ONLINE JOURNAL FOR TVET PRACTITIONERS
e-ISSN: 2289-7410

OJ-TP

Vol. 10 No. 3 (2025) 1-13
https://publisher.uthm.edu.my/ojs/index.php/oj-tp

Preliminary Assessment of TVET Integration in Early Preschool Science Education Through The *Farm-to-Table* Approach

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DOI: https://doi.org/10.30880/ojtp.2025.10.03.001

Article Info

Received: 25 December 2024
Accepted: 30 September 2025
Available online: 18 October 2025

Keywords

IPPK, preschool agriculture, early science, gamification, motor stimulation

Abstract

Planting seeds in young minds goes beyond textbooks, it thrives in soil, sunlight, and hands-on experience. This study explores the effectiveness of the Farm-to-Table approach in enhancing preschoolers' understanding of agriculture through experiential learning aligned with the Early Science (SA 3.4) curriculum and Technical and Vocational Education and Training (TVET) principles. Using a mixed-methods design, 30 preschool children aged 5–6 were assessed through pre- and post-assessment, structured observations, interviews, and task-based evaluations. Results showed a significant increase in post-assessment scores from a mean of 52.00 to 76.83 (t = –14.02, p = 0.008), indicating a 47.7% improvement in agricultural knowledge. Memory reinforcement also rose by 19.18% (t = 8.03, p < 0.001), suggesting enhanced retention and understanding. Furthermore, 90% of the students demonstrated measurable improvements in fine and gross motor skills, as confirmed by Wilcoxon Signed-Rank Test results (Z = –4.10 and –4.21, p < 0.001). Additionally, 85% showed improved classroom collaboration, communication, and teamwork during activities. These findings confirm that the Farm-to-Table approach, when combined with gamification and technical elements, fosters cognitive, physical, and social development. By bridging theoretical knowledge with real-world experiences, this approach not only supports curriculum goals but also prepares children with essential life skills, setting a strong foundation for lifelong learning and holistic growth.

1. Introduction

Early childhood education is pivotal in shaping a child's cognitive, social, and emotional development. Integrating elements of Technical and Vocational Education and Training (TVET) into preschool learning can provide a holistic educational experience, bridging the gap between academic knowledge and practical, real-world applications (Averin et al., 2020; Wang et al., 2016). This paper explores the potential of combining TVET principles with the Farm-to-Table approach, focusing on its implementation in preschool science education.

The National Preschool Assessment Instrument (IPPK) emphasises Skill Unit 3, which focuses on the investigation of living organisms under the Early Science (SA) 3.4 category through plant exploration. While the current framework adequately assesses students' understanding of plant basics, introducing a project-based learning method such as Farm-to-Table can enhance this experience. Farm-to-Table aligns with learning standards and has demonstrated effectiveness in preschool settings. For instance, the Farm-to-Preschool program highlights the importance of teacher support in nutrition education, offering hands-on, real-world learning experiences that stimulate motor skills, enhance memory, and foster classroom collaboration (Hoffman et al., 2016; Bloom et al., 2022). This approach also promotes the consumption of self-grown, healthy food, ensuring freshness and food safety, which is vital for children aged 5 and 6 to prevent diseases such as obesity.

The initiative connects early childhood education with agricultural science, providing an ideal platform to instil healthy eating habits in preschoolers while aligning with the Standard Curriculum and Assessment Document (KSKP). Teachers and Preschool Management Assistants (PPM) play a crucial role in this process, using modules based on the Standard-Based Preschool Curriculum (SMPK) to assess students' abilities through IPPK.

While TVET has traditionally been recognised for alleviating poverty and improving youth employment (Shi & Bangpan, 2022), its integration into early childhood education is a relatively unexplored area. Incorporating TVET elements into preschool learning introduces young learners to the practical applications of scientific concepts, fostering active participation and enhancing their overall competency levels (Abdullah et al., 2021). According to Riyanda et al. (2021), TVET principles can form the foundation of interdisciplinary learning experiences that develop creativity, motor skills, and an understanding of scientific fundamentals. The Farm-to-Table approach exemplifies this integration, offering young learners' hands-on opportunities to explore the interdependence of agriculture, food production, and sustainability (Bustamante et al., 2018; Averin et al., 2020). By bridging theory and practice, this method empowers children to connect academic knowledge with real-world applications. Despite its potential, integrating the Farm-to-Table approach with TVET principles faces challenges, including bureaucratic barriers and limited knowledge among educators. Preschool children are particularly vulnerable to poor nutrition, as evidenced by high obesity rates and low fruit and vegetable intake (Wan Risad et al., 2023). This underscores the need for further research to support teachers in effectively implementing these approaches and understanding their impact on children's nutritional knowledge and behaviour (Sims, 2014).

