



Impact of Hydroponics Training on Students' Practical Skills and Innovation in Tertiary Institutions in Edo State, Nigeria

Salome Emeya, PhD¹; Agege Jane Edeghonghon²

^{1&2}Department of Agricultural Education Faculty of Vocational and Technical Education,
Ignatius Ajuru University of Education, Port Harcourt, Nigeria
08036723436, 07065350407
salo_gee@yahoo.com¹

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Abstract

This study assesses the impact of hydroponics training on students' practical agricultural skills and their agricultural innovation. Hydroponics, a soil-less farming technique, offers sustainable solutions to modern agricultural challenges. Four (4) research questions were raised and answered, while 4 null hypotheses were formulated and tested at the .05 level of significance. The study adopted a quasi-experimental design, utilising pre-test and post-test evaluations to measure skill acquisition and innovation adoption. The population for the study was 59, comprised of 20 agricultural education students from Ambrose Alli University and 39 from the University of Benin. Data collection was done in two phases: a pre-test was administered to both groups before the treatment to assess their baseline knowledge and ensure group equivalency. Treatment: the experimental group was taught using hydroponic skills and Innovation Assessment (HSIA) test items developed by the researcher from personal experiences, curriculum contents of field experience, and literature reviewed over a period of three weeks (three periods per week), while the control group received instruction through conventional lecture, which had an impact on students' practical skills and adoption of

agricultural innovation. It was therefore recommended, among others, that educational boards should integrate hydroponics into secondary school agriculture curricula and also that the government should provide training facilities and organise capacity building for instructors to update their hydroponics expertise and pedagogical strategies. methods. Post-test: The items were face and content validated by three experts, while the reliability of the items was determined using Richardson K21, which yielded a coefficient of 0.78. Data were collected by the researcher and with the help of three research assistants. Data collected were analysed using descriptive statistics (mean and standard deviation) to answer research questions, while ANCOVA was used to test the null hypotheses at the 0.05 level of significance. The findings of this study indicated a general acceptance that hydroponics training

Keywords: Assessment, Hydroponics, Training, Practical Skill, Innovation

Introduction

Hydroponics is gaining prominence as a sustainable approach to food production in urban and resource-limited settings. Its efficient use of water, minimal land requirements, and adaptability to controlled environments make it ideal for modern agriculture (Jones, 2020). Yet, limited empirical data exist regarding its pedagogical benefits, especially in relation to practical agricultural education. Studies by Brown (2022) and Gannon (2024) reveal that hands-on hydroponics projects boost student interest and competence in agriculture. However, Smith et al. (2021) observed that educational research on hydroponics often overlooks student outcomes. Integrating hydroponics into inquiry-based learning environments, as seen in Rosidah et al. (2019), and repurposing waste materials for educational setups, as explored by Fatmawati et al. (2023), offer viable strategies to enhance learning. This study investigates how structured hydroponics training influences students' technical skills, innovation readiness, and sustainability mindset. The goal is to provide evidence for the inclusion of hydroponics in agricultural curricula to produce industry-ready graduates. Hydroponics training enhances students' practical skills and fosters agricultural innovation.

Training, according to Walter (2019), is the process of learning skills needed in a particular job or activity. Dale (2019) asserted that training is the organised procedure by which people learn knowledge or skill for a definite purpose. Dale (2019) further stated that it is a teaching and learning activity carried out for the purpose of helping members

in the organisation to acquire and apply the knowledge, skills, abilities and attitude needed in a particular job of the organisation. With the integration of hydroponics training with project-based and inquiry-based learning, students are better equipped to adopt agricultural innovation techniques.

Agricultural innovation is defined as the process whereby individuals or organisations bring existing or new products, processes and forms of organisation into social and economic use to increase effectiveness, competitiveness, resilience to shocks, or environmental sustainability, thereby contributing to food and nutritional security, economic development, and sustainable natural resources management (Clayton & Pandey 2019). The integration of smart agriculture technologies, such as the Internet of Things (IoT), sensors, and artificial intelligence (AI), has further enhanced hydroponic farming by enabling real-time monitoring and improving resource management (Kagermann et al., 2013; Sambo et al., 2019). However, the successful implementation of these technologies requires proper training and technical expertise among agricultural practitioners.

