Implementation of the aquaponic system as a learning medium approach for junior and senior high school students at the Indonesian school of Makkah

Darmawati Darmawati[1*], *Syamsia* Syamsia[2], *Andi Rahayu* Anwar[3], *Ilmas* Abdurofi[4], *Siti Suliza* Salamat[4], *Rosanna* Roasanna[2], *Burhanuddin* Burhanuddin[1], *Akmaluddin* Akmaluddin[1], *Aris Slamet* Widodo[5], *Mustafa* Mustafa[6], and *Novi* Delviana[6]

[1] Department of Aquaculture, Universitas Muhammadiyah Makassar, Makassar, Indonesia
[2] Department of Agrotechnology, Universitas Muhammadiyah Makassar, Makassar, Indonesia
[3] Department of Agribusiness, Universitas Muhammadiyah Makassar, Makassar, Indonesia
[4] Crop Production Program, Universiti Malaysia Sabah, Sabah, Malaysia
[5] Departement of Agribusiness, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
[6] Sekolah Indonesia Makkah, 18115, Makkah, Saudi Arabia

Abstract. Aquaponics is an agricultural system that combines aquaculture and hydroponic cultivation systems to produce more production at a low cost, limited land resource, water and labour efficiency. Aquaponic system cultivation activities could be applied as a medium level for learning in science and social studies outside the classroom or around the school environment. The learning methods of science and social studies in the schools are mostly carried out in the classroom, while students generally have difficulty in understanding the applied materials due to less interaction with the objects and lack physical activity which effecting students' interest to adapt the method. The community service of this activity aims to increase students' knowledge of biology and entrepreneurship subjects by using aquaponics as a fun learning medium approach. The activity was conducted at the Indonesian School of Makkah where teachers and students were joined as participants of this program. The implementation of the service activity was carried out through three stages: namely socialization, training and application. The results of the program provided incredible contribution to the enhancement of students' knowledge on biology and entrepreneurship materials at the Indonesian School of Makkah.

1 Introduction

Learning media is any form of tool, material, or environment used to facilitate the teaching and learning process with the aim of conveying information, material, or concepts to students in a more effective, interesting, and interactive way. Learning media needs to be designed in such a way as to increase student engagement, strengthen understanding, and support various

* Corresponding author: darmawati@unismuh.ac.id

learning styles and preferences that can be used individually or in combination to create a rich and diverse learning experience. Innovation in learning media is a very useful tool in learning especially in the 21st century by incorporating technology into learning to improve performance in learning skills and educational content in ways that are not possible in traditional classes [1].

Aquaponics is a food production technique that combines hydroponics with a recirculating aquaculture system for the simultaneous production of plants and fish [2], producing fish and vegetables at lower costs [3], utilizing aquaculture waste nutrients as fertilizer for plant growth and reducing environmental pollution [4].

The complexity of aquaponic systems requires careful planning and management to ensure the growth and production of fish and plants. Educators must find ways to reconcile the practical and interdisciplinary nature of aquaponics with established learning goals and standards. This requires careful planning and collaboration among educators from multiple disciplines [5]. It demands a level of commitment and consistency where resources and time are often limited [6]. Teachers must be equipped with the knowledge and skills necessary to design, implement, and manage aquaponic systems effectively. Without adequate training, the potential of aquaponics as an effective learning tool may not be fully realized [7].

Resource limitations can be overcome by implementing aquaponics in school gardens by utilizing available empty space. According to [8]; [9], school gardens provide an active learning atmosphere that strengthens academic, personal, and social skills. This is reinforced by [10]; [11], the application of aquaponics in school gardens as a learning medium for students is expected to develop physical motor skills, by exploring objects around them and learning while playing so that children are active and do not feel bored with activities.

The potential benefits of using aquaponics systems as a learning medium are quite large. Aquaponics systems not only promote sustainable food production methods but also offer a unique educational platform where students can observe and participate in real-world applications of biology, chemistry, physics, and environmental science [12], are engaging learning media [13], effectively attract students' interest in STEM-related disciplines and careers [14], are appropriate and effective for students [15], students directly learn science and mathematics [16], students' science communication and problem-solving skills are improved [17], students' interest in multidisciplinary subjects and understanding of complex topics are increased [18], increase students' environmental awareness, sustainability, and practical knowledge of food production [19], provide students with a rich, engaging, and meaningful learning experience [20].

Based on the description above, this activity aims to introduce the aquaponic system as a learning medium for teachers and students to improve their understanding of environmental issues and be more motivated to learn entrepreneurship from an early age by providing direct and experiential learning opportunities that can improve their understanding of scientific concepts such as biology, chemistry, ecology, and entrepreneurship.