This study seeks to address the identified gaps by focusing on two primary objectives. Firstly, it aims to evaluate the effectiveness of the Farm-to-Table method in enhancing preschool students' understanding of plants and agriculture, as outlined in the IPPK and Early Science standards. Secondly, the study examines the impact of practical agricultural activities on the learning process, particularly through the integration of gamification and technical in preschool settings, to assess their influence on engagement and educational outcomes.

Integrating the Farm-to-Table approach with TVET principles offers a promising avenue for enriching preschool education. By fostering real-world connections, promoting healthy eating habits, and incorporating innovative teaching methods, this approach has the potential to transform early childhood education into a more holistic and impactful experience. However, addressing the existing challenges through targeted research and teacher support is essential for its successful implementation.

1.1 The Effectiveness of Bringing Agricultural Inputs

The method is an innovative approach that engages preschool students in learning about plants and agriculture through practical activities. This method aligns with the IPPK and the Early Science (SA) 3.4 category, which focuses on the investigation of living things, such as plants. While existing assessments are sufficient to gauge students' basic knowledge of plants, the agricultural approach offers a deeper and more engaging learning experience. The combination of this method with the KSKP and IPPK enhances preschool teachers' instructional quality and improves students' understanding of Early Science topics and subtopics.

Several studies have examined the effectiveness of the method in improving preschoolers' understanding of plants and agriculture. One study found that meals prepared through this approach were more nutritious compared to conventional meals. Additionally, the method increased students' interest and motivation to learn, developed social and communication skills, and fostered awareness of healthy eating and environmental sustainability (Growing Minds, 2021; Hashim et al., 2024). Students also benefit from hands-on learning experiences, allowing them to connect theory with practice and understand agricultural processes from start to finish. The effectiveness of this method is further supported by the efforts of Malaysia's Ministry of Health (KKM) to strengthen child and preschool nutrition through the MyHealth KKM initiative launched in 2009.

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1.2 Hands-on Agricultural Approaches in Early Childhood Education

Practical agricultural activities have been shown to positively impact preschool learning. Studies highlight that after-school gardening programs significantly improve children's vegetable intake and physical activity levels. Other research underscores the importance of experiential learning, such as school gardening, farm visits, and cooking activities (Mohamed et al., 2020). These hands-on experiences not only spark interest and motivation among young learners but also contribute to the development of social, communication, and teamwork skills (Hashim et al., 2024). Furthermore, these activities provide opportunities for students to understand healthy nutrition and environmental sustainability through practical engagement, reinforcing memory and applying theoretical concepts learned in the classroom.

Incorporating gamification and technical into project-based learning for preschoolers integrates game elements and digital tools to enhance interaction and engagement during educational activities. Features like achievements, levels, rewards, and challenges motivate children to actively participate and achieve learning objectives. This approach creates a dynamic and enjoyable learning environment, fostering critical skills such as collaboration, creativity, and problem-solving among preschoolers. The combination of gamification and digital tools not only enriches the learning experience but also makes it more effective and appealing, ensuring children are better prepared for future academic and social challenges (Moss et al., 2013).

When combined, these approaches of practical agricultural activities and gamification with digital tools will create a holistic learning environment. It will enable children to connect theoretical knowledge with real-world applications while maintaining high levels of engagement and motivation, ultimately fostering a deeper understanding of sustainability and lifelong healthy habits.