Statement of the Problem

Despite the global emphasis on agricultural innovation and the urgent need for sustainable farming practices, many agricultural education programmes struggle to adequately equip students with the practical, cutting-edge skills required for modern agriculture. Traditional farming methods, which are often the focus of current curricula, are increasingly susceptible to challenges like climate change impacts, water scarcity, and land degradation. This gap between educational output and industry demand results in graduates who may lack the technical competence and innovative mindset necessary to contribute meaningfully to agricultural development and food security. (Rohaeti & Nurhayah, 2023)

Specifically, while hydroponics presents a highly efficient, resource-saving, and innovative agricultural technique, its integration into existing educational frameworks is often limited. Therefore, there is a critical need to evaluate the impact of dedicated hydroponics training on students' practical skills. Furthermore, the extent to which this specialised training influences students' willingness and ability to adopt innovative techniques beyond the classroom remains largely unexplored (Brown, 2022). Additionally, a lack of understanding of the challenges associated with integrating hydroponics into agricultural curricula, and how the training specifically enhances readiness for sustainable practices, hinders its wider implementation. This study seeks to evaluate the extent to which hydroponics training enhances students' practical skills and contributes to agricultural innovation. It will investigate whether exposure to hydroponics can improve students' competencies in controlled-environment farming,

resource management, and problem-solving. Furthermore, it will explore how hydroponics training can bridge the gap between agricultural education and real-world farming challenges, ultimately fostering a new generation of skilled and innovative agricultural professionals.

Aims and Objectives of the Study

The aim of this study is to evaluate the impact of hydroponics training on students' practical skills and their contribution to agricultural innovation. The specific objectives are to:

- i. assess the effectiveness of hydroponics training in enhancing students' practical agricultural skills.
- ii. examine the extent hydroponics training influences students' adoption of innovative agricultural techniques.
- iii. identify the challenges associated with the integration of hydroponics training into agricultural education programmes, and
- iv. identify how hydroponics training can enhance students' readiness for sustainable agricultural practices.

Research Questions

The following research questions were raised to guide the study.

1. How effective is hydroponics training in enhancing students' practical agricultural skills?
2. To what extent does hydroponics training influence students' adoption of innovative agricultural techniques?
3. What are the challenges associated with the integration of hydroponics training into agricultural education programmes?
4. How can hydroponics training enhance students' readiness for sustainable agricultural practices?

Hypotheses

The following research hypotheses were formulated and tested at the 0.05 level of significance.

Ho₁: Hydroponics training does not significantly improve students' practical agricultural skills.

Ho₂: Hydroponics training does not significantly influence students' adoption of innovative agricultural techniques.

Ho₃: There is no significant difference in the perceived severity among the categories of challenges associated with the integration of hydroponics training into agricultural education programmes.

Ho₄: Hydroponics training does not significantly enhance students' readiness for sustainable agricultural practices.

Methodology

The study was carried out in Edo State, Nigeria. It adopted the quasi-experimental research design of a pre-test, post-test nonequivalent control group. According to Agbulu et al. (2020), quasi-experimental design is often used in classroom experiments when experimental and control groups are naturally assembled as intact classes. Four (4) research questions were developed and answered by the study, while four (4) null hypotheses were formulated and tested at a 0.05 significance level.

The population for the study is 59 students of level 300 of the two universities offering agricultural education in Edo State. The sample size of this study was 59 agricultural education students from the two universities that were chosen for the study. The study adopted a purposive sampling technique, with the subjects separated into two groups. Twenty (20) students from Ambrose Alli University, Ekpoma, were assigned to the experimental group, while thirty-nine (39) students of the University of Benin, Benin City, were assigned to the control group.

