# School Gardens: A Model to Support Project-Based Learning

**Puti Siswandari[✉1], Ulvi Asdi Salikha[2], Farah Falasifah[2], and Vira Nurofiah[2]**

[1] Biology Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia

[2] SD Laboratorium UPI Kampus Cibiru, Bandung, Indonesia

✉ puti.siswandari@upi.edu

**Abstract.** Since school gardens are located within the school grounds, the school garden provides an accessible learning environment outside the classroom. On the other hand, school gardens are hard to manage due to limited funding and staff. This study introduced STEM to school garden management using a project-based learning strategy. Participants in this study were nine students of sixth grade who were members of the Green Community extracurricular. Students participated in four stages of school garden STEM project: identify problem and context, background knowledge, problem-solving, and communication for the school garden maintenance. For data acquisition, field notes and photos were collected as observation during a period of twelve weeks of lesson. The result showed that students can actively contribute to the development of the school garden. Collaboration between students, teachers, staff, and the school is required to make the school garden sustainable and produce the best possible outcomes for improvement. The research findings suggest that the school garden can serve as a model for contextual problem-based learning that arises in students' immediate surroundings.

**Keywords:** school gardens, outside learning, project-based learning, STEM

**How to Cite**: Siswandari, P., et al. (2024). School gardens: a model to support project-based learning. *Proceeding The 6th International Conference Elementary Education*, *6*(1), 394-402.

## INTRODUCTION

School gardens, as school green space, have numerous advantages, particularly as learning media. School gardens provide students to encounter with nature and living organisms (Polin & Retzlaff-Fürst, 2021; Cairns, 2017); connect students with nutrition education by raising awareness for increasing consumption of plant-based calories (fruit and vegetables) (Day et al., 2017; Darmody, 2022) and enriching outside learning experiences to improve students' mood and well-being and develop students' social behavior related to communication and teamwork (Harvey, 2020; Polin & Retzlaff-Fürst, 2021). Garden-based activities also increase students' involvement and knowledge of science learning (Williams et al., 2018).

Outside activities such as planting, watering, weeding, composting, and pest monitoring provides hands-on activities for experiential learning, garden maintenance, social interaction, and relaxation (Apanovich et al., 2023). Students working in the garden connect with nature by investigate nature pattern. When the plants can produce a crop, the harvest is consumed or sold to the neighborhood. School gardens can enhance connection between the school and the communities (Moore et al., 2015).

In Indonesia, school gardens are part of the Adiwiyata assessment criteria. Adiwiyata School is an award from the Ministry of Environment to encourage schools to raise environmental awareness among school inhabitants. Adiwiyata School awardee are responsible for maintaining school environmental infrastructure, including school garden, and regulating students and staff environmental attitudes (Prastiwi et al., 2015).

A successful school gardens requires proper management and long-term viability. However, maintaining school gardens is challenging, which leads to their abandonment. Maintaining a school garden requires staff and solid funding, but the school's ability is restricted (Loftus et al., 2017; Laurie et al., 2017). School stakeholder support and inventiveness are required to maintain the school gardens for activities to continue (Harris, 2023).

Garden-based science learning allows for innovative approaches to maintaining school gardens. A programme that integrates the school gardens with the curriculum is required so that students are involved in school gardens maintenance. However, past reports on science learning

in the school gardens have solely focused on obtaining knowledge and experience working in the garden and improving sociocultural skills. Our study examined project-based science learning can contribute to maintaining a school gardens that involves students. This study investigates school gardens as a model of science project-based learning, providing students with contextual issue to solve.

**METHOD**

Participants in this study were nine students of sixth grade who were members of the Green Community extracurricular. This extracurricular programme involves activities to keep the school's green spaces in good condition. Based on the findings of discussions between teachers and students about green spaces in schools, we discovered hydroponic installations in school gardens that were rarely used. The teacher took the initiative to implement problem-based learning in science as a STEM project in the Green Community extracurricular. We considered resurrecting a dormant school gardens when creating this STEM project. Students work as researchers and engineers to make the school gardens productive. The school gardens STEM project was divided into four stage (Figure 1).