1.3 Intervention and Role of TVET in Early Childhood Education

Technical and Vocational Education and Training has long been recognized for its potential to alleviate poverty and improve youth employment in developing countries (Shi & Bangpan, 2022). However, the integration of TVET elements into early childhood education is a relatively unexplored area. Incorporating TVET principles into preschool science exploration can expose young learners to the practical applications of scientific concepts, encouraging active participation and enhancing overall competency levels (Abdullah et al., 2021). Technology and vocational education can form the basis of the core curriculum by providing engaging and interdisciplinary learning experiences that foster creativity, develop motor skills, and understand the fundamentals of science through learning the application of technology (Riyanda et al., 2021). This approach can bridge the gap between theory and practice, empowering children to connect their academic knowledge with real-world applications.

The existing literature on the integration of TVET elements in preschool education provides valuable insights into the challenges and opportunities of this approach. Various past study has highlighted the importance of incorporating Information and Communication Technologies into the TVET pedagogy to meet the demands of the modern workforce. This suggests that integrating digital tools and technologies into the farm-to-table approach can enhance the learning experience and better prepare children for the future (Paudi et al., 2022; Kanwar et al., 2019). Furthermore, it can highlight the effectiveness of leveraging mobile and adaptable technology to improve teaching and learning in TVET (Ismail et al., 2016). This suggests that incorporating mobile devices or interactive digital resources can significantly enhance the exploration of innovative approaches in preschool science education (Varman et al., 2021). This suggests that integrating agricultural approaches into preschool science exploration can nurture a love for learning while fostering a holistic understanding of scientific concepts, paving the way for continuous development throughout a child's educational journey (Zeng et al., 2017).

1.4 Farm-to-Table Approach

The existing literature suggests that school gardens can have a positive impact on children's environmental attitudes and behaviours (Williams & Dixon, 2013). Quantitative studies have shown improvements in scientific achievement and food-related behaviours, while qualitative studies have documented a wider range of social and environmental benefits (Blair, 2008). For instance, one study found that school gardening increased children's vegetable consumption, recognition, and willingness to taste new vegetables (Ratcliffe et al., 2009) Another study in Taiwan identified seven key benefits of school gardening, including improved life skills, relationships, and connection to nature (Chang et al., 2016).

However, the evidence is not entirely conclusive, as some studies have reported mixed or limited effects on environmental attitudes (Blair, 2008). Further research is needed to better understand the factors that influence the success of school gardening programs, such as teacher support, curriculum integration, and program sustainability. This study aimed to build on the existing research by exploring the impact of a school gardening program on the environmental attitudes of elementary school students (Kim et al., 2021). The childcare garden intervention, employing the Farm-to-Table approach, significantly improved children's ability to identify fruits

and vegetables (FV) and enhanced their FV consumption during tasting sessions (Mokhtar et al., 2022; Wethington et al., 2005).

To enhance the clarity and connectivity of the concepts discussed, the following diagram illustrates the integration of TVET elements, the Farm-to-Table approach, and the Early Science 3.4 category from the Malaysian Preschool Curriculum (IPPK). This visual representation demonstrates how these components work together to support a holistic and practical learning environment, ultimately contributing to the development of students' scientific understanding, 21st-century skills, and overall competitiveness from an early age as shown in Figure 1.