2 Methodology

This international collaborative community service activity was carried out at the Indonesian School of Makkah, located at Hera Complex, Al-Gassalah District, Jabal Nur Makkah, Al-Gassalah District, Makkah, Saudi Arabia. The activity implementation teams are lecturers from the Faculty of Agriculture, Muhammadiyah University of Makassar and the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah. The participants of the activity involved with 2 teachers and 23 students of junior and senior high schools, Indonesian School of Makkah. The activity took place in August - September 2024. The method of implementing the activity is divided into three stages, namely socialization, training, and evaluation of the implementation of the activity.

2.1 Socialization

The socialization of the activity was carried out by the head of the research team from the Muhammadiyah University of Makassar with the teachers of the Indonesian Makkah school as partners in community service activities. The material presented was related to the objectives of the implementation, targets to be achieved, approach methods, implementation schedules, the roles of teachers and students during community service activities [21-22]. The activity was continued with a discussion to align perceptions about the right approach methods to be applied so that the objectives of the activity could be achieved according to the conditions of the partners (teachers and students) and the school environment to support the implementation of the aquaponic system as a learning medium for students.

2.2 Training

This training aims to improve the skills of teachers and students regarding the application of aquaponics as a learning medium. Although aquaponics offers many benefits in biology learning, its application in the schools is still facing several challenges such as limited facilities and costs to build an aquaponics system, as well as the lack of knowledge and skills of teachers in managing the system as a learning medium approach. According to [23], it is important to conduct training programs for teachers that they could learn how to manage this system as a learning medium approach.

2.3 Evaluation of services activities

The evaluation method used in the implementation of this activity is the Pre-posttest method in the form of a list of questions. Before the aquaponics training was carried out, junior high and high school students were tested first (pre-test) to determine the initial level of understanding. To improve understanding, then after the aquaponics training was carried out, junior high and high school students were tested again (post-test) to determine the extent of the level of absorption and mastery of aquaponics cultivation methods with the same instruments as during the pre-test activity.

3 Results and Discussion

3.1 Socialization figure

Socialization of the application of aquaponics as a learning medium approach for biology and entrepreneurship subjects by providing information to school principals and teachers about the working system of the aquaponics system (Fig.1) and learning materials related to biology and entrepreneurship subjects. According to [7], the use of aquaponics as a learning medium approach not only strengthens students' understanding of the material, but also encourages them to care more about the environment and sustainability. Furthermore, [12] found that the application of aquaponics has also been proven to improve students' scientific skills, such as observation, data collection, analysis, and problem solving.

Based on the results of the discussion, it was obtained that the teacher did not know and understand the working mechanism of the aquaponic system and its relationship to the subjects in the Indonesian Makkah school. However, after the team explained the aquaponic system and the working mechanism of this system, then continued with the teacher's explanation regarding the biology lesson material related to the aquaponic system and entrepreneurship, the SIM teacher explained that previously he had applied hydroponic

vegetables but the results were not as expected due to limited knowledge and equipment owned. Aquaponics also helps students understand the importance of cooperation between organisms in maintaining the balance of the ecosystem, thereby increasing their understanding of the importance of biodiversity in the surrounding environment. According to [24], through the application of aquaponics, students can learn how to utilize natural resources efficiently and sustainably. This is supported by [25], aquaponic-based learning is able to foster students' curiosity and increase their involvement in the learning process, because they can see directly how the theories learned in class relate to the phenomena they observe.

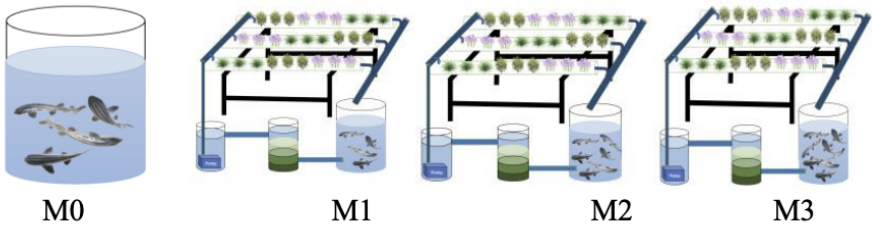

Fig.1. Ilustration of the working principle of the aquaponic system [24]

3.2 Training

This training aims to improve the skills of teachers and students regarding the application of aquaponics as a learning medium. The practice of implementing the aquaponic system begins with an introduction to the hydroponic system, aquaculture and business analysis. Aquaponics is a combination of hydroponics and aquaculture so that the discussion of aquaponics begins with an explanation related to the hydroponic system, which is a technique for cultivating plants without using soil, which is continued with an explanation of fish farming in ponds (aquaculture) and how to calculate costs, production and feasibility of aquaponic businesses. Aquaponics offers many benefits in learning, but its application in schools still faces several challenges such as limited facilities and costs to build an aquaponic system, as well as a lack of teacher knowledge and skills in managing this system as a learning medium. According to [22]; [23], it is important to conduct training programs for teachers so that they can learn how to manage this system as a learning medium.

