JCCE
Journal of Community Capacity Empowerment
THE FACULTY OF AGRICULTURE
Universitas Tunas Pembangunan Surakarta (UTP)

Enhancing Youth Agricultural Literacy with Vertical Farming in Non-Formal Education Settings

Natalia Deswita Fitriyani[1], Zainal Mustofa[1], Agustina Tri Suryaningsih[1], Norbertus Citra Irawan*[1], Adhisty Puri Damayanti[1], Dewi Rahmawati Intan Permatasari[1]
[1]Universitas Tunas Pembangunan, Surakarta, Indonesia
*email: irawan@lecture.utp.ac.id

Abstrak

Urban youth often lack access to practical agricultural education, especially in non-formal learning environments where structured curricula are limited. The community faces increasing challenges in food security, environmental awareness, and sustainable skill-building among students with limited exposure to farming. The community service program aimed to improve students' understanding of vertical agriculture through practical and inclusive educational activities. The facilitators delivered hands-on workshops at PKBM Cahaya Rejeki, involving 20 students in interactive sessions using recycled materials to build vertical gardens in limited urban spaces. The team applied the Wilcoxon Matched-Pairs Signed-Rank Test to compare students' pre-test and post-test results, finding a statistically significant increase in their agricultural knowledge. Field observations confirmed the positive outcome, as students showed increased enthusiasm, curiosity, and confidence throughout the activities. The program bridged educational and environmental gaps by offering a simple, relatable, and replicable gardening model. The initiative demonstrated that vertical gardening could serve as a powerful tool to promote sustainability, practical skills, and ecological literacy among underserved urban youth. The findings suggest that local governments, educators, and community institutions should collaborate to integrate urban farming into non-formal education programs, thereby ensuring a broader impact and promoting long-term behavioral change.

Keywords*: urban, sustainability, wilcoxon, gardening, collaboration*

1. INTRODUCTION

Urban youth often experience limited exposure to agriculture due to the absence of practical learning in non-formal education settings. Many students in community-based institutions lack access to hands-on farming experiences that foster food literacy and environmental awareness. Studies show that many urban children have never grown their own food, raised a plant, or cared for an animal, with their agricultural experience often limited to occasional field trips or visits to relatives' gardens (Hess & Trexler, 2011). Furthermore, a systemic disconnect persists between urban populations and food systems, with limited practical engagement leading to diminished appreciation of where food comes from and the broader ecological implications of food consumption (Park, 2022).

Schools outside the formal system rarely integrate agriculture into their learning models, leaving a significant gap in sustainable skill development. Vertical gardening offers an accessible and adaptable approach that aligns well with urban constraints such as limited land and waste accumulation. Land scarcity in large cities is a direct result of land conversion for residential, industrial, and infrastructural purposes. Verticulture offers a solution by utilizing vertical space, which enables higher plant density in smaller areas and maximizes available space (Daniels et al., 2023; Davis et al., 2019). Verticulture also shows promise as an innovative solution for overcoming land scarcity in urban areas to improve household food security (Solikah et al., 2020). Gupta and Gangopadhyay (2023) stated that urban agriculture and waste recycling are essential strategies for strengthening food security in urban areas, as they provide access to locally sourced food and reduce reliance on long-distance supply chains.

Students can learn to grow food efficiently using recycled containers and small spaces, making it ideal for densely populated environments. Communities require youth who understand how to produce food, conserve resources, and adapt to urban ecological challenges.

Community service plays a strategic role in addressing educational and ecological gaps among marginalized urban youth. Education is considered a key factor in social welfare, in addition to empowerment. It plays a significant role in shaping public mindset, whether through

formal or non-formal channels (Aini et al. 2021; Syahra, 2003). Agricultural empowerment through vertical gardening provides more than technical knowledge, it cultivates independence, creativity, and civic responsibility. Community initiatives can bridge formal and informal learning systems, equipping students with practical tools to contribute meaningfully to household food security. Universities and local institutions must transfer knowledge and skills that enhance youth participation in urban sustainability practices. Companies and organizations should develop human resource strategies focused on building the knowledge and skills necessary to meet their sustainability and eco-friendly objectives (Esthi et al., 2023). Structured community service (PKM) programs support local development goals by creating educational interventions that fill gaps where formal systems fall short.