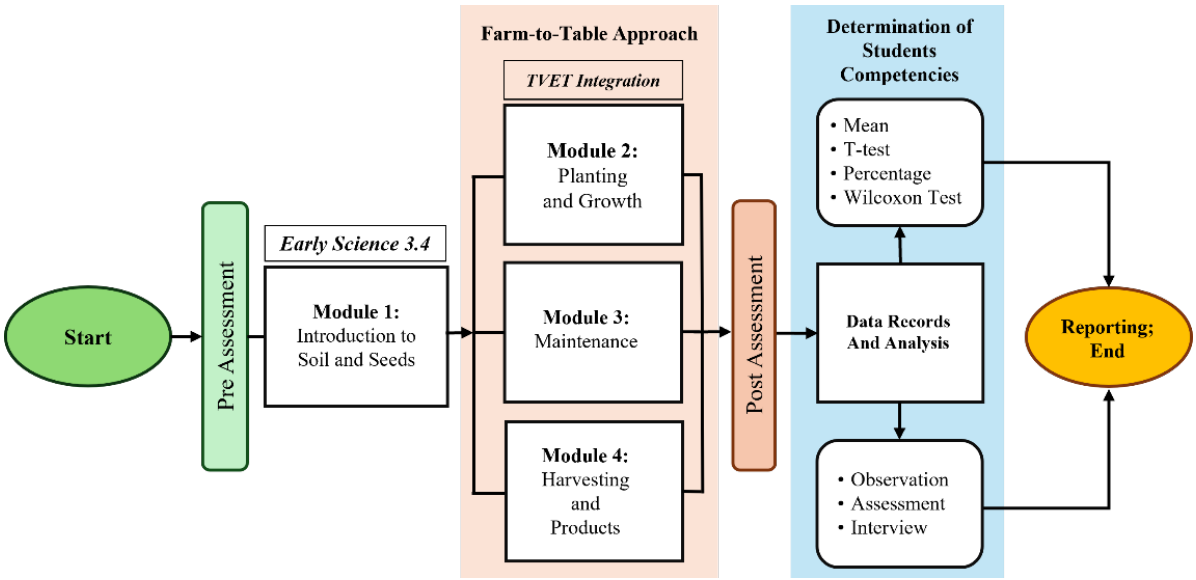

Fig. 1 *Interconnectivity concepts of Farm-to-Table approach*

2. Methodology

This study adopts a mixed-methods approach, combining qualitative and quantitative methods to provide a comprehensive analysis of the research issue. This approach enables a deeper understanding of the research questions by leveraging the unique strengths of both methods (Varman et al., 2021).

The quantitative method offers numerical data and statistical analysis, while the qualitative method provides in-depth insights and contextual understanding. The mixed-methods approach offers advantages, such as its ability to address complex research questions and provide a more holistic understanding of the research topic (Creswell et al., 2017). Additionally, the increasing acceptance and application of this approach in educational research highlight its capability to capture the depth and diversity of educational phenomena (Johnson et al., 2007). The research design of this module is divided into several key sections, with the time allocated for each section structured according to its requirements. The breakdown of the design is attached in Table 1.

Table 1 *Research design structure*

No	Phase	Details	Steps
1	Preparation	Developing data collection methods	Selecting educational methods
		Consent, interviews, checklists	
2	Implementation	Module 1: Introduction to Soil and Seeds	Teaching and Learning
		Module 2: Planting and Growth	
		Module 3: Maintenance	
		Module 4: Harvesting and Products	
3	Data Collection	Data collection and conducting interviews	Interviews
4	Data Analysis	Quantitative analysis to measure learning achievements	Learning Outcomes
5	Reporting	Comprehensive report	Introduction, Methodology

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This study is conducted over a minimum duration of 14 to 21 days, depending on the growth rate of the selected plants for the project. If the plants die during subsequent modules, the project can be restarted from **Module 1** at any time.

2.1 Research Sample

The research sample consists of 30 preschool children aged 5 to 6 years. The participants were selected using a simple random sampling method from preschools willing to participate in the study. The sampling process involved communication with the preschool authorities to obtain permission for the project and distributing information letters to parents. These letters outlined the project's objectives, procedures, and benefits. Collaboration with parents and teachers was emphasized to provide a multidimensional perspective and enhance data collection accuracy. To ensure consistency in baseline knowledge, refined inclusion criteria were recommended, targeting children with no prior exposure to similar interventions. A longitudinal design was also suggested to facilitate the assessment of long-term impacts on children's learning and development (Pemakanan Kanak-Kanak & Pra-Sekolah., 2009).

2.2 Data Collection Instruments

This study utilized observation methods, including interviews and task assessments, to gather information and evaluate the achievements of preschool children. This table outlines a structured approach to research methodologies tailored for assessing preschool students' learning and development during project-based activities. The methods which improve from Kozlowski & Ilgen (2006), suggests the assessment divided into groups which are pre-assessment and post-assessment, observational study, interview, and task assessment which are strategically designed to evaluate key dimensions such as knowledge acquisition, engagement, skill development, and the overall impact of the educational intervention. Each method is grounded in evidence-based practices, ensuring the collection of robust and reliable data (Ahmed, 2024).

