

PERFORMANCE ANALYSIS OF SOLAR-POWERED AUTOMATED TYROLEAN SPRAYER FOR TEACHING FINISHING IN BRICK/BLOCK LAYING AND CONCRETING IN TECHNICAL COLLEGES IN NORTH- CENTRAL NIGERIA

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ABSTRACT

This study focuses on the performance analysis of a Solar-Powered Automated Tyrolean sprayer for teaching finishing techniques in brick/block laying and concreting (BBC) in technical colleges in North-Central, Nigeria. The increasing need for sustainable, cost-effective, and efficient construction tools in technical education necessitates the integration of renewable energy technologies such as solar power into practical training equipment. The study examined the design, construction, and operational performance of the sprayer, emphasizing its suitability for instructional purposes. This study was conducted in North-Central Nigeria. The study was guided by two aims and objectives, two research questions, and one hypothesis. The study adopted a research and development (R&D) and quasi experimentation research design. R&D research design is not just about studying a problem, it is about: creating, testing, and improving a working solution the design process also includes feasibility, quality control and analysis while quasi experimentation research design is to compare the student performance and response from the control and experimental group. The sample population of the study was 94 comprised of 42 experts and 52 students for the performance test. The instrument was validated by four experts. The data collected were analyzed using mean and standard deviation. The study found that the Solar-Powered automated Tyrolean sprayer significantly improved finishing quality, reduced manual labor, and enhanced students' practical skills acquisition. The study concludes that Solar-Powered Automated Tyrolean sprayer is an effective instructional tool that promotes sustainable construction practices and modern skill development in technical education. It is recommended that technical colleges adopt such innovative technologies to improve teaching efficiency and align with global trends in green construction and automation.

Keywords: Technical Colleges in North-Central Nigeria, Teaching Finishing in BBC, Performance Analysis, Solar- Powered, Automated Tyrolean Sprayer,

Introduction

Technical Education in Nigeria plays a crucial role in equipping learners with practical skills for employment and national development. In building technology programmes, particularly in technical colleges, students are trained in brick/block laying and concreting, which includes finishing techniques such as plastering and surface texturing (Nwankwo 2021). Technical College is an educational institution that focuses on providing practical and vocational skills in various trades such as construction, engineering, and technology. These institutions aim to prepare students for employment and self-reliance.

Technical colleges in North-Central Nigeria play a crucial role in skill development, particularly in fields like building technology. According to Hurst (2018), Technical Education emphasizes hands on training and competency-based learning. The integration of modern tools such as Solar-Powered Automated Sprayers enhances the quality of training by exposing students to current industry practices. This aligns with the National Board for Technical Education (NBTE) objectives of producing skilled manpower. Furthermore, Technical colleges serve as innovation hubs where students can learn to design, construct, and maintain equipment (Okoro, 2016). This fosters creativity and entrepreneurship among brick/block laying and concreting students

Brick/Block Laying and Concreting (BBC) are fundamental construction processes involving the arrangement of masonry units and the use of concrete to form structural elements. These skills are essential in building construction (Oboro, 2016). BBC requires precision, alignment, and proper bonding techniques. Concreting involves mixing, placing, and curing concrete to achieve desired strength and durability. Proper finishing techniques are necessary after laying blocks and casting concrete to ensure durability and aesthetic appeal. This is where tools like the Tyrolean sprayer become relevant in Technical colleges, where students are trained to master these processes through practical exercises (Olaitan, et al 2016). The teaching of Solar-Powered Automated Tyrolean Sprayer enhances efficiency and exposes Technical college students to modern Tyrolean finishing.

Teaching finishing is an instructional process of imparting skills related to the final stage of construction work, such as plastering, Tyrolean, and surface decoration. Finishing is critical because it determines the aesthetic and functional quality of a building (Okoro, 2016). Effective teaching of finishing involves both theoretical knowledge and practical application. According to Olaitan, et al (2016), students learn better when they engage directly with tools and materials. The use of automated Tyrolean sprayers in teaching improves learning outcomes by demonstrating modern techniques. It allows students to understand the principles of uniform application, texture creation, and material handling. Moreover, teaching finishing with advanced tools in BBC enhances student academic performance, and employability, skills relevant in the construction industry.

Performance analysis refers to the systematic evaluation of how well a system, machine, or process operates under specified conditions. In engineering and technical education, it involves measuring efficiency, effectiveness, reliability, and productivity of equipment or processes (Nwankwo, 2021). Performance analysis typically involves both qualitative and quantitative methods. Quantitative analysis includes measurements such as time taken to complete a task. According to Orhorhoro, (2018), performance evaluation helps in identifying system strengths and weaknesses, thereby improving design and efficiency.