The use of aquaponics in biology learning provides students with the opportunity to understand various ecological and biological concepts holistically. Aquaponics as an integrated farming system allows students to learn the relationship between fish and plants, where fish waste rich in nitrogen functions as nutrients for plants, while plants help filter water for fish. This process helps students understand how organic matter cycles in an ecosystem. This contextual learning is important to develop students' understanding of ecological concepts that may be difficult to understand if only taught in theory [12]. This is a direct example of mutualistic symbiosis, where two different organisms work together to mutually benefit each other [6]. According to [26], practice-based learning such as aquaponics helps students to more easily understand abstract concepts and makes learning more fun and meaningful.

Fig. 2. Plant nursery practices by students of the Indonesian School of Makkah.

In addition to improving the understanding of biological concepts, the application of aquaponics as a learning medium can also help develop students' scientific skills. In a study conducted by [7], it was found that students who learned through the aquaponics method showed improvements in observation skills, data collection, analysis, and problem solving. This is because aquaponics provides students with the opportunity to conduct simple research where they can observe plant growth and fish behaviour in a system that they maintain themselves. Students also learn to record and analyse plant growth data and changes in water quality in the aquaponics system, which can improve their understanding of the scientific method. The development of these scientific skills is also relevant to STEM (Science, Technology, Engineering, and Mathematics)-based learning, which is currently a major focus in global education. By using aquaponics as a learning tool, students can learn about science (biology), technology (aquaponics systems), engineering (system design and maintenance), and mathematics (measurement and data analysis) in one series of activities [23]. This approach allows students to develop the skills they need to face global challenges in the future.

The implementation of aquaponics also has a positive impact on increasing students' environmental awareness. In a study conducted by [27], students involved in learning through aquaponics showed an increased awareness of the importance of environmental sustainability and understanding the positive impacts of sustainable agricultural practices. Aquaponics as a learning medium not only teaches biological concepts, but also educates students about the importance of maintaining ecosystem balance and how humans can utilize natural resources sustainably.

Aquaponics not only serves as a tool for learning biology, but also as a means of in-depth and meaningful character learning [24]. Learning biology through aquaponics also has a positive impact on the formation of student character, especially in terms of environmental awareness. According to [27], students involved in aquaponic practices showed an increased understanding of environmental issues and were more motivated to contribute to environmental conservation efforts. This is in line with the objectives of the education curriculum in Indonesia which not only emphasizes cognitive achievement, but also the development of student character. By involving students in the process of maintaining the aquaponic ecosystem, they learn to be responsible for the organisms they maintain, thereby fostering a sense of concern for the environment and awareness of the impact of human activities on nature.

3.3 Evaluation of Services Activities

The program evaluation was conducted on 23 junior high and high school students who had participated in the activity. Indicators and benchmarks of success by knowing the increase in students' knowledge, skills, and motivation. Success criteria by comparing the level of knowledge and skills before and after the activity. The score value for the method of implementing aquaponics at Indonesian School of Makkah based on several indicators is presented in Table 1 and the score value of participant satisfaction with the implementation of the activity is presented in Table 2.

Table 1. Evaluation score for the implementation of community service

INDICATOR	SCORE	CRITERIA
Socialization	4.41	Very satisfied
Training	4.23	Very satisfied
Mentoring Activities	4.32	Very satisfied
Average Score	**4.32**	**Very satisfied**

Table 2. Community satisfaction score with program implementation.

INDICATOR	SCORE	CRITERIA
Program implementation	4.29	Very satisfied
Program suitability	4.36	Very satisfied
Solutions to problems	4.23	Very satisfied
Accuracy of appropriate technology	4.32	Very satisfied
Process & accuracy of empowerment methods	4.35	
Success confidence	4.38	Very satisfied
Average Score	**4.35**	**Very satisfied**

*Information
1.00 – 1.80 = Very Dissatisfied
1.81 – 2.60 = Not satisfied
2.61 – 3.40 = Neutral
3.41 – 4.20 = Satisfied
4.21 – 5.00 = Very Satisfied

Based on Table 1, it is known that the evaluation score of the implementation of the aquaponic application program as a learning medium approach for junior and senior high school students of Indonesian School of Makkah based on the indicators of socialization, training and mentoring activities is 4.32 with a very satisfied category. Based on Table 2, it is known that the participant satisfaction score for the empowerment program that has been implemented is 4.35 with a very satisfied category.

4 Conclusions

In conclusion, the application of aquaponic system as a medium approach for biology subject in junior and senior high schools at the Indonesian School of Makkah provides a positive impact on understanding and developing the applicable concepts, scientific skills, and students' environmental awareness. While students perceived very satisfaction from the community program. However, limited application and practical method of biology subject in the school faced a challenge that is required to be solved. The support from various parties to cater adequate training on aquaponics could be an effective and relevant learning medium practice for students in this modern era. By engaging students in contextual and interactive activities, the implementation of aquaponic program would improve the quality of biology learning and support the formation of environmentally conscious characters for the young generation.

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