The implementation strategies emphasize age-appropriate techniques, including the use of visual aids, systematic observation tools, guided interviews, and task-based evaluations (Slade et al., 2019). These approaches facilitate meaningful interactions and foster an environment conducive to learning while enabling educators to document and analyse the cognitive and behavioural outcomes of young learners systematically. This framework offers valuable insights for advancing research in early childhood education. The data collection structure is outlined in Table 2.

Table 2 *Data collection structure*

Research Method	Method	Implementation
Pre and Post Assessment	Objective: To measure students' understanding before and after the project.	1. Use visual aids, pictures, and simple language that preschool children can understand. 2. Conduct interactive assessments such as quizzes or hands-on activities.
	Pre-assessment: Ask questions or conduct simple activities to assess students' prior knowledge in Module 1. Post-assessment: Ask similar questions or conduct activities after the project to evaluate students' learning.	
Observational Study	Objective: To study student engagement, participation, and skill development throughout the project.	1. Use checklists or rating scales to record observations systematically. 2. Video recordings may be used for later detailed analysis.
	Structured Observation: Record observations based on specific indicators such as engagement, collaboration, following instructions, motor skills, and understanding of growth processes and classroom collaboration.	
Interview	Objective: To gather in-depth feedback from students, teachers, and parents about the project's impact.	1. Provide a set of guiding questions tailored to the comprehension level of preschool students.
	Conduct short and structured interviews with students about the module.	
Task Assessment	Objective: To create a tangible record of student learning and progress.	1. Guide students in completing worksheets suitable for their age with the help of the teacher and assistants.
	Ask students to complete tasks that include drawings, photos, and notes about each project step. Include sections for each module where students can document their activities and observations.	

In summary, the proposed strategies for enhancing the research sample aim to ensure methodological rigor, diversity, and comprehensive representation, thereby improving the reliability and applicability of the study's findings. By employing simple random sampling, and involving diverse preschool settings, the study can capture a more holistic understanding of the factors influencing preschool children's learning outcomes (Creswell et al., 2017). Furthermore, the integration of longitudinal tracking and active collaboration with parents and teachers strengthens the depth and accuracy of the data collected (Muktasam et al., 2019). With these measures in place, the research framework is well-positioned to systematically assess student engagement, skill development, and learning progress (Pakpahan et al., 2022). The following section presents the detailed timeframe for implementing the assessment methods, as outlined in the Rubric time chart below in Table 3, to ensure timely and structured execution of each phase of the study.

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Table 3 *21 days rubric time for modules 1 to 4*

Day	Module	Activities	Learning Outcomes
Day 1-3	Module 1: Introduction to Soil and Seeds	Introduction to soil and seeds. Hands-on activity: Planting seeds in soil.	• Understand the importance of soil for plant growth. • Identify different types of seeds.
Day 4-6	Module 1 (Continued)	• Discussion on seed types and soil composition. • Observation of seed germination.	• Explain the process of seed germination. • Demonstrate the basic care of planted seeds.
Day 7-9	Module 2: Planting and Growth	Teach about plant care: • Watering, light, and soil conditions. • Observation and record growth stages.	• Describe the factors that affect plant growth. • Record and document plant growth.
Day 10-12	Module 2 (Continued)	Group activity • Compare different plants' growth. • Record observations in a journal.	• Compare the growth of different plant species. • Analyse plant development over time.
Day 13-18	Module 3: Maintenance	Discuss plant maintenance: • Removing weeds, checking for pests, and adding nutrients. Hands-on activity: • Plant maintenance • Discuss how to solve common plant issues.	• Identify common plant problems. • Understand how to maintain healthy plants. • Apply plant care techniques. • Demonstrate proper maintenance of plants.
Day 19-21	Module 4: Harvesting and Products	• Introduction to harvesting methods. • Harvest plants and observe the final product.	• Understand the process of harvesting. • Discuss how plants are turned into products (fruits, vegetables).
Day 21	Review and Assessment	• Review all modules. • Conduct final assessments through observation and tasks.	• Demonstrate understanding of the entire project. • Evaluate learning progress through task completion.

