The learning of aquaponics practice in university

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Abstract. This study aims to obtain a description of the performance capabilities of aquaponic technology and the assessment of product and packaging of harvest kale. The aquaponic practice used a STREAM (Science Technology Religion Art Mathematics) approach. The method was explanatory sequential mixed method. The research was conducted on one class of Biology Education students in 6th semester. The sample was chosen purposively with 49 students. The study instruments are student worksheet, observation sheet, rubric performance and product assessment, interview sheet and field notes. The indicator of performance rubrics on the manufacture of aquaponic technology consisted of the product rubric, cultivation criteria and packing method of kale. The interview rubric is in the form of student constraints on the manufacture of aquaponics. Based on the results, most students have performance in designing technology that is categorized as enough up to good. Almost all students produce a very good kale harvest. Most of the students produce kale packaging products that are categorized as enough. The implications of this research are the learning of aquaponic with the STREAM approach can equip student’s performance and product capabilities.

1. Introduction
The aquaponics is one topic of the Urban Farming Movement. The Aquaponics is a combination of vegetable cultivation and fish farming [1]. Indonesia especially Bandung is facing a problem of a constriction of agricultural land [2]. In Indonesia, data from Badan Pusat Statistik on February, 2016 showed that unemployed graduates increased by 20% compared to February, 2015 [3]. Indonesia has abundant human resources requiring preparation in facing the ASEAN Economic Community. The Implementation of the ASEAN Economic Community has had an impact with the entry of foreign workers into Indonesia. It is a challenge and an opportunity to provide good management of Indonesian human resources [4]. A college graduate is one of the human resources. The Government issued Presidential Regulation number 08 of 2012 regarding KKNI (Kerangka Kualifikasi Nasional Indonesia/Indonesia National Qualifications Framework) to meet the needs of the world of work [2]. In KKNI has a terminology is learning outcomes in accordance with the profile of graduates. The undergraduate profiles on Biology Education Studies Program in one State University on Bandung are Biology Educators, Researcher Educational and Edupreneur [2].
The one approach to learning that can be done to prepare the undergraduate profiles through STREAM (Science Technology Religion Art Mathematics). STREAM is the development of STEM that have been developed in other countries, example United States [5], Japan, Australia [6], Turkey [7], Malaysia [8]. STEM learning has been widely carried out through a variety of research in Indonesia. STREAM is following the steps in the form of cycle design engineering process that include: Ask, Imagine, Plan, Create, Improve, back to ask and so on. Ask: The first cycle begins with a question step on the problem at hand. Imagine: the second cycle is continued by thinking and using knowledge, creative ideas to solve problems. Plan: the third cycle is thinking of materials / materials / resources to create technology. Create: the step in fourth cycle is creating the design and follow the plan that has been made before. Improve: the fifth cycle is analyzing the technology that has been made whether it works or not. If the technology is not working properly then the technological design is redesigned so that it can work according to the purpose of manufacture [6]. Indicators of religion are appreciating, living and implementing the religious teachings adhered [9]. Religion adhered in this study is Islam because this study conducted on Islamic University. Art associated with creativity, innovation, design in making technology and the products produced [10,11]. The Next Generation Science Standards (NGSS) issued a framework for students. This framework helps students to build three-dimensional learning. Three dimensions include scientific and engineering skills; the concept of cross-cutting (cross-cutting concepts) in studying science and engineering; and understanding of the core material in the study on science [5].

The STREAM learning is suitable using performance assessment and product assessment. The performance assessment is an alternative assessment to observe and evaluate the results of creative skills/products. In the performance assessment and product assessment using guidelines is the assessment rubric. The one of form of assessment rubric is an analytic rubric with specific criteria [12]. Biology Education Studies Program in Bandung city, Indonesia. Biology Education has a fish pond measuring 1.5 meters x 3.5 meters in the area of Biological garden. The fishes that are being cultivated are tilapia. Kale is one of the plants that is suitable for aquaponics. Kale is a fast growing plant [1]. This study cultivates the kale to harvest. Based on this background, a research question is developed: "What is the general overview of student performance assessment and product assessment in aquaponic experiment with the STREAM approach?". After that, another further research question were asked, such as: performance assessment in producing aquaponic technology, assessment of kale production, product assessment in packing kale harvest and challenges that the students faced in the practice of producing aquaponics. The objective of the study was to obtain a general overview of student performance assessment and product assessment in aquaponic experiment with STREAM approach.

2. Methods
The method of explanatory sequential mixed methods design [13]. The quantitative data derives assessment of performance and product assessment by making a percentage. The qualitative data comes from group interviews and field notes. The purposive sampling is a Biology Education student of 6th semester of class A. The purposive sampling because class A has more male students amount than of class B. The number of samples is 49 students. It consists of 10 male students and 39 female students.

The indicator of performance assessment rubrics is the creation of aquaponics technology that is appropriate to the design. The rubric of product assessment that is good of the kale harvest criteria and way of packing of the kale post-harvested. The interview rubric is student's constraints on aquaponics practice. The instruments has been validated by 2 fellow lecturers, 1 expert from Studies Program of Biology Education and 3 experts as advisory commission.