Many existing agricultural extension services target rural farmers, overlooking students in urban non-formal institutions. Stakeholders often miss opportunities to introduce low-cost, space-efficient technologies such as vertical gardening in youth education. Community-based programs frequently remain disconnected from informal learners who face real-time challenges in accessing urban food and addressing skill gaps. These underserved groups require innovative solutions that make agriculture relevant, practical, and achievable within their learning environments. An integrated community service approach can fill this void through direct engagement, adaptive teaching, and localized practice.

Local communities are increasingly facing food security threats and urban waste issues, both of which impact the well-being of youth and the sustainability of their neighborhoods. Students in non-formal education must become part of the solution by learning how to grow food responsibly in confined spaces. Vertical gardening offers a high-impact entry point into agriculture, environmental education, and entrepreneurship. The urgency to involve young learners in hands-on agriculture grows as cities continue to expand and climate conditions fluctuate. Urban resilience depends on equipping young people with tools that empower self-sufficiency and promote green innovation.

The program team formulates PKM activities through a structured series of workshops and interactive demonstrations. Educators introduce core agricultural concepts, environmental values, and practical skills using vertical gardening models. Participants engage in step-by-step construction of garden units using recycled bottles and organic soil. Trainers incorporate visual materials and real-time discussions to foster collaborative learning and creativity. Every activity promotes a cycle of exploration, application, and reflection, ensuring knowledge retention and student involvement.

The primary objective of the PKM program is to increase students' understanding of vertical agriculture through practical and inclusive educational activities. The initiative aims to cultivate youth interest in sustainable food production while building their environmental responsibility and problem-solving skills. Instructional design targets learners of all academic levels, making content accessible and relevant to everyday life. Community service also seeks to inspire behavioral change that supports long-term ecological balance.

The PKM initiative contributes to youth empowerment, environmental awareness, and urban resilience. Students gain confidence in their ability to produce food, manage waste, and apply scientific knowledge in their homes or communities. Educators create a multiplier effect by training youth who can later share their skills with peers and families. Urban food systems benefit from young contributors who value sustainability and innovation. Local networks grow stronger when community members take ownership of learning and development through accessible agricultural solutions.

2. METHODS

Main Method

The community service team conducted the PKM program using a participatory education model that combined lecture-based delivery, visual media, and hands-on demonstration. The facilitators introduced vertical gardening techniques using recycled materials, including plastic bottles, to simulate accessible urban farming. The program followed a step-by-step approach starting from concept introduction, group discussion, visual explanation, and practical garden construction. The instructional process encouraged active participation and critical thinking by allowing students to build, observe, and reflect on their learning outcomes. The team ensured consistency in the learning experience by using standardized modules adapted to the students' backgrounds and learning pace. Each session included a feedback loop to ensure real-time understanding and address individual questions directly.

Community Service Location and Participants

The PKM activities took place at PKBM Cahaya Rejeki, located in Banyuanyar, Surakarta. The learning center serves as a non-formal education institution focused on youth who have dropped out of or never accessed formal schooling. The PKM target group consisted of 20 students from junior and senior high schools enrolled in the center's general education and vocational programs. Most participants came from low-income families with limited exposure to agriculture or environmental literacy: the urban setting and narrow land availability made vertical gardening an ideal and relatable topic for practical learning. The facilitators tailored every learning module to local conditions, emphasizing real-life relevance and the potential for small-scale food production at home.

Community Service Impact Analysis Method

The PKM evaluation method aimed to determine whether the intervention significantly improved students' understanding of vertical gardening. The analysis employed the Wilcoxon Matched-Pairs Signed-Rank Test, a non-parametric statistical technique used to compare two related samples, in this case, the pre-test and post-test results from the same participants (Ahmad and Sari, 2025). The test was chosen due to its suitability for small samples and ordinal data characteristics, both of which were present in the PKM context. The evaluation focused on measuring changes in knowledge before and after the vertical gardening workshops conducted for 20 students at PKBM Cahaya Rejeki.