The structured rubric for the 21-day learning schedule provides a comprehensive framework for guiding students module is meticulously allocated a specific timeframe to ensure an in-depth understanding of the concepts and practices related to soil preparation, plant care, and harvesting techniques. The activities are systematically designed, beginning with foundational knowledge in Module 1 and progressively advancing to practical applications and final assessments in Module 4. If the plant dies between days 7 and 9, the students will restart the process from day 1, returning to Module 1.

The activities within each module are diverse, encompassing classroom discussions, hands-on planting exercises, group comparisons, and reflective journal observations (Slade et al., 2019). Practical sessions, such as pruning and harvesting, are incorporated to enhance students' engagement with real-world applications (Snapp et al., 2023). Each activity is strategically aligned with measurable learning outcomes, enabling students to track their progress. For instance, outcomes include understanding seed germination processes, applying effective plant maintenance techniques, and documenting growth stages (Muktasam et al., 2019; Slade et al., 2019).

. The final phase of the schedule is dedicated to review and assessment, allowing students to consolidate their learning, evaluate their progress, and demonstrate their understanding of the project's objectives. This comprehensive approach ensures that students achieve a robust understanding of gardening principles, fostering practical skills and theoretical knowledge in a structured and outcome-focused manner.

3. Data Analysis

3.1 Effectiveness of the Farm-to-Table Method

To evaluate the effectiveness of the Farm-to-Table method in enhancing preschoolers' understanding of plants and agriculture, several components were assessed. Pre-assessment and post-assessment scores measured conceptual understanding, supported by statistical proofs (mean, t-test, p-value and z-core). Practical agricultural knowledge was evaluated through observations of hands-on activities like gardening and harvesting. Additionally, critical thinking and problem-solving skills were assessed based on children's participation and engagement throughout the programme.

3.2 Impact of Practical Agricultural Activities on Learning Development

The study employs various analytical approaches to explore the impact of practical agricultural activities on learning development. Structured observations are used to gather data on real-world work experiences, memory reinforcement, sensory motor stimulation, and classroom collaboration enhancement (Abdul Razzaq et al., 2009; Mokhtar et al., 2022). Descriptive analyses summarise these observations, calculating metrics such as mean, maximum, average, and standard deviation for each component. Key components, including the ability to gain real-world experience, memory retention, sensory motor stimulation, and strengthened classroom collaboration, are evaluated using a numerical scale of 1 to 5 adopted from Smichdt (2016) as outlined in Table 4. Using this numerical scale, the assessment of each component of agricultural activities can be conducted more consistently and presented in a way that is easily understood.

Table 4 *Numerical scale for component assessment*

Score	Description
1	Very low achievement or unsatisfactory
2	Low achievement or requires improvement
3	Moderate achievement or satisfactory
4	Good achievement or very good
5	Very high achievement or excellent

The total score obtained by all 30 students was computed. This total represented the cumulative performance of the group and was critical for subsequent calculations. The mean (average) score was derived by dividing the total cumulative score by the number of students (n=30). This calculation ensured that the analysis accounted for individual variations while providing a summary measure of the group's collective knowledge prior to the intervention; calculated as shown in Equation 1.

$$Mean\ Score = \frac{Total\ Sum\ of\ Score}{Number\ of\ Students} \quad (1)$$

The mean score as derived from the analysis, served as the baseline metric for evaluating the effectiveness of the programme (Snapp et al., 2023). This score was later compared to post-assessment scores to determine the extent of learning improvement attributable to the Farm-to-Table intervention. By employing this method, the analysis ensured consistency and objectivity in quantifying the students' initial understanding, laying the groundwork for subsequent discussions of the programme's impact (Chiero & Mobley, 2021).

4. Results and Findings

The analysis indicates a significant improvement in both variables studied, providing evidence that the interventions or actions undertaken in this study had a positive impact which resulting to the students' competencies towards the approach. With the rejection of both null hypotheses, these findings confirm that the observed variables underwent significant changes aligned with the objectives of the study.

H_{01}: The Farm-to-Table method *does not enhance* preschool children's understanding of plants and agriculture based on the IPPK and Early Science.

H_{02}: Practical agricultural activities *have no impact* on the learning process development through gamification and technical in preschool.