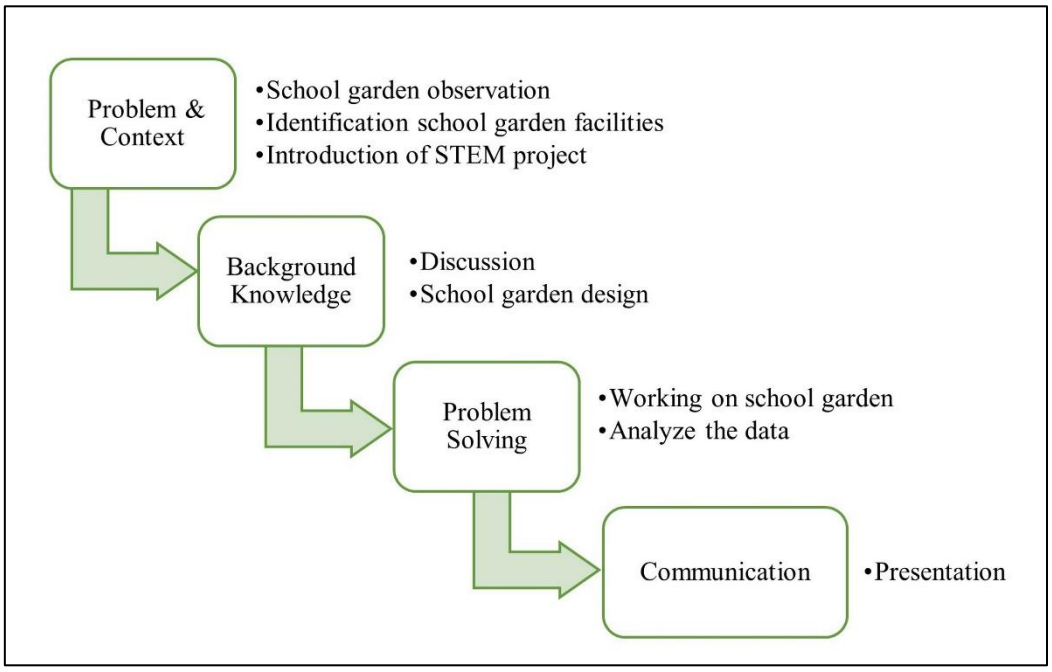


**Figure 1.** School Gardens STEM Project

***Stage 1: Problem & Context***

We introduced the problem of the school gardens by allowing students to observe the school gardens. Students express their thoughts on the current state of the school garden. We discussed ways to improve the school gardens and analysed the situation with the school gardens.

***Stage 2: Background knowledge***

Students collaborate in groups to gather information about school gardens topics from the internet. Student engaged in active reading to develop plants in soil and non-soil mediums. They must develop a design to improve the school gardens for plant production and maintenance. Following the reading exercise, students in home groups form expert groups to study plant growing material and hydroponics.

***Stage 3: Problem Solving***

Each expert group examines the concept of plant growing materials and hydroponics. Students presents the design outcome to work on the school gardens. Students select the type of plant to be utilised, determine the nutritional content of the plant, and observe plant growth.

***Stage 4: Communication***

Students gather conclusion and present their result.

This case study to investigates school gardens as a model of science project-based learning. For data acquisition, field notes and photos were collected as observation during a period of twelve weeks of lesson (September-December 2022). Reflective field notes were recorded to observe student activities and interaction, unique attributes, and progress of the project. Data were analysed using thematic analysis for identifying, analyzing, and interpreting patterns of qualitative data (Clarke & Braun, 2017).

**RESULTS**

Science study in the school gardens can help to solve problems with garden maintenance. Students assist in cleaning up the garden (once a week), monitoring plant development and pests, and harvesting. School gardens maintenance is a contextual issue in the school environment that can provide students with real-life experience. The school gardens STEM project is a collaborative endeavour between students and teachers to ensure the sustainability of the school gardens. This activity addresses the limited staff in school gardens maintenance. The students' frequency visiting the school gardens has risen. Students assist with maintenance, while teachers offer comments and concerns for activity implementation. Students and teachers investigate garden challenges in order to fix the problem.

**School Gardens STEM Project**

*Stage 1: Identifying problem*

The school gardens STEM project activity begins with observing the condition of the school gardens. Students identify problems in the school gardens, such as weed abundance and rarely used hydroponic systems. Some of the constituent pipes of the hydroponics system are broken. Based on these problems, the teacher directs students to design a school gardens to be implemented.

