



DEVELOPMENT OF BIOLOGICAL GARDENING SKILLS AND ENHANCED ACADEMIC PERFORMANCE THROUGH STEM-BASED LEARNING AMONG NCE STUDENTS, NORTH-WEST, NIGERIA

BY

Nuru, R.A.,

Department of Biology,
Federal College of Education, Zaria
mumbilly882@gmail.com | (+234) 8067679515

Musa, H.R.

Department of Biology,
Federal College of Education, Zaria

&

Ezeaghasi, N. E

Department of Biology,
Federal College of Education, Zaria

Abstract

This study explored the development of biological gardening skills and enhanced academic performance through STEM-based learning among Nigerian Certificate in Education (NCE) students in Zaria, Nigeria. The study employed a quasi-experimental, non-randomized pre-test-post-test control group design involving 135 NCE pre-service biology students from two federal colleges of education in northwest Nigeria. The experimental group engaged in hands-on biological gardening activities for six weeks, while the control group received traditional classroom instruction. Data were collected using the Biology Garden Concept Performance Test (BGCPPT), a 25-item multiple-choice assessment, and analyzed using mean, standard deviation, and t-test. Results indicated that STEM-based learning significantly improved students' biological gardening skills and academic performance. The experimental group achieved a higher mean post-test score ($M = 28.33$) compared to the control group ($M = 18.98$), with a statistically significant effect ($p < 0.05$). There was an improvement in the acquisition of STEM-based biological gardening skills. Gender differences were negligible, with females slightly outperforming males, suggesting equal benefits for both genders. The study recommends that the National Commission for Colleges of Education should incorporate STEM-based approaches into biology education curricula to enhance the acquisition of biological gardening skills and academic performance, among others.

Keywords: Development, Biological Gardening, Skills, Enhanced, Academic Performance, STEM-Based Learning.

Introduction

In our rapidly evolving technological era, science education serves as the cornerstone of national development

(Aithal & Maiya, 2023). Beyond workforce preparation, scientific literacy determines a nation's economic competitiveness and geopolitical

influence. Among scientific disciplines, biology occupies a unique position - bridging theoretical knowledge with practical applications in medicine, agriculture, and environmental conservation (Izah & Ogwu, 2023). However, traditional pedagogical approaches often fail to translate classroom concepts into real-world competencies (Okpara, 2024), creating a critical gap in science education. Biological gardens emerge as transformative educational spaces that address this challenge.

According to Kalgi, & Hire (2024) biological gardens are planned and maintained outdoor space where plants such as flowers, vegetables, herbs, and trees are grown. Stagg, Hetherington & Dillon (2025) added that they range from small home gardens to large botanical gardens to school gardens. School gardens are considered open-air laboratories for students. These living laboratories (Kalgi & Hire, 2021) provide an ideal platform for integrated STEM learning, where students investigate plant biology and ecosystem dynamics (science), implement smart irrigation and monitoring systems (technology), design sustainable garden layouts and composting solutions (engineering), and calculate growth metrics and resource requirements (mathematics). This hands-on approach cultivates not only academic mastery but also essential life skills, environmental stewardship, patience, and responsibility (Bwegyeme & Munene, 2021). Research confirms that such experiential learning significantly enhances knowledge retention and practical problem-solving abilities (Zuiker & Riske, 2021).

The development of these competencies is particularly vital for NCE students. As future educators, they must embody both subject mastery and sustainable practices to effectively nurture environmental consciousness in their students (Hogan & O'Flaherty, 2021). STEM-based biological gardening offers an ideal framework for this dual development, merging theoretical

understanding with actionable skills. Projects such as creating automated plant watering systems and analyzing garden ecosystem data help students connect classroom concepts to tangible outcomes. This method not only improves academic performance but also fosters innovation, teamwork, and practical skills that students can apply beyond the classroom (Tariq, 2024). This approach cultivates a new generation of learners who can think critically, solve problems creatively, and contribute to sustainable development in their communities. The integration of science, technology, engineering, and mathematics through practical applications creates a powerful learning environment that prepares students for the challenges of the modern world. Asogwa (2024) highlights that biological gardens provide a hands-on, multidisciplinary approach to STEM education by combining science, technology, engineering, and mathematics to understand soil chemistry, plant biology, ecosystems, and climate change. This is achieved through the use of hydroponics, intelligent irrigation systems, composting systems, water-saving methods, efficient garden designs, space management, fertilizer ratio calculations, and plant growth monitoring.