4.1 Analysis of Pre-assessment and Post-assessment Scores

The analysis of pre-assessment and post-assessment scores from 30 preschool students participating in the Farm-to-Table program demonstrates a significant improvement in their understanding of plants and agriculture as shown in Table 5 and Table 6. This suggests that while most students showed improvement, some demonstrated more significant gains than others (Chiero & Mobley, 2021).

Table 5 *Paired sample statistics*

Pair	Mean	N	Std. Deviation	Std. Error Mean
Pre assessment	52.00	30	6.49	1.18
Post assessment	76.83	30	10.30	1.88

The results indicated a statistically significant increase in scores following the implementation of the program. The mean score increased from 52.00 to 76.83, resulting in a mean difference of 24.83. The standard deviations for the pre-assessment and post-assessment scores were 6.49 and 10.30, respectively, indicating some variability in the students' scores, with more variation seen in the post-assessment.

Table 6 *Paired sample correlation and t-test*

Pair	N	**r**	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Pre assessment – Post assessment	30	.543	24.83	10.60	-14.02	29	0.008 (<0.05)

The correlation between pre- and post-assessment scores was moderate and statistically significant (r = 0.543, p = 0.008), suggesting a positive relationship between scores before and after the intervention. The paired t-test showed a significant difference in scores (t = -14.02), with a mean increase of 24.83, confirming that the Farm-to-Table method led to a statistically significant improvement in children's understanding of agriculture. The average pre-assessment score was 52, while the post-assessment score increased substantially to 76.83, marking a 47.7% improvement in student knowledge as shown in Equation 2. Hence, the H_{01} hypothesis was rejected, confirming that the module significantly improved agricultural knowledge among the students.

$$\% = \frac{(Post - assessment) - (Pre - assessment)}{Pre - assessment} \times 100$$
$$\% \, Increase = \frac{76.83 - 52}{52} \times 100 \approx 47.7\% \quad (2)$$

4.1.1 Analysis of Learning in Real-Life Experiences (Hands-on)

Based on Schmidt (2016), numerical scores; 90% of students achieved a score of 4 or higher in Modules 3 and 4, suggesting a high success rate in gaining meaningful real-life experience. This implies that hands-on activities are very effective in facilitating experiential learning. These findings emphasize the positive influence of the Farm-to-Table assessment in improving both knowledge retention and skill development in preschool.

4.1.2 Memory Reinforcement

80% of students demonstrated an improvement in their understanding of the process, highlighting the significant impact of practical activities on memory retention. The paired sample *t*-test analysis in Table 7 revealed a statistically significant improvement in memory reinforcement scores among the students. The memory reinforcement scores improved from 73.00 to 87.00, $t = 8.03$, $p < .001$. The effect sizes, represented by correlation coefficients ($r = 0.591$), indicate a moderate impact. These findings affirm the effectiveness of experiential, hands-on interventions in significantly enhancing children's understanding and memory retention of agricultural and plant-related concepts.

Table 7 *Paired sample correlation and t-test*

Pair	N	Pre	Post	r	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Pre assessment – Post assessment	30	73	83	.591	14.0	7.12	8.03	29	0.001 (<0.05)

As shown in Equation 3, the average pre-activity score was 73%, which increased to 87% following the activity, illustrating a notable enhancement in student performance. his suggests that experiential learning, such as the activities in this program, is effective in enhancing students' ability to recall and apply knowledge (Sutapa & Suharjana, 2019; Pillado et al., 2020). The 19.18% improvement in scores underscores the program's success in strengthening students' grasp of the concepts related to plant growth and agriculture.

$$\% \, Increase = \frac{87 - 73}{73} \times 100 \approx 19.18\% \tag{3}$$

4.1.3 Motor Skill Stimulation

Through observations, 80% of students exhibited measurable improvements in motor skill development following participation in the Farm-to-Table program. This observed trend aligns with the results of the Wilcoxon Signed-Rank Test, which further confirmed a statistically significant increase in both fine and gross motor skills, as shown in Table 8 below. Based on the Wilcoxon Signed-Rank Test results, approximately 90% of the student demonstrated improvement in both fine and gross motor skills following the intervention. These findings highlight the effectiveness of hands-on, experiential learning in fostering developmental outcomes among preschoolers (Mohamed et al., 2020). Therefore, the result rejects H_{02}, confirming that practical agricultural activities significantly influence the development of the learning process through gamification and technical in preschool students.