Data collection was done in two phases: a pre-test was administered to both groups before the treatment to assess their baseline knowledge and ensure group equivalency. Treatment: the experimental group was taught using hydroponic skills and Innovation Assessment (HSIA) test items developed by the researcher from personal experiences, the curriculum contents of field experience, and literature reviewed over a period of three weeks (three periods per week), while the control group received instruction through conventional lecture methods. Post-test: Both groups were tested immediately after the three-week instruction (post-test). Each of the items had a 4-point rating scale and contained options A-D, with one option as the correct answer, while the remaining three serve as distracters. Any question answered correctly was scored 1 point, while a wrong answer got zero points. In making a decision, a mean value of 2.50 was used for decision-making; any mean score value of 2.50 and above indicates that the respondents agreed on the item, while any mean score below was regarded as not agreed.

To obtain the validity of the instrument, copies of the instrument were sent to three experts in the Departments of Vocational and Technical Education (Agricultural Education option), Ambrose Alli University Ekpoma and University of Benin, Benin City. The experts conducted both content and face validity assessments to ensure that the designed experiments were appropriate and relevant and accurately measured the intended learning outcomes. Specifically, content validity involved evaluating whether the experiments adequately covered the key concepts and objectives of the course, while face validity focused on the clarity, presentation, and practical suitability of the experiments as perceived by the expert.

The reliability of the study was determined by administering ten copies of the instrument to agricultural education students in the Department of Vocational and Technical Education.

Faculty of Education, University of Delta, Agbor, that were not part of the population for the study. Thereafter, the Kuder-Richardson 20 formula was applied (1-) to obtain the reliability coefficient, which yielded a reliability of 0.78, indicating that the instrument was highly reliable. The Hydroponics Skill and Innovation Assessment (HSIA) was administered to the experimental and control groups through the research assistant. The instruments were administered to the experimental and control groups as a pre-test; thereafter, the treatment was applied to the experimental group.

The data generated was analysed using mean and standard deviation for the research questions. A mean gain indicates that the experimental group performed more than the control group, while a mean loss indicates a better performance in the hydroponics training and innovative assessment (HSIA) in favour of the control group. While the hypotheses were tested using Analysis of Co-variance (ANCOVA) at the 0.05 level of significance. The use of ANCOVA was to control the errors of initial non-equivalence arising from the use of intact classes as subjects of the study. In testing the hypothesis, when the P-value is greater than .05, the null hypothesis is accepted. When the P-value is less than .05, the null hypothesis is rejected.

Results

Research Question 1

How effective is hydroponics training in, enhancing students' practical agricultural skills?

Table 1: Mean and Standard Deviation of Student Scores in Hydroponics Training in Enhancing Students' Practical Agricultural Skills.

Group	N	Pre-test		Post – test		Mean diff.	Mean Gain
		\bar{x}	SD	\bar{x}	SD		
Experimental	20	9.77	2.22	40.3	5.34	30.53	14.51
Control	39	8.53	2.34	24.55	6.65	16.02	

Source: Researcher (2025)

Table 1 shows the pre-test and post-test mean scores of students in hydroponics training to enhance their practical agricultural skills for both experimental and control groups. The result shows that the students in the experimental group had a pre-test mean score of 9.77 with a standard deviation of 2.22 and a post-test mean score of 40.03 with a

standard deviation of 5.339. The difference between the pre-test and post-test mean for the experimental group was 30.53, while the control group had a pre-test mean score of 8.53 with a standard deviation of 2.34 and a post-test mean score of 24.55 with a standard deviation of 6.65. The difference between the pre-test and post-test mean for the control group was 16.02, with a mean gain of 14.51 for the experimental and control groups. This shows that the mean score for the experimental group was higher than the control group, indicating that hydroponics training had an impact on enhancing students' practical agricultural skills.

Research Question 2

To what extent does hydroponics training influence students' adoption of innovative agricultural techniques?