Despite these demonstrated benefits, a significant research gap persists regarding STEM-based gardening interventions for Nigerian teacher trainees. This study specifically intends to examine how integrated STEM gardening activities impact both skill development and academic performance among NCE students in Northwest Nigeria.

Statement of the Problem

Science education in Nigeria struggles to connect theoretical knowledge with practical application, particularly in biological and environmental sciences. Despite recognizing the value of hands-on learning, teacher training programs at the NCE level appears to remain heavily reliant on textbook instruction. This in-turns leaves future biology

teachers ill-equipped to teach practical concepts or address real-world challenges in their classrooms. A key issue is the persistence of traditional teaching methods that fail to cultivate essential skills in conservation and applied learning. Although STEM education has proven effective globally for developing problem-solving abilities, its adoption in Nigerian teacher colleges remains limited due to inadequate resources and training. Additionally, biological gardens, which could serve as valuable hands-on learning spaces seems to be underutilized, resulting in graduates who understand theory but lack practical competencies. The problem is further complicated by regional environmental challenges like soil degradation and water scarcity, as well as potential gender disparities in science engagement, none of which are sufficiently addressed in current curricula.

Existing assessment methods worsen these gaps by prioritizing theoretical knowledge over practical skills. Standardized tests fail to measure critical abilities like innovation, problem-solving, and environmental stewardship, leaving a disconnect between classroom instruction and real-world needs. This study investigates how STEM-based biological gardening can enhance both skill development and academic performance among NCE students in North-West Nigeria. The findings aim to guide reforms in teacher education, ensuring future educators are better prepared to deliver effective, practical science instruction.

Objectives of the Study

This study aims to achieve the following specific objectives:

1. Determine the effectiveness of STEM-based biological gardening in enhancing academic performance among NCE students in North-West Nigeria.
2. To assess the improvement in students' practical competencies in plant cultivation, soil management, and sustainable agricultural practices

through hands-on biological gardening activities.

3. Examine gender differences in the acquisition of biological gardening skills and academic performance when STEM-based approaches are implemented.

Research Questions

To achieve the study's objectives, the following research questions were raised to guide the investigation:

1. What differences exist in academic performance between students taught using STEM-integrated biological gardening and those exposed to traditional classroom methods?
2. To what extent do hands-on biological gardening skills enhance students' competencies in plant cultivation, soil management, and other practices?
3. Are there gender-based variations in the acquisition of biological gardening skills and academic performance when STEM-based approaches are applied?

Null Hypotheses

The following null hypotheses were formulated in this study:

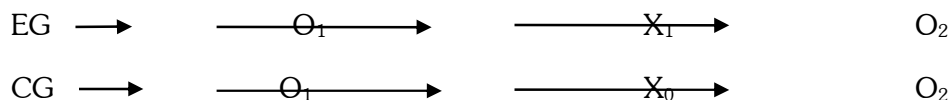
- HO₁:** There is no significant difference in academic performance between students taught using STEM-integrated biological gardening and those exposed to traditional classroom methods.
- HO₂:** There are no significant gender-based variations in academic performance when STEM-based approaches are applied.

METHODOLOGY

Research Design

The study employed the quasi-experimental of non-randomized pre-test-post-test, non-equivalent control group design.

Fig 1: Research Design



KEY: EG – Experimental group, O₁ – Pre-test, O₂ – Post-test, CG – Control group, X₁ – Treatment and X₀ – No Treatment.

Quasi-experimental designs are chosen because they enable researchers to study causal relationships in real-world and educational settings where randomization is impractical or unethical, while still maintaining practical relevance and strong external validity. They are cost-effective, flexible, and ethically appropriate for evaluating interventions among naturally occurring groups.

Population and Sample

The population for the study consisted of 8530 NCE two students from seven (7) Federal Colleges of Education in the northwest zone, Nigeria. The study sample comprised 135 NCE II biology students (60 males and 75 females). Simple random sampling was employed in selecting the two (2) FCEs from seven (7) using the lottery method. One class in each school was used as the experimental group and the other as the control group. One was assigned to the control group with a sample size of 63 students, while the other was assigned to the experimental group with a sample size of 72 students. One intact class was used from each school for the research purpose.

Instrumentation

One instrument was used for this study: the Biology Garden Concept Performance Test (BGCPT), which is a 25-item multiple-choice test with four options (A-D). Three of them are distractors, and the other one is the correct option. BGCPT was developed by the researcher to determine the

performance of students in gardening. Scoring of BGCPT is dichotomous because of the correct and incorrect options in the alternative provided in the test. Each question attracts four (4) marks, totaling 100 marks. The items were prepared based on Bloom's taxonomy of the cognitive domain to ensure the test items cover the different cognitive levels of the students. The content validity was also established by two experts in science education from Ahmadu Bello University, Zaria. The test-re-test method was used to determine reliability with 50 students from FCE Katsina. The PPMC coefficient value of 0.78 was determined. The experimental group was exposed to gardening for six (6) weeks, and the control group was taught the same concepts for the same period without exposure to gardening. Both groups were administered a pretest before their exposure to the different methods of teaching. Then, at the end of the teaching period, a post-test was administered to both groups.