Students have been divided into some groups. The one group consists of 3 people to facilitate observation and enable student performance in aquaponics practice. Interviews were conducted to 9 students. The group interviews consists of 3 upper groups, 3 middle and 3 lower groups.

Before the aquaponic practice was carried out, the students were assigned to make mini-proposals. The mini-proposals contain the problem of producing aquaponics, how to solve the problems of aquaponics, the theory of aquaponics, determining the tools, materials, workings, design of the
manufacture of aquaponics. The students were assigned to draft a budget for the manufacture of aquaponics and to integrate the manufacture of aquaponics with the religion aspect.

3. Result and Discussion

3.1. The student's performance assessment of the aquaponics technology production

Figure 1 shows the performance results on creation of aquaponics technology that match the design. Figure 1 shows that student performance is 14.28% categorized very good; 42.86% is categorized enough; and 42.86% are poor categorized. These results show that most students already have enough performance in the creating of aquaponics technology. Based on field notes, students were seen active in aquaponics practice. Before of aquaponics practice, students assigned to make of aquaponics mini-proposal according to worksheet.

![Performance Results of Aquaponics Technology Production](image)

**Figure 1.** Figure of The Student’s Performance Assessment of The Aquaponics Technology Production

In the previous study, the topic of composting showed that the students' performance assessments reached 100% categorized as poor on the manufacture of composter technology [2]. Thus, on the performance of producing aquaponics, there was an improvement that most of the students had performance assessments categorized as enough until very good. Meanwhile, some of the other students had performances categorized as poor. Those students still had a difficulty in designing the technology of aquaponics. Based on the field notes and observations it is found that there was still a discrepancy in the tools, materials, and workings of aquaponic production that had been written in mini-proposals with real conditions during the practicum. The students were still having difficulties in designing technology because they were not familiar with the Student Worksheets using STREAM approach. The students feel that the time was not enough to make mini-proposals [2].

3.2. The student's product assessment of the kale harvest

Figure 2 shows product assessment of the kale harvest produced by students. The results showed that among others 81.63% is very good category and 18.37% is good categorized. These results have shown that most students has very good category in production the kale. Thus, there was no repetition of Aquaponics production because the products assessment on the kale were already categorized as very good and good. It is based on STEM learning that the STEM stages on the Improve stage by analyzing the technology created whether work or not, changing the design back better [6].

3.3. Product assessment of kale harvesting package

Figure 3 shows the assessment in packaging the kales. Packaging kale products related to aspects of Art on the STREAM approach. Figure 3 shows that the ability of students in packaging the kales, those were 24.49% in very good category and 75.51% were categorized as enough. The results have shown that most of the compost were packaged differently with other groups. The students did not give the reasons
for the selection of packaging and the packaging used was less interesting. The packaging of kale harvest products meets one criteria on the rubric assessment so it is categorized as enough. However, when compared with compost lab work that some of the compost packaging products were categorized as poor. Thus, the students already have improvement in the packaging of kales.

**Figure 2.** Figure of The Student’s Product Assessment of The Kale Harvest

**Figure 3.** Figure of The Student’s Product Assessment of Kale Harvesting Package

### 3.4. The student constraints in the aquaponics practice

Based on the results of the group interview to 9 students (3 students of upper category, 3 students of medium category, and 3 students of lower category). The questions posed were student difficulties in aquaponics practice. Students are familiar with prescription of practice modules and demonstrations conducted by lecturers before lab work. Thus, students seek information about the creating of aquaponics by searching for other sources of learning. Students learned the tutorials of aquaponics on the internet.

Another constrain, students had difficulty in cultivate of the kale. Snail pests had attack the kale. The kale experienced nutrition less so that the growth was less good. However, the results of the study show that ability of student in the harvesting of kale was largely categorized in very good. In fact, if the kale maintained very good still so allows overall of the harvesting kale was very good category. The other difficulty of maintaining of the kale due to technical constraints was distance between the lecturing building and fish pond far apart. The students allowed the kale to grow by themselves without the controlling of snail pests. The students did not seek any other information about pest control and nutrient addition on the kale.

The performance assessment in indicators of the aquaponic technology. The product assessment are the harvest of kale and the packaging of kale. STREAM perspectives used in this study is a perspective originated from STEM ie technology, engineering, and mathematics that are intercepts are in the science
[14] STEM added aspects of religion and art. It is chosen because the technology, religion, engineering, art and mathematics involved are interrelated and supportive of science. The crosscutting Analysis Concept of STREAM which refers to STEM. Cross-cutting concept facilitates students to make interdisciplinary connections: Science, Technology, Religion, Engineering, Art and Mathematics. The crosscutting concept will make students better understand science and engineering in theory and practice [5]. The Cross-cutting Concepts Analysis of Aquaponics is presented in Table 1.