Table 2: Mean and Standard Deviation of how Hydroponics Training influences Student's Adoption of Innovative Techniques. (N=59)

Group	N	Pre-test		Post – test		Mean diff.	Mean Gain
		\bar{x}	SD	\bar{x}	SD		
Experimental	20	7.67	3.32	55.32	5.43	47.65	24.56
Control	39	6.34	2.65	30.24	4.45	23.09	

Source: Researcher (2025)

Table 2 revealed that the pre-test and post-test mean scores of the extent of hydroponics training influence students' adoption of innovative techniques for both experimental and control groups. The result shows that the students in the experimental group had a pre-test mean score of 7.67 with a standard deviation of 3.32 and a post-test mean score of 55.32 with a standard deviation of 5.43. The difference between the pre-test and post-test mean for the experimental group was 47.65, while the control group had a pre-test mean score of 6.34 with a standard deviation of 2.65 and a post-test mean score of 30.24 with a standard deviation of 4.45. The difference between the pre-test and post-test mean for the control group was 23.09, with a mean gain of 24.56 for the experimental and control groups. This shows that the mean score for the experimental group was higher than the control group, indicating that the hydroponics training had an influence on the students' adoption of innovative techniques.

Research Question 3

What are the challenges associated with the integration of hydroponics training into agricultural education programme?

Table 3: Mean and Standard Deviation of Student Scores on the Challenges Associated with the Integration of Hydroponics Training into Agricultural Education Programme.

Group	N	Pre-test		Post – test		(N=59)	
		\bar{x}	SD	\bar{x}	SD	Mean diff.	Mean Gain
Experimental	20	8.66	2.43	50.05	4.23	41.84	29.14
Control	39	6.35	2.11	19.05	5.32	12.07	

Source: Researcher (2025)

Table 3 summarises the results of the pre-test and post-test mean scores of the experimental and control groups on the challenges associated with the integration of hydroponics training into the agricultural education programme. The result shows that the students in the experimental group had a pre-test mean score of 8.66 with a standard deviation of 2.43 and a post-test mean score of 50.05 with a standard deviation of 4.23. The difference between the pre-test and post-test mean for the experimental group was 41.84, while the control group had a pre-test mean score of 6.35 with a standard deviation of 2.11 and a post-test mean score of 19.05 with a standard deviation of 5.32. The difference between the pre-test and post-test mean for the control group was 12.07, with a mean gain of 29.14 for the experimental and control groups. This shows that the mean score for the experimental group was higher than the control group, indicating that challenges exist with the integration of hydroponics training into the agricultural education programme.

Research Question 4

How can hydroponics training enhance students' readiness for sustainable agricultural practices?

Table 4: Mean and Standard Deviation of Student Scores on how Hydroponics Training Enhance Students' Readiness for Sustainable Agricultural Practices.

Group	N	Pre-test		Post – test		Mean diff.	Mean Gain
		×	SD	×	SD		
Experimental	20	9.64	3.53	54.35	5.38	44.71	26.87
Control	39	7.25	3.43	25.09	6.25	17.84	

Source: Researcher (2025)

Table 4 presented the summary of the pre-test and post-test mean scores of the experimental and control groups on how hydroponics training has enhanced students' readiness for sustainable agricultural practices. The result shows that the students in the experimental group had a pre-test mean score of 9.64 with a standard deviation of 3.53 and a post-test mean score of 54.35 with a standard deviation of 5.38. The difference between the pre-test and post-test mean for the experimental group was 44.71, while the control group had a pre-test mean score of 7.25 with a standard deviation of 3.43 and a post-test mean score of 25.09 with a standard deviation of 6.25. The difference between the pre-test and post-test mean for the control group was 17.84, with a mean gain of 26.87 for the experimental and control groups. This shows that the mean score for the experimental group was higher than the control group of hydroponics training, which enhances students' readiness for sustainable agricultural practices.

Null Hypotheses

Ho₁: Hydroponics training does not significantly improve students' practical agricultural skills.

Table 5: ANCOVA Result of Students Showing the Difference between Students Trained in Hydroponics and those taught with Conventional Method.