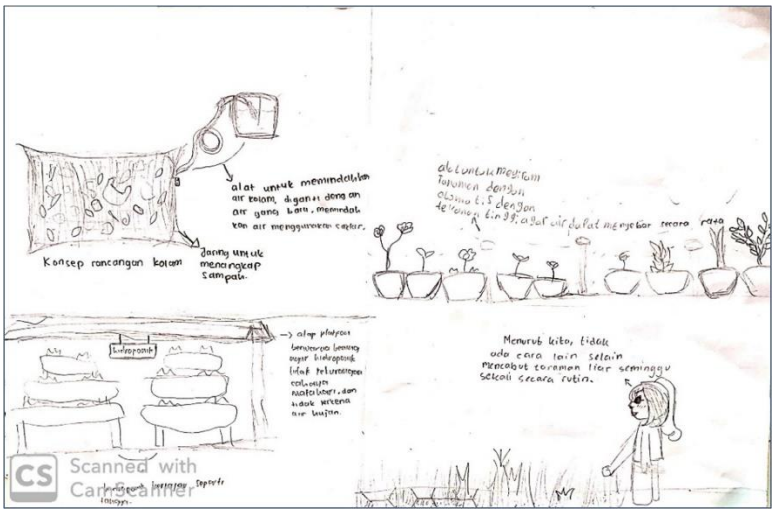


**Figure 2.** School gardens design by students

Students decided to weed weeds regularly once a week to overcome the growth of weeds. Students suggested installing a transparent roof so that the hydroponic installation is not directly exposed to rain while receiving sunlight. Students propose erecting a net to catch the pile of leaves to avoid dry leaves falling into the pool area. Students also suggested installing automatic watering systems between plant pots.

*Stage 2: Exploring ideas related to solving the problem*

To identify the issues in the garden, students do field observations in the school gardens. The garden is underutilized, according to the students. Teachers involved in the Green Community asked students to organize and perform garden improvement. Students do a literature review to learn about growing plants, commencing with the usage of hydroponics and garden maintenance.


**Figure 3.** Science activities on school gardens STEM project. A) Introduction of problem meeting; B) Literature review by students; C) Water pH check using pH water on hydroponics system

*Stage 3: Developing a plan and a solution to solve the problem*

Students attempted to produce water spinach in October 2022 using our school gardens hydroponics system. The crop yields we received, but not very good. Water spinach chlorosis. Students believe the given nutritional content is insufficient. Additionally, it will frequently rain in October and November 2022, which can interfere with the hydroponic system's ability to concentrate nutrients (because the hydroponic installation installed outdoor and no roof).


Hydroponic systems used indoors can prevent weather changes. Plants, however, cannot grow healthily without sunlight. Therefore, more lights are needed for lighting in indoor hydroponic systems. Trays and infraboard can be used to construct indoor hydroponic systems that support the net pot. Since there is already enough light present indoors to support plant development, more light is required to ensure that the photosynthesis process continues to function as efficiently as possible. We add light to an indoor hydroponic system that is 20 cm away from the top of the net pot. We use LED Lamp T5-8W.

After the first harvesting, we redesign the planting strategy and maintenance procedures. We plant seeds first. We transferred the plants to the hydroponic system after 7 days of sowing. The hydroponic system received liquid nutrition (AB Mix) on the ninth day. The water spinach appeared to be growing nicely as the twentieth day following planting rolled around. Our water spinach crop was destroyed by the school's pet hens on the 28th day after sowing. Unfortunately,

there is no guardrail around the chicken coop area due to the state of our garden. We talked about creating a wall to separate the hydroponic space from the chicken coop after the second harvest. We choose paranet as our guardrail based on the discussion's findings. We take a measurement of the garden's length to know the needs to build the paranet fence

*Stage 4: Presenting the solution*

Student report their school gardens working progress every two weeks. At the end of the lesson, students present the result.


**Figure 5.** Mathematics on school gardens STEM project. A) Students measure perimeter of the garden; B) Students measure the weight of the harvest; C) Students measure the height of plant

STEM learning experience at school gardens showed science serves as the foundation of knowledge for caring for the growth and development of plants in a hydroponic system (soil-less planting method). Technology involved when seedling plants, using outdoor hydroponics system, building indoor hydroponics, and building paranet fence. Engineering involved when we build indoor hydroponics and build the fence. Mathematics is used to calculate the length of the fence, the number of plants that grow, their height, their weight during harvest, and other plant-related quantities.