The evaluation process began with the development of structured instruments comprising pre-test and post-test questions. Each test consisted of 10 multiple-choice and short-answer items that covered fundamental aspects of vertical gardening, including definitions, benefits, techniques, plant selection, and environmental impact. Before the activities began, all participants completed the pre-test. After the final session, the same students completed an identical or equivalent post-test to measure shifts in understanding.

The operational flow of the evaluation included five key stages:

a. Setting the hypothesis,
   - Null Hypothesis (H_0): There is no significant difference in students' understanding of vertical gardening before and after the PKM intervention.
   - Alternative Hypothesis (H_1): There is a significant improvement in students' understanding of vertical gardening after the PKM intervention.
b. Designing the test instruments,
c. Administering tests before and after intervention,
d. Scoring and coding the responses,
e. Applying the Wilcoxon test using statistical software.

Table 1. Measurement Instrument for Pre- and Post-PKM Evaluation

No.	Evaluation Indicator	Measurement Tool	Scoring Method	Expected Change
1	Understanding of vertical gardening concepts	Pre-test & Post-test	Likert scale 1–5	Increase in average score
2	Ability to identify vertical gardening techniques	Multiple-choice questions	Correct answer = 1 point	Higher number of correct answers
3	Recognition of the environmental benefits of vertical gardening	Short-answer response	Rubric-based scoring	More complete and relevant answers
4	Confidence in applying vertical gardening at home	Self-assessment checklist	Likert scale 1–5	Positive shift in self-reported confidence

The Wilcoxon test was used to analyze the ranked differences between pre-test and post-test scores for each participant. The test did not require the assumption of normally distributed data, making it appropriate for the limited sample size of 20 students. The PKM team compiled the scores into a dataset and input them into statistical software. The test compared the median differences to determine whether post-test scores showed a statistically significant increase over pre-test results.

A significance level (α) of 0.05 was used as the threshold. A p-value of less than 0.05 indicated a statistically significant improvement in knowledge due to the intervention. If the test yielded $Z < 0$ and $p < 0.05$, the null hypothesis was rejected, confirming that the vertical gardening PKM had a measurable and positive impact on student understanding. The Wilcoxon Matched-Pairs Signed-Rank Test provided both quantitative credibility and educational insight, supporting the broader goal of increasing agricultural literacy among youth in non-formal education settings.

3. RESULTS AND DISCUSSION

The community service program successfully conducted a vertical gardening literacy intervention among 20 non-formal education students at PKBM Cahaya Rejeki. The facilitators delivered the material using an interactive module supported by visual media, hands-on demonstration, and real-time feedback. The team measured students' understanding before and after the program using structured instruments that aligned with the learning objectives. The analysis applied the Wilcoxon Matched-Pairs Signed-Rank Test to determine whether significant changes occurred in student knowledge and confidence. The results provided a reliable basis to evaluate the educational effectiveness of the vertical gardening initiative.

Table 2. Wilcoxon Matched-Pairs Signed-Rank Test Output

Z	-3.934
Asymp. Sig. (2-tailed)	0,000

a. Wilcoxon Signed-Rank Test

b. Based on negative ranks

Source: Primary Data Analysis

The Wilcoxon test results indicate a statistically significant improvement in students' understanding of vertical gardening after the PKM intervention. The test generated a Z value of -3.934 and a p-value of 0.000, which falls below the standard threshold of 0.05. The negative Z score reflects that most post-test scores were higher than pre-test scores, confirming the hypothesis that the intervention enhanced agricultural literacy. The result validates that students

not only grasped theoretical content but also retained practical applications through guided demonstrations and experiential learning. These results are consistent with previous studies by Fadilatunnisyah et al. (2024) and Mukramah et al. (2023), which applied a significance level (α) of 0.05, where a p-value below 0.05 indicated a statistically significant improvement in understanding. When the analysis yielded $Z < 0$ and $p < 0.05$, the null hypothesis (H_0) was rejected.

