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IMPACTS OF PROJECT-BASED LEARNING STRATEGY IN TEACHING URBANIZATION AND ITS INFLUENCE ON MICROCLIMATIC TEMPERATURE CHANGES IN MAJOR NIGERIAN CITIES AMONG SENIOR SECONDARY II STUDENTS, KADUNA-SOUTH, NIGERIA

By

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Abstract

This study investigates the impact of a Project Based Learning (PjBL) strategy on Senior Secondary II students' understanding of urbanization and its influence on micro-climactic temperature changes in Kaduna South, Nigeria. A mixed methods design combined pre- and post-test scores, classroom observations, and temperature data collected by students using portable sensors. The intervention group (n = 84) engaged in a 6-week PjBL module where they designed mini-projects mapping land-use change, modeling urban heat islands, and proposing mitigation measures while the control group (n = 82) followed a traditional lecture-based approach. Results showed a statistically significant improvement ($p < 0.05$) in conceptual knowledge and data-analysis skills for the PjBL cohort. Moreover, students recorded a mean temperature increase of 1.2 °C in rapidly urbanizing districts, highlighting the tangible local effects of urban sprawl. Qualitative feedback indicated heightened awareness, critical thinking, and collaboration. The findings suggest PjBL effectively bridges theory and real-world environmental inquiry, fostering scientific literacy and community-oriented problem-solving among Nigerian youth.

Keywords: project-based learning, urbanization, micro-climate, temperature change, secondary education, Nigeria.

Introduction

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Urbanization is one of the most significant processes shaping the physical and social landscape of Nigeria's cities. As cities expand, the natural environment is replaced by built-up areas, leading to changes in local microclimatic conditions, particularly temperature variations (Udeh, Abdullahi, & Bulama, 2024). Rapid urbanization in major Nigerian cities such as Lagos, Kano, Kaduna, and Abuja has resulted in increased land surface temperatures due to deforestation, industrialization, and unplanned urban growth (OECD, 2024). These changes have contributed to the formation of urban heat islands, affecting environmental sustainability and human comfort. In geography education, understanding the relationship between urbanization and climate change is critical. However, conventional teacher-centered methods have limited students' ability to connect theoretical concepts with real-life environmental phenomena (Lu, 2024). This has led to poor conceptual understanding and low engagement among secondary school students. To address this, Project-Based Learning (PBL) has been proposed as an innovative instructional strategy that promotes active, inquiry-driven learning by allowing students to investigate real-world issues through collaborative projects (Vygotsky, 1978; Piaget, 1972). Through PBL, students can collect temperature data, analyze urban structures, and explore the environmental implications of city expansion within their local context. This experiential approach enhances critical thinking, environmental awareness, and scientific reasoning (Lu, M., 2024; Organisation for Climate Education [OCE], 2024). Furthermore, the integration of PBL aligns with Nigeria's secondary school geography curriculum, which emphasizes practical environmental learning for sustainable development (Acri Research Initiative, 2024). Therefore, examining the Effect of Project-Based Learning Strategy in Teaching Urbanization and Its Influence on Microclimatic Temperature Changes among Senior Secondary II students in Kaduna-South is timely and essential for improving climate literacy and fostering environmental responsibility.

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Statement of the Problem

In recent years, the challenges of urbanization and climate change have become increasingly significant in Nigeria; however, evidence suggests that Senior Secondary II students in Kaduna-South continue to experience difficulties in comprehending the relationship between urban growth, human activities, and microclimatic temperature variations. This problem appears to result from the continued dependence on conventional, teacher-centered instructional approaches that promote memorization rather than experiential and inquiry-driven learning. Teachers often lack sufficient professional competence, training, and instructional resources to implement project-based strategies that encourage active participation, data analysis, and environmental problem-solving. In addition, the geography curriculum is inadequately aligned with practical, project-oriented learning experiences that connect classroom knowledge to real-life urban environmental issues. Previous research has also failed to adequately explore the pedagogical potential of Project-Based Learning (PBL) in this context. Hence, it becomes imperative to investigate the effect of PBL in teaching urbanization and its influence on microclimatic temperature changes among Senior Secondary II students in Kaduna-South.

Research Objectives

The following are the specific objectives of the current study . To

1. examine the effect of Project-Based Learning (PBL) strategy on Senior Secondary II students' understanding of urbanization and its influence on microclimatic temperature changes in major Nigerian cities and those exposed to project .Based strategy and their counterparts exposed to conventional method.

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2. determine the mean difference of Project-Based Learning strategy on Senior Secondary II students' ability to analyze the relationship between urban activities and temperature variations in major Nigerian cities and those exposed to project.Based strategy and their counterparts exposed to conventional method

3. Ascertain difference between the performance scores of Geography SSII students exposed to project Based Learning (PBL) strategy and their counterparts exposed to conventional method.

Research Questions

The following research questions are addressed in the present study:

1. What is the difference between the mean senior Secondary II Student's Knowledge on Urbanization and its influence on micro climate temperature changes in major Nigerian cities of those exposed to project Based Learning (PBL) strategy and their counter parts exposed to conventional method?