**Table 1.** School gardens learning objectives

| Content | Description |
|---|---|
| Student engagement in integrated STEM practices | ○ Decide and select suitable additional nutrients for hydroponics,<br>○ Design and create irrigation system<br>○ Data handling of the results<br>○ Implement scientific knowledge and investigation to make school gardens be productive |
| Student engagement in developing 21st century skills | ○ Critical thinking and problem solving<br>○ Collaboration, teamwork, leadership<br>○ Creativity<br>○ Communication, information, and media literacy |
| Values, ethics, and attitudes | Creativity, as a part of school community |

This school gardens STEM project activity encourages students to visit the school garden more frequently. Students explore the garden, watch activities that occur in the garden, and notice shortcomings that occur in the garden. The findings of student observations were used in a follow-up discussion with the teacher about school gardens maintenance. This discussion can provide students and teachers with information about school gardens improvement.

**DISCUSSION**

This study showed that learning activities in the school gardens accustomed to being part of a science project-based learning approach. Students not only study about scientific events that occur in the garden, but they also participate in garden maintenance. Students can observe plants and their interactions with other organisms and abiotic elements, such as weather, while students work in the garden. Students can check the number of yellowing leaves on each plant, supply nourishment, and monitor pest attacks for vegetable and fruit production. Students and teachers discussed the report findings to determine the next steps for managing the school gardens. Teachers can connect with stakeholders to find solutions to the garden's limited facilities.

According to Williams et al. (2018), students engage in activities in the school gardens. Gardening activities potentially develop students' interests, learning, and academic identity in science. Students' passion for working in the garden during planting and monitoring the pH of hydroponic water demonstrates science-motivated learning. Students preferred making hydroponic nutrients because students may create solutions using glassware. In learning activities, students can tell their friends about their working experiences in the garden. Sharing experience activities while working in the garden reveals socioecological practices that allow students to convey their environmental awareness (Moore et al., 2015). A pleasant learning environment contributes to developing a socioecological attitude and understanding of the surroundings. Polin and Retzlaff-Fürst (2021) discovered a high intensity of students' emotions of enjoyment, pride, and surprise while working in the gardens. School gardens promote greater socialization and happy feelings than learning in the classroom.

Learning activities in the school gardens can affect students' perceptions of the school environment by increasing their awareness and sensitivity (Prastiwi et al., 2015). Students must develop a sense of responsibility for the school environment to establish a comfortable learning environment. The outcomes of this school gardens STEM project demonstrate that students are aware of and responsible for garden maintenance to achieve optimal harvest results and a neat garden. The results of student responses showed students' awareness of solving real-life issues as a STEM learning experience (Gupta et al., 2019). Students can model their prototypes or solutions with problem-solving activities; then, students discuss with teachers to investigate school gardens maintenance (Laksmiwati et al., 2023).

Planting food plants in schools promotes nutrition education and encourages students to eat more vegetables and fruit (Huys et al., 2017). Students can investigate food topics to change eating habits that will affect their 'healthy' or 'unhealthy' future as members of the food system (Cairns, 2017; Darmody, 2022). Food nutrition learning in the school gardens can collaborate with the school health unit to create a clean school environment and a healthy school model (Zakky et al., 2023). School gardens describe urban farming in areas with limited space for agriculture (Purwaningsih et al., 2021). Food plants planted in the school gardens promote local food production (Laurie et al., 2017; Banoet et al., 2022). This activity gives students experience with gardening practices and management (Agustina et al., 2023) and values the harvest results obtained from planting water spinach that is cared for by students (Syamsia et al., 2023). Students must understand the origins of the food they consume as the impact of industrial food systems that alienate natural food sources (Graves et al., 2016; Cairns, 2017).

The limitation of this study includes participant and observer bias and generalizability. The participants are limited to nine students in sixth grade. The participants are members of Green Community extracurriculars because they take an interest in the environment (40%) or they only join the club to have activities (60%). Observer bias is a limitation particularly consisting of four teachers as a team in guiding this school gardens project. Teachers have focus group discussions regarding the preparation, implementation, and evaluation of this project. The results of this study show the school gardens as a model for project-based learning, but it remains a single case study.

This study only explains the school gardens model as a contextual topic in project-based learning implementation. This activity is carried out in schools with the participation of students, teachers, stakeholders, and community members. According to Hoover et al. (2017), creating a school gardens requires a precise garden curriculum aligned with learning outcomes. Teachers with knowledge and skills in gardening programs are needed to help with this. Teacher self-

efficacy is the key to the sustainability of the curriculum in the school gardens STEM project when teaching agricultural-based lessons in the school gardens (Graves, 2016; Nissa, 2020). Schools provide gardening programmes for teacher training. For the school gardens to be sustainable, community partnerships in funding and garden improvement are required.