Performance analysis also extends to evaluating how well students can use the equipment. It measures skill acquisition, accuracy, and productivity improvement when using

modern tools like automated sprayers (Nwankwo 2021). Furthermore, performance analysis ensures that the developed system meets the intended educational and industrial standards. It helps determine whether the innovation is suitable for teaching purposes and real-world application (Orhororo, et al, 2018). Engineers often use tools such as efficiency ratios, benchmarking, and comparative analysis with existing systems. Performance analysis is essential for validating the effectiveness of any engineering innovation, ensuring it meets operational, educational, and safety requirements. In the context of a Solar-Powered Automated Tyrolean Sprayer, performance analysis examines how effectively the sprayer performs finishing tasks.

Solar-Powered Sprayer is a technology that converts sunlight into electrical energy using photovoltaic (PV) cells. This renewable energy system is widely used due to its environmental friendliness, cost-effectiveness, and sustainability (Kurma, 2019). Solar-Powered Sprayer consists of major components such as solar panels, charge controllers, battery, and DC motor among others. Solar panels capture sunlight and convert it into direct current (DC) electricity. The charge controller regulates the voltage, while the battery stores energy for later use. According to Hassan et al (2018) Solar energy systems are among the most renewable energy technologies. It reduces operational costs and promotes sustainable construction practices. Solar powered sprayer is particularly beneficial in technical education because they expose students to green technology. Students learn how renewable energy systems operate, maintain them, and apply them in practical situations. In the case of a Tyrolean sprayer, solar-power eliminates the need for fuel or grid electricity, making it suitable for rural and off-grid areas like many parts of North-Central Nigeria.

Solar-Powered Automated Tyrolean Sprayer is a mechanical device used for applying Tyrolean finishing on walls using a spraying mechanism rather than manual application. Tyrolean finishing involves hand-operated spraying tools, which can be labor-intensive and inconsistent. Automation improves efficiency, consistency, and speed. According to Hurst (2018), automation in construction equipment significantly increases productivity and reduces human effort. The Automated Tyrolean Sprayer ensures uniform distribution of mortar, leading to better finishing quality.

The sprayer works by feeding Tyrolean material into a hopper, where it sprayed onto the wall surface. Automation may include adjustable pressure control, flow rate regulation, and even programmable settings (Oboro, 2016). In technical colleges, this equipment is highly valuable for training students in modern construction techniques. It helps bridge the gap between traditional craftsmanship and modern mechanized construction practices. Advantages include: Increased speed and productivity, uniform finishing, reduced labor stress, improved quality. The automated Tyrolean sprayer represents a significant advancement in construction technology, enhancing both efficiency and teaching effectiveness.

Statement of the Problem

Despite the importance of finishing in construction, many technical colleges' graduates lack adequate practical skills due to outdated teaching methods and lack of modern equipment.

The conventional method of applying Tyrolean finishing manually presents several challenges: It is labor-intensive and time-consuming, it produces inconsistent finishing quality, it limits students' exposure to modern construction technology and it reduces students' interest and engagement. Additionally, the lack of reliable electricity in many parts of North-Central Nigeria makes it difficult to use electrically powered equipment in training. This study seeks to address this gap by analyzing the performance of a solar-powered automated Tyrolean sprayer for teaching finishing in technical colleges in North-Central Nigeria.

Purpose of the Study

The aim of this study is to analyse the performance of Solar-Powered Automated Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting technical colleges in North-Central Nigeria. Specifically, the study sought to:

- i. Evaluate the validity of Solar-Powered Automated Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria.
- ii. Determine the Effect of Solar Powered-Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria.

Research Questions

- i. To what extents the Solar-Powered Automated Tyrolean Sprayer is valid for teaching Tyrolean finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria?
- ii. What is the Effect of Solar-Powered Automated Tyrolean Sprayer for Teaching Tyrolean Finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria?

Hypothesis

H₀: There is no significant difference in the in the post-test mean performance scores of students taught Tyrolean finishing using Solar-Powered Automated Tyrolean Sprayer and those taught using the conventional method in technical colleges in North-Central Nigeria.