RESULTS

The study examined how STEM-based learning affects the development of biological gardening skills and enhanced academic performance among NCE students in Northwest, Nigeria. The analysis examines how teaching method (STEM-based vs. traditional method), gender, and pretest scores influenced students' posttest performance.

Table 1: Summary of Means and Standard Deviation Values for post Post-Test Scores of Experimental and Control Groups

Groups	N	Mean	SD	Mean diff
Experimental	73	28.33	5.41	9.35
Control	62	18.98	5.76	
Total	135			

From Table 1, the **experimental group had a higher average score (28.33)** compared to the **control group (18.98)**. The significance of the mean difference was tested in the related hypothesis.

Table 2: Summary of Means and Standard Deviation Values for pre- and post-rubric scores on acquisition of STEM-based biological gardening skills of the Experimental group.

Groups	N	Mean	SD	Mean diff
Pretest	73	20.8		29.7
Post test	73	50.5		

Table 2 revealed an improvement in the acquisition of STEM-based biological gardening skills with a mean difference of 29.7. This indicates the method enables the students to develop their skills.

Table 3: Summary of Means and Standard Deviation Posttest Scores of Males and Females in Experimental Group only.

Gender	N	Mean	SD	Mean diff
Male	32	23.57	6.81	0.84
Female	41	24.41	7.62	
Total	73			

From the table above, the **females (Mean = 24.41)** performed slightly better than the **males (Mean = 23.57)**. However, the significance of the mean difference of 0.84 was tested in the related hypothesis.

Table 4: t test analysis of mean post test scores of students' academic performance in both groups

Groups	N	Mean	SD	df	t calc	P value	Decision
Experimental	73	28.33	5.41	133	82.56	0.000	*Significant
Control	62	18.98	5.76				
Total	135						

***Significant @ $p \leq 0.05$**

The table shows a statistically significant difference in post-test academic performance between the experimental (mean = 28.33) and control (mean = 18.98) groups, with a t-calculated value of 82.56 and a p-value of 0.000, which is less than the

significance level of 0.05. Therefore, the null hypothesis is rejected, indicating that the intervention had a significant positive impact on the experimental group's academic performance.

Table 5: t-test analysis of mean post-test scores of male and female students' academic performance in the experimental group only.

Gender	N	Mean	SD	df	T calc	P value	Decision
Male	32	23.57	6.81	71	7.869	0.06	Not Significant
Female	41	24.41	7.62				
Total	73						

***Not Significant @ $p \leq 0.05$**

The results show that there is no statistically significant difference in mean post-test academic performance scores between male (mean = 23.57) and female (mean = 24.41) students in the experimental group, with a t-value of 7.869 and a p-value of 0.06, which is greater than the 0.05 significance level. Therefore, the null hypothesis is retained—there is no significant gender-based difference in academic performance in this group.

Discussion

The findings of this study provide compelling evidence that STEM-integrated biological gardening instruction can significantly enhance students' academic performance and practical skills acquisition, supporting the broader literature on garden-based learning as an effective hands-on and interdisciplinary educational approach. The substantial gain in both theoretical knowledge and applied competencies confirms the crucial role of active, experiential learning environments in science education, resonating with studies emphasizing how real-world contexts like gardening facilitate deeper engagement and skill development (Gulhan, 2023; Eugenio-Gozalbo et al., 2020).

However, while the study robustly highlights the positive impact of the intervention, the exceptionally high t-value (82.56) reported between experimental and control groups calls for cautious interpretation. Such an extreme statistic suggests a possible overestimation of effect size or methodological factors such as sample characteristics or measurement precision

that may have influenced outcomes. Future research would benefit from triangulating findings with multiple measures and ensuring balanced group equivalence to strengthen internal validity, particularly given the non-randomized design employed.

The noted lack of statistically significant gender differences aligns with emerging trends that inclusive, hands-on STEM activities can mitigate traditional gender gaps in science achievement (Campbell, Kelly-Weber, & Lavallee, 2021; Thompson, 2022). This supports advocating for pedagogical strategies that contextualize learning in authentic, practical experiences to promote gender equity. Nevertheless, the marginal difference observed in favor of female students, though not significant, suggests avenues for further inquiry into subtle intersectional factors that might influence differential engagement or outcomes.