Table 8 *Wilcoxon Signed-Rank Test results*

Skill Type	Pre Median	Post Median	Z-score	*p-value*
Fine Motor Skills	3	4.5	−4.10	< .001
Gross Motor Skills	2	4	−4.21	< .001

Specifically, fine motor skill scores improved from a median of 3.00 to 4.50 ($Z = -4.10$, $p < .001$), while gross motor skills increased from 2.00 to 4.00 ($Z = -4.21$, $p < .001$). The convergence of descriptive and inferential findings reinforces the effectiveness of experiential, hands-on agricultural activities in promoting motor development among preschool learners. This improvement highlights the value of hands-on, physical activities in fostering motor development in young children, supporting the idea that experiential learning can stimulate both cognitive and physical growth (Sutapa et al., 2021; Zeng et al., 2017). Therefore, the result rejects $H0_2$, confirming that practical agricultural activities significantly influence the development of the learning process through gamification and technical in preschool education.

4.1.4 Strengthening Classroom Collaboration

The Farm-to-Table program also had a positive impact on classroom collaboration, with 85% of students demonstrating improved teamwork and cooperation during the activities. This suggests that the hands-on nature of the program encouraged students to work together, fostering social skills and strengthening their ability to collaborate in a group setting (Zeng et al., 2017). However, 15% of the students faced challenges, particularly in Modules 2 and 3, which may have been due to individual factors such as lack of interest or difficulties engaging with certain tasks. Despite these challenges, the overall trend shows that the program effectively enhanced collaboration and teamwork among most students, supporting its value in promoting social and cooperative learning in the classroom (Mannogaran et al., 2023).

5. Conclusion

This study provides empirical evidence that the Farm-to-Table approach, when aligned with TVET elements and Early Science curriculum standards, significantly improves preschoolers' learning outcomes. The 47.7% increase in conceptual understanding, 19.18% boost in memory retention, and 90% improvement in motor skills collectively demonstrate the holistic benefits of integrating practical agriculture into early education. The method not only bridges theoretical knowledge with real-world practice but also promotes collaboration and cognitive engagement through gamified and technical elements. Despite the comprehensive mixed-methods design, this study had several limitations. The sample size was limited to only 30 preschoolers from a single region, which may affect the generalizability of the findings. The short intervention period of 21 days may not fully capture long-term behavioural and cognitive impacts. Additionally, reliance on observational and self-reported data from young children and teachers may introduce subjective bias. Although multiple instruments were used to triangulate data, the absence of a control group limits causal interpretations. Future studies should consider longitudinal designs, larger and more diverse samples, and the inclusion of control conditions to strengthen the

robustness and applicability of the findings. Nonetheless, the study clearly demonstrates the relevance of linking this approach to TVET, as it fosters core competencies such as critical thinking, teamwork, problem-solving, and hands-on technical skills. These findings suggest that TVET principles are not only adaptable but also impactful when introduced at the preschool level, setting a strong foundation for future learning, real-world readiness, and lifelong skill development. Nevertheless, the results highlight the potential of this approach to foster well-rounded, competitive learners in early childhood settings.

Acknowledgement

The author would like to express gratitude to the preschool students and parents for their participation and valuable insights during the study. Appreciation is also extended to colleagues and peers who provided support and feedback throughout the research process. Lastly, thanks to the relevant authorities for their ongoing efforts in promoting this educational approach.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Muhammad Nazarwin; Muhammad Zakwan Anas;* ***data collection:*** *Siti Khadijah, Aiman Fikri;* ***analysis and interpretation of results:*** *Muhammad Nazarwin, Muhammad Zakwan Anas, Emir Azreen;* ***draft manuscript preparation:*** *Muhammad Nazarwin, Muhammad Zakwan Anas, Emir Azreen, Siti Khadijah, Aiman Fikri. All authors reviewed the results and approved the final version of the manuscript.*

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

While preparing this work, the author(s) utilized ChatGPT to enhance the readability and language of the text. Following the use of this tool, the author(s) thoroughly reviewed and edited the content as necessary and assume full responsibility for the publication's content.

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