**Table 1.** The Cross-cutting concepts analysis on aquaponics practice concepts that surround of the subject matter (science)

| The aquaponic production | Process: ask-imagine-plan-create-improve |
|--------------------------|------------------------------------------|
| 1. The requirements of the planting media for plants | Ask : Identifying the problems and creating the research problems |
| 2. The type and composition of the planting media for plants | Imagine : Looking for solutions to the problem of the aquaponic production |
| 3. The preparation procedures of planting media for plants | Plan : Determining the planting media for the kale, tools, materials, designed techniques to produce aquaponics |
| 4. The type of fishes | Create : Creating the planting media for the kale and aquaponics according to the design that had been created |
| 5. The type of plants | Improve : Analyzing and testing the results on created aquaponic according to its function. Whether the produced Aquaponics worked according to the design. If the aquaponics did not work according to the design then re-design is done to get the result fit with the design. |
| 6. The aquaponic production procedure | |
| 7. The cultivation of fishes | |
| 8. The cultivation of plants (for example is kale) | |
| 9. The control of aquaponics to keep working | |
| 10. The criteria of kale that is ready to harvest | |
| 11. The procedure of harvesting the kale | |

| Cross-cutting concept | Explanation |
|-----------------------|-------------|
| 1. Cause and effect: mechanism and explanation | Cause and effect: students were guided to analyze the causal effects of the planting media and aquaponics can affect the growth of the kale. |
| 2. Scale, proportion and quantity | Scale, proportion and quantity: a bridge between science and mathematics in determining the composition of the types and planting media, measuring the growth of the kale until it is ready to harvest. |
| 3. Systems and system models | System and system models: a bridge between science and engineering by designing aquaponics |
| 4. Energy and matter: flows, cycles and conservation | Energy and matter: flows, cycles and conservation: The principle of aquaponics works by continuously utilizing water (recirculation) from the cultivation of the fishes to the kale and vice versa from the kale to the fishes’ pond. Water recirculation was driven by a water pump in a pond. The process on the aquaponics that remains fish feed and fish feces contains ammonia. The bacteria converted ammonia into nitrite and nitrate as fertilizer for plants. The Fish secreted the carbon needed for photosynthesis. The carbon needed for photosynthesis. Photosynthesis supplied oxygen and maintained water quality for the fishes’ growth. Photosynthesis requires solar energy [1]. |

| Technology | Religion |
|------------|----------|
| 1. Creating a combination of media | 1. Appreciating the islamic teachings: Taking care for the God-given natural resources for caring for the aquaponic by cultivating the |
2. Using simple tools and materials available in the environment in aquaponic production, fishes and kale plants, observing every day to ensure air circulation stays the way, stirring pools for nutrients to rise up to optimally absorbed plants. Maintaining the fish by feeding and caring for plants from pests and plant diseases. Plant growth is calculated every week. Observation is done until the spinach is ready for harvest that is marked by the height of kale is 25-40 cm, no more tillers and intricate stems.

2. Living the Islamic teachings: Thanking God for the available natural resources. Being grateful to God that He has created the fishes, the kale, the bacteria, the solar energy and various planting media for the kale used on Aquaponics. In aquaponics, the components involved were the fishes, the kale and the bacteria that had a mutualism symbiotic relationship (biotic factors). The abiotic factors were the energy of sunlight, oxygen, nitrate, nitrite, water, carbon, planting media that will affect the growth of fishes and the kale.

3. Implementing the islamic teachings (doing, applying, fulfilling, delivering): producing aquaponic to give benefit to the environment such as fishes get oxygen from the kale. The kale obtained a source of carbon from fishes and nutrients from the remaining fish feed and fish feaces. The rest of the fish feed and fish feces were unraveled by bacteria. Aquaponics provides economic benefits such as recreation, hobbies and oxygen for the environment. Aquaponics is an example of urban farming movement that has been delivered and will be continued to be socialized to the urban community of Bandung city. The aquaponic production as an act of worship that will be rewarded by God if it is done in the right way and sincerely.

| Art | Engineering |
|-----|-------------|
| 1. Creating a design of the planting media | 1. Creating the innovative and creative aquaponic technology |
| 2. Creating an aquaponic design by utilizing the tools and materials available in the environment | 2. Packaging interesting kale harvest products while still keep paying attention to the well kale post-harvest procedures |

Mathematics

1. Calculating the tools and materials needed
2. Determining the planting media composition for the kale
3. Measuring the growth of the kale
4. Calculating the required cost budget

(The Cross-cutting Analyses adopted from Bybee’s, 2013 and developed by Agustina, et. al, 2017)

Based on the results of the study, the performance assessment of the aquaponic production has increased compared to compost. The product of kale harvest and the ability to package the kale harvest when compared to the compost production showed an enhancement in capability of product assessment and in packaging of product [2].

4. Conclusion
The conclusion of this study is the assessment of student performance in producing technology that were categorized as enough. Almost all students produced a very good kale harvest and most students packaged the kales that were categorized as enough. Thus, the aquaponic learning can equip student’s performance and product abilities with STREAM approach.

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