Source	Type III Sum of Squares	Df	Mean Square	F-cal	Sig.	Decision
Corrected model	4.189 ^a	2	2.099	1.984	.142	
Intercept	1103.241	1	1104.251	1043.707	.000	
Pre-test CP	3.084	1	4.093	3.869	.052	
Treatment CP	.003	1	.004	.003	.948	S
Error	117.387	112	1.058			
Total	38573.000	115				
Corrected Total	121.685	114				

Source: Researcher (2025)

Table 5 shows that the calculated value of F-cal is .003 ($P > 0.05$); the value was less than the 0.05 level of significance established by the researcher. This indicated that the f-ratio is higher than the significance level of 0.05. It therefore implies that the hypothesis was rejected against the alternate hypotheses; thus, there was a significant difference between hydroponics training, which significantly improves students' practical agricultural skills.

H₀₂: Hydroponics training does not significantly influence students' adoption of innovative agricultural techniques.

Table 6: ANCOVA Result of Students showing the influence Hydroponics training on students' adoption of innovative agricultural techniques. Difference between Students trained in hydroponics and those taught with conventional method.

Source	Type III Sum of Squares	Df	Mean Square	F-cal	Sig.	Decision
Corrected model	4.189 ^a	2	2.099	1.984	.142	
Intercept	1103.241	1	1104.251	1043.707	.000	
Pre-test CP	3.084	1	4.093	3.869	.052	
Treatment CP	.003	1	.004	.003	.948	S
Error	117.387	112	1.058			
Total	38573.000	115				
Corrected Total	121.685	114				

Source: Researcher (2025)

Table 6 shows that the calculated value of F-cal is .003 ($P > 0.05$); the value was less than the 0.05 level of significance established by the researcher. This indicated that the f-ratio is higher than the significance level of 0.05. It therefore implies that the hypothesis was rejected against the alternate hypotheses. Thus, there was a significant difference in the influence hydroponics training has on students' adoption of innovative agricultural techniques.

H₀₃: There is no significant difference in the perceived severity among the categories of challenges associated with the integration of hydroponics training into agricultural education programmes.

Table 7: ANCOVA Result of Students showing the perceived severity among the categories of challenges associated with the integration of hydroponics training into agricultural education programmes. Difference between Students trained in hydroponics and those taught with conventional method.

Source	Type III Sum of Squares	Df	Mean Square	F-cal	Sig.	Decision
Corrected model	2.125 ^a	2	1.044	1.871	.142	
Intercept	1103.241	1	1104.251	1043.606	.000	
Pre-test CP	3.084	1	3.039	3.869	.052	
Treatment CP	.002	1	.003	.002	.837	S
Error	117.251	112	1.058			
Total	24462.000	115				
Corrected Total	111.435	114				

Source: Researcher (2025)

Table 7 shows that the calculated value of F-cal is .002 ($P > 0.05$); the value was less than the 0.05 level of significance established by the researcher. This indicated that the f-ratio is higher than the significance level of 0.05. It therefore implies that the hypothesis was rejected against the alternate hypotheses; thus, there was a significant difference in the perceived severity among the categories of challenges associated with the integration of hydroponics training into agricultural education programmes.

Ho₄: Hydroponics training does not significantly enhance students' readiness for sustainable agricultural practices.

Table 8: ANCOVA Result of Students showing that hydroponics training does enhance students' readiness for sustainable agricultural practices. Difference between Students trained in hydroponics and those taught with conventional method.

Source	Type III Sum of Squares	Df	Mean Square	F-cal	Sig.	Decision
Corrected model	3.1795 ^a	2	2.055	1.562	.124	
Intercept	1104.412	1	1104.251	9021.403	.000	
Pre-test CP	2.056	1	2.078	2.535	.034	
Treatment CP	.003	1	.004	.003	.456	S
Error	176.762	112	1.085			
Total	44352.000	115				
Corrected Total	101.865	114				

Source: Researcher (2025)

Table 8 shows that the calculated value of F-cal is **.003 (P>0.05)**; the value was less than the 0.05 level of significance established by the researcher. This indicated that the f-ratio is higher than the significance level of 0.05. It therefore implies that the hypothesis was rejected against the alternate hypotheses; thus, there was a significant difference between hydroponics training, which significantly improves students' practical agricultural skills.