Finally, the implications for teacher education are particularly insightful. By integrating STEM principles within biological gardening, educators receive practical exposure that bridges the pervasive theory-practice divide, which is a persistent challenge in teacher preparation programs (Filgona, Sababa, & Filgona, 2016). Encouragingly, the approach champions both content mastery and pedagogical skill-building, but it also highlights the need for ongoing professional development to equip teachers with competencies for implementing such innovative outdoor and interdisciplinary curricula effectively. In summary, this study adds to the growing recognition of garden-based STEM education as a multifaceted strategy for enriching science learning and skills acquisition while advocating

for inclusive practices that support all learners. Continued research should address methodological rigor, explore nuanced gender dynamics, and prioritize teacher capacity-building to fully realize the potential of such experiential educational models.

Conclusion

The results of this study provide compelling evidence for the effectiveness of STEM-integrated biological gardening in biology education. The approach significantly improved both academic performance and practical skills while demonstrating equitable benefits across genders. These findings support the wider adoption of experiential, interdisciplinary approaches in science teacher preparation programs, particularly in contexts where sustainable agricultural practices are crucial for community development.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. The intervention or instructional strategy used be adopted or scaled up by the government in similar educational contexts to improve student achievement.
2. Biology Educators should continue using inclusive, hands-on approaches that engage all students regardless of gender.
3. The Federal government and educational policymakers should prioritize funding and infrastructure for practical STEM education, including school gardens.

References

- Aithal, P. S., & Maiya, A. K. (2023). Innovations in the higher education industry: shaping the future. *International Journal of Case Studies in Business, IT, and Education*, 7(4), 283-311.
- Asogwa, V. C. (2024). Hybridizing global best practices in agricultural education for sustainable national development and economic competitiveness. *International Journal of Agricultural Education & Research*, 2 (2), 147, 173(2).
- Bwegyeme, J., & Munene, J. C. (2021). Experiential Learning; Learning Abilities That Enhance Problem Solving Ability. *International Journal of Experiential Learning; Case Studies*, 6(1), 1-14.
- Campbell, A. C., Kelly-Weber, E., & Lavalley, C. (2021). University teaching and citizenship education as sustainable development in Ghana and Nigeria: Insight from international scholarship program alumni. *Higher Education*, 81(1), 129-144.
- Eugenio-Gozalbo, M., et al. (2020). Gardens as Science Learning Contexts Across Educational Stages. *International Journal of Science Education*.
- Filgona, J., Sababa, L. K., & Filgona, J. (2016). Effect of hands-on learning strategies on senior secondary school students' academic achievement in topographical map studies in Ganye educational zone, Adamawa State, Nigeria. *International Journal of Social Science and Humanities Research*, 4(3), 276-287.
- Gulhan, F. (2023). The order of garden-based learning from science education to STEM education. *Eurasian Journal of Science and Environmental Education*, 3(1), 17-23.
- Hogan, D., & O'Flaherty, J. (2021). Addressing education for sustainable development in the teaching of science: The case of a biological sciences teacher education



- program. *Sustainability*, 13(21), 12028.
- Izah, S. C., & Ogwu, M. C. (Eds.). (2023). Sustainable utilization and conservation of Africa's biological resources and environment (Vol. 32). Springer Nature.
- Kalgi, D., & Hire, J. (2024). Significance of horticultural designs and flower arrangements in the hospitality industry. *Current Scenario in Science and Technology, Environment, Agriculture, Health, Water Resources, Social Science, Literature & Industrial*, 59.
- Okpara, G. C. (2024). Enhancing Nigerian Education: A Philosophical Exploration of Diverse Teaching Methods. *Nnamdi Azikiwe Journal of Philosophy*, 14(1).
- Stagg, B. C., Hetherington, L., & Dillon, J. (2025). Towards a model of plant awareness in education: A literature review and framework proposal. *International Journal of Science Education*, 47(4), 539-559.
- Tariq, M. U. (2024). Enhancing students and learning achievement as 21st-century skills through transdisciplinary approaches. In *Transdisciplinary Approaches to Learning Outcomes in Higher Education* (pp. 220-257). IGI Global.
- Thompson, R. (2022). Practical STEM activities and gender equity in science education. *Science Education Review*.
- Zuiker, S. J., & Riske, A. K. (2021). Growing garden-based learning: mapping practical and theoretical work through design. *Environmental Education Research*, 27(8), 1152-1171.