School gardens are an approach to learning science, hands-on activities, social development, and food nutrition awareness. As part of a sustainable school gardens maintenance effort, activities in the school gardens give students responsibility for planning, monitoring, and harvesting (Zuiker & Riske, 2021). School gardens learning is not only limited to attending the school but can also be done in discussions using a virtual garden. According to Lochner (2021), virtual gardens are suitable for exchanging gardening information around the world; then, students study the climate and plants through virtual meetings. The school gardens is a part of educational sustainable development. Learning in the school gardens raises awareness of food security, improves nutrition, and promotes sustainable agriculture.

## CONCLUSION

The school gardens STEM projects can be a project-based learning approach due to the involvement of students in carrying out projects to maintain the school garden for it to be sustainable. The school gardens STEM projects help students gain agriculture litercy, science literacy, and social behavior. This activity fosters critical thinking, teamwork, and creativity. Students' participation in the school garden contributes to the garden's technical maintenance.

School gardens activities require a precise curriculum for application in learning. Implementing the STEM school gardens project can bring fresh variants to teaching science, allowing students to learn freely, contextually, and about real-life concerns. Teachers and stakeholders might collaborate with agricultural or government institutions in the agriculture sector to raise funds and support for school gardens. The connection between students, teachers, schools, parents, and communities creates a school gardens support system.

## ACKNOWLEDGMENTS

The authors gratefully acknowledge the SEAMEO STEM ED “Project-based Learning Course” webinar: Dr. Mark Windale, Dr. Edward Reeve, and Dr. John Stiles for professional learning community (PLC) meeting via Zoom to encourage authors to implement school gardens STEM project. We also thank SD Laboratorium UPI Kampus Cibiru to provide us facilities to do the project.

## REFERENCES

Agustina, R., Fatmawati, F. A., Zahrani, F., Zulwati, P. R., Fauziah, S., Faridah, I., Hartanti, T., Insyaroh, N., Ardiansyah, H. (2023). Gardening education in early childhood: important factors supporting the success of implementing it. *International Journal of Community Research and Engagement*, *16*(1), 1-13. https://doi.org/10.5130/ijcre. v16i1.8478

Apanovich, N., Okyere, S. A., Mensah, S. L., Frimpong, L. K. (2023). Education for sustainable development: societal benefits of a community garden project in Tuscon, Arizona. *Societal Impacts*, *1*(1), 1-4. https://doi.org/10.1016/j.socimp.2023.100011

Banoet, J., Sutarto, J., Handayani, S. F. (2022). Integrative holistic garden at earlt childhood education to reduce children stunting. *Journal of Primary Education*, 11(1), 29-35.

Cairns, K. (2017). Connecting to food: cultivating children in the school garden. Children’s Geographies, 15(3), 304-318. https://doi.org/10.1080/14733285.2016.1221058

Clarke, V. & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology*, *12*(3), 297-298. http://dx.doi.org/10.1080/17439760.2016.1262613

Darmody, M. (2022). Widening capabilities through a food and sustainability education initiative. *Educational Action Research*, *30*(4), 585-603. https://doi.org/10.1080/09650792.2022.2058042

Day, K., Tsupros, M. M., Schober, D. J. (2022). To plant a garden is to believe in tomorrow: A case study of a Chicago community-based organization focused on health education through

school gardens. *Journal of Prevention & Intervention in the Community*, *50*(1), 72-88. https://doi.org/10.1080/10852352.2021.1915938

Graves, L. A., Hughes, H., Balgopal, M. M. (2016). Teaching STEM through Horticulture: implementing an edible plant curriculum at a STEM-centric elementary school. *Journal of Agricultural Education*, *57*(3), 192-207. https://doi.org/10.5032/jae.2016.03192

Gupta, R., Fraser, J., Rank, S. J., Brucker, J. L., Flinner, K. (2019). Multi-Site Case Studies About Zoo and Aquarium Visitors' Perceptions of the STEM Learning Ecology, Visitor Studies, 22(2), 127-146. https://doi.org/10.1080/10645578.2019.1661737

Harris, M. A. (2023). Growing among trees: a 12-month process evaluation of school based outdoor learning interventions. *Journal of Adventure Education and Outdoor Learning*, *23*(3), 232-243. https://doi.org/10.1080/14729679.2021.2001758

Harvey, D. J., Montgomery, L. N., Harvey, H., Hall, F., Gange, A. C. Watling, D. (2020). Psychological benefits of a biodiversity-focussed outdoor learning program for primary school children. *Journal of Environmental Psychology*, *67*, 1-8. https://doi.org/10.1016/j.jenvp.2019.101381