Discussion of Findings

The findings of the study **revealed that** hydroponics training significantly improved students' practical agricultural skills, as shown by a higher mean gain (30.26) in the experimental group compared to the control group (16.02). The 14.24 difference in mean gains indicates that the training had a substantial positive effect. The study is in agreement with the findings of Gannon (2024), who indicated that hydroponics training significantly enhances students' practical agricultural skills. Hands-on involvement in hydroponic systems allows students to develop expertise in modern farming techniques while also increasing their interest in food production. By cultivating and consuming their own produce, students gain firsthand experience in plant care and nutrition management, reinforcing theoretical agricultural knowledge. The study was also in consonance with the findings of Rohaeti and Nurhayati (2023) in a study titled Education on Hydroponic Technology to Increase the Productivity of Modern Farmers; the study underscores the transformative potential of hydroponic training in educational environments. By providing students with practical agricultural skills, these programmes contribute to the broader goal of advancing sustainable and technologically driven farming practices. Future research should explore the long-term impact of hydroponic education on students' career trajectories and agricultural productivity.

The findings revealed that hydroponics training significantly increased students' adoption of innovative agricultural techniques, as evidenced by a higher mean gain of 47.65 in the experimental group compared to 23.09 in the control group. The 24.56 mean gain difference highlights the strong influence of hydroponics in promoting modern, innovation-driven agricultural practices among students. This study was also in agreement with the study carried out by Yachya et al. (2023); it was found out that hydroponic training significantly influenced students' adoption of agricultural innovation techniques, evidenced by a 56.33% increase in knowledge among Perlaungan Islamic High School students, enhancing their understanding and application of hydroponic cultivation in educational settings.

The findings of the study **revealed that** students that were exposed to hydroponics training identified significantly more challenges (mean gain of 41.84) than those in the

control group (mean gain of 12.07), with a difference of 29.14. This indicates that while hydroponics is beneficial, its integration into agricultural education faces key challenges such as high costs, infrastructure demands, technical complexity, and curriculum alignment. Addressing these barriers is essential for effective implementation. This study also aligned with the study of Verma et al. (2024), which highlights several challenges associated with the integration of hydroponics training into agricultural education programmes, including substantial initial investment costs, energy-intensive operations, and the necessity for specialised technical expertise. These hurdles can hinder widespread adoption and effective implementation of hydroponics in educational settings. Additionally, the need for updated curricula and training resources to keep pace with advancements in technology, such as automation and AI-driven monitoring, poses further challenges for educators aiming to incorporate hydroponics into their programmes.

The findings of the study **revealed that** hydroponics training significantly enhanced students' readiness for sustainable agriculture, with the experimental group showing a mean gain of 44.71, compared to 17.84 in the control group. The 26.87-point difference indicates that hydroponics training better prepared students to adopt sustainable farming practices, highlighting its importance in climate-smart agricultural education. The study was also in conformation with the study carried out by Petrás (2020) on agricultural innovation, which enhances students' practical skills by integrating modern technologies and innovative teaching methods, fostering adaptability and decision-making abilities. This approach addresses the gap in traditional education, promoting practice-orientated learning essential for success in the evolving agricultural sector.

Conclusion

The findings of this study demonstrate that hydroponics training significantly enhances students' practical skills and fosters innovative thinking in agriculture. By bridging the gap between theoretical knowledge and practical application, hydroponics training equips students with the tools needed to address contemporary agricultural challenges. These outcomes highlight the transformative potential of hands-on agricultural education. However, success depends on resource availability, instructor expertise, and curricular integration. By equipping students with both technical and creative competencies, hydroponics training aligns education with global sustainability goals.

Recommendations

The following recommendations were made:

1. Educational boards should integrate hydroponics into secondary school agriculture curricula; this will modernise agricultural education and promote skill-based learning.

2. The government should allocate funds for infrastructure, teacher training, and curriculum development to facilitate hydroponics integration into agricultural education.
3. Public-private partnerships and clear guidelines will address logistical and technical challenges, ensuring the sustainability and scalability of hydroponics training in schools.
4. The government should invest in training facilities and capacity building, which would equip students with practical, eco-friendly farming skills aligned with global sustainability goals, thus ensuring long-term food security and environmental stewardship.

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