fish are laid on wood boards attached to upright wooden struts and the whole structure is covered by a mosquito net [20]](image2)

**Figure 2:** a hangar fish dryer, the fish are laid on wood boards attached to upright wooden struts and the whole structure is covered by a mosquito net [20]
3. Conclusion

This paper showed how to provide STEM education through Sutaphan and Yuenyong [16] context based STEM education learning approach. The issues of manufacturing the fish drying will be discussed. Then, teacher will ask students to think about if possible to produce the fish dryers and process of fish drying. The possible the designing the manufacturing the fish drying will be discussed through list five capitals, some existing knowledge and requiring knowledge for further designing.

Then, classroom will move to the need for knowledge stage where students will investigate knowledge related to their possible designing the manufacturing the fish drying. Teacher may scaffold students to read the literatures related to the manufacturing the fish drying. That knowledge includes; for examples, nutrients in dry fish, fish species in local areas, measuring sizes of fish, energy sources for drying fish, literatures of the fish drying techniques and dryers. After students learn some more related knowledge, they could develop their prototypes or products which concurrent through knowledge based that could be provided on the decision making and development of prototype or product stage. The questions as scaffolding of students’ making the prototypes of the dryer and process of fish drying.
will be provided in the development of prototype or product stage. These scaffolding included what ingredients and its ratio using in fish drying, what materials for constructing a dryer are, what the maximum amount of fish in the minimum time is, what the quality of dried fish is, what appropriate temperature for drying is, and so on.

The test and evaluation of the solution stage, the scaffolding questions will be also provided to support students’ development of test and evaluation framework. These questions, for examples, included 1) test about time of drying - how long to reach the appropriate dry fish based on temperature, maintaining nutrients, health and safety (minimising microbial growth), tasty and smell alterations, size of fish; 2) test about quality of dried fish – it maintains nutrients, health and safety (minimising microbial growth), tasty and smell, 3) test about appropriate temperature that depends on maintaining nutrients, health and safety (minimising microbial growth), tasty and smell alterations, size of fish, time of drying; and so on.

In the socialization and completion decision stage, students may learn to improve for completion of their prototypes and products of dryers and process of fish drying from social media and a distinguished panel of judges. Through socialization, they may learn the value of entrepreneurship because the designing of the manufacturing the fish drying may allow students to learn about some constrains such as affordability, attitudes, social acceptance, entrepreneurial and technical skills [18].

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