Students demonstrated more substantial confidence in identifying techniques, understanding environmental impacts, and explaining the benefits of vertical gardening. The pre-test responses indicated minimal prior knowledge, whereas the post-test answers demonstrated improvement across all evaluation indicators, particularly in concept clarity and technique recognition. The shift in Likert-based self-assessment also suggested growth in students' willingness and ability to apply vertical gardening at home. These gains align with the PKM's core objective and reflect the impact of a contextualized, learner-centered approach in non-formal education environments. Previous studies by Anggarani et al. (2024) have shown that vertical gardening programs can enhance students' scientific literacy, improve their understanding of sustainable practices, and develop practical skills related to garden construction and environmental awareness. Such initiatives are recommended to be sustained through regular training to foster a culture of sustainability.

The results affirm constructivist learning theory, which emphasizes knowledge acquisition through active involvement and real-world context. Students constructed their understanding by engaging directly in vertical gardening activities, making learning meaningful and sustainable. The program also aligns with Kolb's experiential learning cycle, where concrete experiences, reflective observation, abstract conceptualization, and active experimentation are sequenced in a specific order (Subekti, 2020). The increase in test scores and self-reported confidence confirms that students internalized concepts through hands-on participation and peer collaboration. Irawan (2023) emphasized that enhancing the effectiveness of education and training in agriculture requires concrete actions and collaborative efforts. This includes developing accessible and relevant content, adopting interactive and practical approaches, and strengthening communication and collaboration with learners to gain a deeper understanding of their challenges and needs.

Field observations supported the quantitative results, revealing enthusiastic participation and high levels of engagement during every session. Students demonstrated curiosity when introduced to recycled materials and independently brainstormed ways to implement vertical gardening at home. Many participants asked questions beyond the module, including about composting and herbal planting. Facilitators observed visible progress in student discussions and an improvement in teamwork during group activities. The atmosphere remained collaborative, and students appeared proud to showcase their completed vertical garden prototypes.

The PKM successfully turned abstract agricultural concepts into relatable experiences. The use of recycled materials and practical demonstrations captured student interest and created emotional engagement with the learning process. These factors helped students overcome initial discomfort and develop curiosity. Students expressed satisfaction in seeing their garden structures take shape, which deepened their sense of ownership. The alignment between content, local context, and delivery methods reinforced learning retention and facilitated long-term behavioral change.

Vertical gardening offers an ideal medium for introducing sustainable practices in urban environments. Students realized the potential to transform small, unused spaces into productive green areas. The lessons also encouraged environmental responsibility by emphasizing waste reduction and resource efficiency. The program demonstrated that low-cost, replicable gardening models could integrate seamlessly into students' daily lives, especially in space-

constrained neighborhoods. This achievement opens new opportunities for youth-led food initiatives and local ecological restoration in urban areas.

Figure 1. Concept introduction of vertical garden

Figure 2. The participants of the PKM program

Figure 3. Practical garden construction

Figure 4. Practical garden construction

4. CONCLUSION

The community service program successfully fulfilled its primary objective: to increase students' understanding of vertical agriculture through practical and inclusive educational activities. The Wilcoxon Matched-Pairs Signed-Rank Test showed a significant improvement in post-test scores compared to pre-test scores, confirming the positive impact of the intervention on students' agricultural literacy. Field observations reinforced the statistical results, as students actively participated in hands-on gardening sessions, demonstrated curiosity, and asked insightful questions about vertical farming, composting, and home-based applications. Participants gained not only technical knowledge but also a sense of empowerment and ecological awareness. The use of recycled materials and space-saving techniques made the content highly relatable, especially in urban, low-income settings. Based on these findings, the program recommends scaling similar interventions to other non-formal education institutions with localized adaptations. Education policymakers should consider integrating urban agriculture modules into non-formal curricula as a strategy to enhance sustainability education and food security awareness. Future programs can expand their scope by incorporating entrepreneurship training, enabling students to transform their agricultural skills into income-generating activities. The initiative also underscores the importance of

collaboration among local governments, universities, and community learning centers in establishing long-term support systems for youth-driven urban farming innovations.

REFERENCES

Ahmad, F., & Sari, N. I. (2025). Exploring the Wilcoxon test in science education: A literature review of empirical research. *Indonesian Journal of Educational Science, 7*(2), 158–170.file:///C:/Users/Lenovo/Downloads/4712-Article%20Text-20941-1-10-20250312.pdf.