Methodology

The study was carried out to analyze the performance of Solar-Powered Automated Tyrolean Sprayer for Teaching Finishing in North-Central, Nigeria. The study adopted Research and Development (R&D) research design. The sample population was 94, comprised of 42 experts for the development phased and 52 NTC III Students for the performance test. The instrument for data collection was force gauge/ dynamometer, clamps Meter and structured questionnaire. The instrument was validated by experts. Research question was answered using Statistical Package for Social Science (SPSS). The result of the data was analyzed using mean and standard deviation.

Result

Research Questions1: What is the Validity of Solar-Powered Automated Tyrolean s\Sprayer for teaching Tyrolean finishing in brick/block laying and concreting?

Table 1: showed the Mean and Standard Deviation of the respondents on the validation of Solar-powered Automated Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting in North-Central Nigeria. The result showed that the mean of the respondents ranges from 2.61 to 3.72 and the standard deviation also ranges from .000 to .515 respectively. The cluster mean of the respondents is 3.36 and the standard deviation of .398 the result from Validations indicate that the Solar-powered Automated Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting in North-Central Nigeria, is of good standard and can be used for teaching finishing in technical colleges as the mean for all the question items were above the decision mean of 2.50.

Table 1: Validation of Solar-Powered Automated Tyrolean Sprayer for teaching Tyrolean finishing in brick/block laying and concreting

S/N	Question Items	N	Mean	SD	Decision
1	Design of the solar-powered automated Tyrolean sprayer is appropriate for construction finishing work.	42	3.17	.384	Agreed
2	The sprayer is appropriate for use in technical colleges	42	3.67	.485	Agreed
3	The structural frame of the sprayer is strong and durable.	42	3.16	.384	Agreed
4	The sprayer design allows easy maintenance and repair.	42	3.72	.461	Agreed
5	The solar-powered Tyrolean sprayer operates effectively without interruption	42	3.61	.502	Agreed
6	The sensor or timer used in the system improves spraying accuracy	42	3.05	.236	Agreed
7	The DC motor installed in the sprayer provides sufficient rotational power	42	3.00	.000	Agreed
8	The system sprayer mortar evenly on the wall surface.	42	3.50	.515	Agreed
9	The use of solar energy makes the machine environmentally friendly.	42	3.11	.323	Agreed
10	The sprayer improves work output compared to manual methods.	42	3.72	.461	Agreed
11	The solar panel installed on the sprayer can generate adequate power for operation.	42	3.77	.428	Agreed
12	The wiring and electrical connections are properly installed	42	3.94	.236	Agreed
13	The solar power sprayer is suitable for outdoor construction activities.	42	3.22	.428	Agreed
14	The machine operates without frequent breakdown.	42	3.22	.428	Agreed
15	The sprayer reduces manual labour during Tyrolean finishing.	42	2.61	.502	Agreed
16	The spraying speed of the sprayer is satisfactory.	42	3.55	.511	Agreed
17	The control system of the sprayer is easy to understand	42	3.33	.485	Agreed
18	The sprayer can effectively demonstrate practical finishing operations to students	42	3.15	.416	Agreed
Aggregate men		42	3.36	.398	Agreed

Source: Field study (2025).

Research Question 2

What effects will the use of Solar-Powered Automated Tyrolean Sprayer and conventional method of teaching Tyrolean finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria has on student mean performance scores in the pos-test?

The result of the performance score of students in table 2 indicated post-test mean performance scores of students taught using Solar-Powered Automated Tyrolean Sprayer (Experimental group) had 81.67 and standard deviation of 6.2214 and those taught using conventional method (control group) had 57.06 and standard deviation of 7.8326. The mean scores difference of 24.61 showed that the students in the experimental group who were taught using Solar-Powered Automated Tyrolean Sprayer has a better performance compared to the ones in the control group.

Table 2: Mean and Standard Deviation of Post-test performance score for Students thought Tyrolean finishing using Solar-Powered Automated Tyrolean Sprayer (experimental group) and those though using Conventional method (control group)

Group	N	Post-test		Mean Score Difference
		\bar{X}	SD	
Experimental	25	81.67	6.2214	24.61
Control	27	57.06	7.8326	
Total	52			

Source: Field Study (2025), Where: N = Number of students, \bar{X} = mean score, SD = standard deviation

Hypothesis: There is no significant difference in the post-test mean responses of bricks/blocks laying and concreting students taught Tyrolean finishing using Solar-Powered Automated Tyrolean Sprayer and those taught using conventional method in technical colleges in North-Central Nigeria.