Hoover, A., Vandyousefi, S., Martin, B., Nikah, K., Cooper, M. H., Marty, E., Duswalt-Epstein, M., Burgermaster, M., Waugh, L., Linkenhoker, B., Davis, J. N. (2021). Barriers, strategies, and resources to thriving school gardens. *Journal of Nutrition Education and Behaviour*, *53*(7), 591-601. https://doi.org/10.1016/j.jneb.2021.02.011

Huys, N., De Cocker, K., De Craemer, M., Roesbeke, M., Cardon G., De Lepeleere, S. (2017). School gardens: a qualitative study on implementation practices. International Journal of Environmental Research and Public Health, *14*, 1-12. https://doi.org/10.3390/ijerph14121454

Laksmiwati, P. A., Lavicza, Z., Cahyono, A. N., Yunianto, W., Houghton, T. (2023). Unveiling the implementation of STE(A)M Education: An exploratory case study of Indonesia from experts' and policymakers' perspectives, *Cogent Education*, *10*(2), 1-18. https://doi.org/10.1080/2331186X.2023.2267959

Laurie, S. M., Faber, M., Maduna, M. M. (2017). Assessment of food gardens as nutrition tool in primary schools in South Africa. *South African Journal of Clinical Nutrition*, *30*(4), 80-86. https://doi.org/10.1080/16070658.2017.1271609

Lochner, J. (2021). Educators' intentions for learning in Virtual School Garden Exchanges: a comparison with the aims of Education for Sustainable Development. *Environmental Education Research*, *27*(8), 1172-1191. https://doi.org/10.1080/13504622.2021.1921116

Loftus, L., Spaulding, A. D., Steffen, R., Kopsell, D., Nnakwe, N. (2017). Determining barriers to use of edible school gardens in Illinois. *Journal of The American College of Nutrition*, *36*(7), 507-513. https://doi.org/10.1080/07315724.2017.1326323

Moore, S. A., Wilson, J., Kelly-Richards, S., Marston, S. A. (2015). School gardens as sites for foraging progressive socioecological futures. *Annals of the Association of American Geographers*, *105*(2), 407-415. https://doi.org/10.1080/00045608.2014.985627

Nissa, K. (2020). School gardens as a learning approach and their effects on students in primary school. *Proceeding International Conference on Culture, Language, and Literature*, 378-384. https://proceeding.umsu.ac.id/index.php/ic2lc

Polin, S. & Retzlaff-Fürst, C. (2021). The school garden: a social and emotional place. *Frontiers in Psychology, 12*, 1-11. https://doi.org/10.3389/fpsyg.2021.567720

Prastiwi, L., Sigit, D. V., Sedayu, A. (2015). The correlation between students' perception about school garden with the attitude of school environment management. *Biosfer*, *8*(1), 29-33.

Purwaningsih, O., Pamungkas, P. B., Triwahana, T. (2021). School garden as a learning alternative in the era of COVID-19 pandemic. *Abdimas: Jurnal Pengabdian Masyarakat Universitas Merdeka Malang, 6*(4), 534-540. https://doi.org/10.26905/abdimas.v6i4.5512

Syamsia, S., Tahir, H., Abdurofi, I., Rahmi, R., Syarif, A. (2023). Natural sciences and social sciences learning in school garden, Indonesian School of the Haque, Netherlands. *Journal of Community Service and Empowerment*, *4*(3), 478-485. https://doi.org/10.22219/jcse.v4i3.27793

Williams, D. R., Brule, H., Kelley, S. S., Skinner, E. A. (2018). Science learning gardens (SciLG): a study of students' motivation, achievement, and science identity in low-income middle

schools. *International Journal of STEM Education*, *5*(8), 1-14. https://doi.org/10.1186/s40594-018-0104-9

Zakky, M. Suliyanto, H., Indrayanti, T., Syawal, R. (2022). Development model of school gardens through vegetables go to school (VGtS) activities for improving nutrition of elementary age children in Batang Regency, Central Java Province. *Proceedings of the International Symposium Southeast Asia Vegetable*, 44-53. SR 23, pp. 44–53. https://doi.org/10.2991/978-94-6463-028-2_7

Zuiker, S. J. & Riske, A. K. (2021). Growing garden-based learning: mapping practical and theoretical work through design. *Environmental Education Research*, 1152-1171. https://doi.org/10.1080/13504622.2021.1888886