Aini, N. B. Q., Gayatri, S., Prasetyo, A. S. (2021). Pengaruh unsur modal sosial terhadap keberhasilan pokdarwis di Desa Pandansari [Universitas Diponogoro]. https://eprints2.undip.ac.id/id/eprint/5035/1/ArtikelPengaruhunsurmodalsosialterhadapkeberhasilan kelompok %28NURUL%29.pdf.

Anggarani, D. A., Delinda, A., & Maghfirlana, A. A. (2024). Enhancing science literacy and green building concept-based schools through the utilization of used plastic bottles as vertical gardens. *Journal of Sustainable Society Empowerment,* 1(1), 11–20. https://doi.org/10.64460/js2e.v1i1.9.

Daniels, A., Fink, M., Leibold, M., Wollherr, D., Asseng, S. (2023). Optimal control for indoor vertical farms based on crop growth. *IFAC-PapersOnLine*, 56(2), 9887-9893. https://doi.org/10.1016/j.ifacol.2023.10.666.

Davis, M. M., Espinosa, A. L. V, Ramirez, F. R. (2019). Beyond green facades: active air-cooling vertical gardens. *Smart and Sustainable Built Environment*, 8(3), 243-252. https://doi.org/10.1108/SASBE-05-2018-0026.

Esthi, R. B., Irawan, N. C., Susilowati, Y., Kartini, T. M., Widodo, Z. D. (2023). Effect of green education-training quality and green knowledge sharing on eco-friendly technology adoption in crabs agroindustry companies. *IOP Conf. Series: Earth and Environmental* Science, 1276, 1-8. https://doi.org/10.1088/1755-1315/1267/1/012082

Fadilatunnisyah, F., Fakhirah, R. S., Fasha, E. A., Putri, A. K., & Putri, D. A. J. D. (2024). The use of the Wilcoxon Signed-Rank Test to analyze the effect of learning motivation levels before and after being accepted at a dream university. *IJEDR: Indonesian Journal of Education and Development Research*, 2(1), 581–588. https://doi.org/10.57235/ijedr.v2i1.1887.

Hess, A. J., & Trexler, C. J. (2011). A qualitative study of agricultural literacy in urban youth: what do elementary students understand about the agri–food system?. *Journal of Agricultural Education*, 52(4), 1–12. https://doi.org/10.5032/jae.2011.04001.

Irawan, N. C. (2023). Peran Penyuluh dalam Mengembangkan Korporasi Pertanian Terpadu Pelatihan, Konsultasi, dan Bimbingan. *Agriekstensia*, 22(1), 14–27. https://doi.org/10.34145/agriekstensia.v22i1.2413.

Gupta, R & Gangopadhyay, S. (2013). Urban Food Security through Urban Agriculture and Waste Recycling: Some Lessons for India. *Vikalpa: The Journal for Decision Makers*, 38. 13-22. https://doi.org/10.1177/0256090920130302.

Mukramah, W. A. N., Halim, A., Winarni, S., Yusrizal, Safrida, Jannah, M., & Wahyuni, A. (2023). The effect of using comic-based e-module assisted by the Flipbook Maker for remediation of Newton's law misconceptions. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, 9(8), Article e4389. https://doi.org/10.29303/jppipa.v9i8.4389.

Park, S. J., Yeatman, H., Russell, J., & MacPhail, C. (2022). Barriers to Urban Food Action: Relevance of Food Pedagogies. *Sustainability*, 14(3), 1300. https://doi.org/10.3390/su14031300.

Solikah, U. N., Rahayu, T., Dewi, T. R. (2020). Optimalisasi urban farming dengan vertikultur sayuran. *Wasana Nyata*, 3(2), 168–173. https://doi.org/10.36587/wasananyata.v3i2.529.

Subekti, A. S. (2020). Undergraduate novice researchers' experiences in conducting mini-research in education: Kolb learning cycle. *Indonesian Research Journal in Education (IRJE)*, 4(2), 448–460. https://online-journal.unja.ac.id/index.php/irje/index.

Syahra, R. (2003). Modal sosial: Konsep dan aplikasi. *Jurnal Masyarakat Dan Budaya*, 5(1), 1-22. https://doi.org/10.14203/jmb.v5i1.256.