Table 3 showed the independent samples test that was conducted to compare the post-test mean scores of students taught Tyrolean finishing using Solar-Powered Automated Tyrolean Sprayer and those taught using Conventional method. The result from the table showed that there was a significant difference between the mean scores in control group (mean = 57.06 and $SD = 7.832$) and Experimental group (mean = 81.67 and $SD = 6.221$) from the table it can be seen also that (p -value $0.00 < 0.05$). Therefore, the null hypothesis was rejected. This confirmed that there is significance difference in the post-test mean performance scores of students taught bricks/blocks lying and concreting using Solar-Powered Automated Tyrolean Sprayer and those using Conventional method.

Table 3: Independent Sample t-test of Post-test Mean Performance Scores of Students thought finishing using Solar-Powered Automated Tyrolean Sprayer and those taught using Conventional method (Experimental and Control Group).

Group	N	Post-test		t-value	p-value
		\bar{X}	SD		
Experimental	27	81.67	6.221	10.439	0.000
Control	27	57.06	7.832		

p-value $0.00 < 0.05$ significant

Discussion of Findings

Findings of this study revealed that respondents generally agreed on all the evaluated performance parameters, indicating that the solar powered Tyrolean sprayer is effective, safe, and suitable for teaching finishing in brick/block laying and concreting, particularly in technical colleges in North Central Nigeria. The findings on validation revealed that the developed solar-powered automated Tyrolean sprayer met the required engineering and instructional design specifications for teaching Tyrolean finishing in brick/block laying and concreting. The validation results showed that the sprayer components solar panel, battery, DC motor, and frame functioned in an integrated and efficient manner. This agrees with studies on solar-powered sprayers by Hassan et al (2018) which emphasize that proper component selection and system integration (solar panel–battery–pump linkage) are critical to achieving functional reliability and efficiency. The validation outcomes further demonstrated that the sprayer achieved consistent spray flow rate, uniform material distribution, and stable operation under varying sunlight conditions., the validation findings support the assertion that solar-powered spraying systems provide a simple, cost-effective, and user-friendly alternative to conventional manual systems. The system's ability to operate independently of grid electricity confirms its suitability for technical colleges in North Central Nigeria, where power supply may be inconsistent. Findings on the effect of Solar-Powered Automated Tyrolean Sprayer shows that there was difference in the post-test performance mean scores of students taught using Solar-Powered Automated Tyrolean Sprayer and those taught using conventional method for teaching Tyrolean finishing. Findings showed that, students taught using Solar-Powered Automated Tyrolean Sprayer performed better than those taught using conventional method for teaching Tyrolean

Test for hypothesis confirmed that there was significant difference in the post-test mean scores of students taught bricks/blocks laying and concreting using Solar-Powered Automated Tyrolean Sprayer and those taught using conventional method in Technical Colleges in North-Central, Nigeria.

Conclusion

The performance analysis of the Solar-powered automated Tyrolean sprayer demonstrates that the system is a viable instructional and practical tool for teaching Tyrolean finishing in brick/block laying and concreting in technical colleges in North-Central Nigeria. The findings indicate that the integration of solar energy with automated spraying technology enhances operational efficiency, consistency in surface finishing, and reduces the physical stress associated with manual application methods. The sprayer met the key design objectives, including adequate pressure delivery, uniform material distribution, and reliable energy supply under typical solar conditions in the region. Students exposed to the equipment showed improved skill acquisition, better understanding of modern construction techniques, and increased engagement during practical sessions. Furthermore, the use of renewable energy aligns with sustainable development goals and addresses the challenge of unstable power supply in many technical institutions. However, certain limitations were observed, such as dependency on solar irradiance, initial cost of installation, and the need for technical know-how for maintenance. Despite these constraints, the overall performance confirms that the solar-powered automated Tyrolean sprayer is effective for both instructional delivery and practical application in construction education.

Recommendations

Based on the findings of this study the following recommendations are offered:

- i. There is need to make policies and plan programs/projects that are aimed towards encouraging the utilization of Solar-Powered Automated Tyrolean Sprayer in building construction.
- ii. Government and educational stakeholders should provide funding and subsidies to support the procurement and installation of such systems in technical institutions.
- iii. Awareness programs should be created to promote the benefits of renewable energy technologies in the construction industry.
- iv. The education agency should enhance supervision to ensure that the Solar-Powered Automated Tyrolean Sprayer is properly used in Technical Colleges in North-Central Nigeria.
- v. Partnerships between technical colleges and construction industries should be strengthened to facilitate practical exposure and technology transfer.

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