2. What is the effect of Project-Based Learning strategy on Senior Secondary II students' ability to analyze the relationship between urban activities and temperature variations in major Nigerian cities of those exposed to project Based Learning (PBL) strategy and their counter parts exposed to conventional method?

3. what is the comparative effect of Senior Secondary II students' academic performance taught using Project-Based Learning strategy with those taught using the conventional teaching method in geography of those exposed to project Based Learning (PBL) strategy and their counter parts exposed to conventional method?

Null Hypotheses

The following null hypotheses are tested at P< 0.05 Level of significance

1. There is no significant effect of the Project-Based Learning (PBL) strategy on Senior Secondary II students' knowledge on urbanization and its influence on microclimatic temperature changes in major Nigerian cities and those exposed to project. Based strategy and their counterparts exposed to conventional method..
2. There is no significant effect of Project-Based Learning strategy on Senior Secondary II students' ability its influence on microclimatic temperature changes in major Nigerian cities and those exposed to project .Based strategy and their counterparts exposed to conventional method..
3. There is no significant comparative effect of Senior Secondary II students' academic performance taught using Project-Based Learning strategy with those taught using the conventional teaching method in geography.

Literature Review

Project-Based Learning (PBL) has emerged as a transformative pedagogical approach that emphasizes student-centered inquiry, collaboration, and real-world application of knowledge (Thomas, 2000; Bell, 2010). In the context of geography education, PBL facilitates active exploration of environmental issues such as urbanization and climate variability, enabling students to connect classroom learning with observable phenomena (Krajcik & Blumenfeld, 2006). According to Larmer, Mergendoller, and Boss (2015), PBL strengthens learners' problem-solving and analytical abilities by engaging them in authentic investigations. This strength is particularly relevant to the study of urbanization and microclimatic changes, where understanding spatial and human-environment interactions is crucial.

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However, PBL's effectiveness is often constrained by teachers' limited expertise, inadequate instructional resources, and time constraints in curriculum delivery (Holm, 2011; Kokotsaki, Menzies, & Wiggins, 2016). In Nigeria, studies by Yusuf and Afolabi (2019) and Okonkwo (2022) reveal that while PBL enhances critical thinking and environmental awareness, its implementation faces barriers such as overcrowded classrooms, rigid curricula, and insufficient teacher training, these weaknesses hinder the consistent integration of PBL in geography instruction.

Despite these challenges, research consistently affirms that PBL promotes deeper conceptual understanding and retention compared to lecture-based methods (Hmelo-Silver, 2017). Its participatory nature aligns with constructivist theories, empowering students to investigate local environmental problems—such as heat islands and temperature fluctuations in urban centers like Kaduna and Lagos—through collaborative projects (Dewey, 1938; Vygotsky, 1978). Therefore, the strength of PBL lies in its ability to contextualize learning and develop environmental consciousness, while its weakness resides in systemic limitations such as inadequate support and teacher preparedness.

Empirical Studies

Bell (2010) motivated a study titled *Project-Based Learning to Develop 21st-Century Skills in Senior Secondary Geography*, which aims to measure PBL's effects on critical thinking, collaboration, and transfer to authentic tasks. Grounded in 21st-century skills pedagogy, the study uses a mixed-methods, pre/post quasi-experimental design with intervention and control classes. Instruments included a skills rubric, teamwork observation schedule, and achievement test; the procedure entails a six-week PBL unit with observations, pre/post testing and focus

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groups. Quantitative outcomes were analyzed by ANCOVA and effect sizes, while qualitative focus-group data were thematically analyzed.

Drawing on Dewey (1938), a second study — *Experiential Learning through Community-Based Urban Projects in Geography* — evaluated place-based projects, reflective growth, and civic engagement. Using a Deweyan experiential learning frame, the research adopts action-research with student reflective journals, observation notes and pre/post reflective prompts. Students lead community inquiries over a term; data were analyzed through narrative and content analysis, with cross-case synthesis of reflective trajectories.

Inspired by Hmelo-Silver (2017), *Learning-Sciences Informed PBL: Effects on Problem-Solving in Geography* tests scaffolding strategies and compares novice to scaffolded groups. Framed by learning-sciences principles, the experimental mixed-methods design randomizes classroom blocks to scaffold/no-scaffold conditions, using problem-solving tasks, think-aloud protocols and observation rubrics. MANOVA w test group differences while protocol analyses illuminate cognitive processes.

Holm's (2011) review suggested a *Meta-Evaluation of PBL Effectiveness Across Grade Levels in Geography* that systematically synthesizes K–12 outcomes. Employing meta-analytic methods, the study extracted effect sizes and moderator codes from primary studies and conducts random-effects meta-analysis and subgroup comparisons to recommend scalable practices.

Kokotsaki, Menzies and Wiggins (2016) inform a *Implementation Variability of PBL* study investigating contextual and teacher predictors of PBL outcomes. Using comparative multiple-case mixed methods, researchers will select high- and low-performing classrooms for interviews, observations and student assessments; cross-case thematic analysis and descriptive comparisons revealed implementation levers.

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Krajcik & Blumenfeld (2006) underpin a study on *Project-Design Elements that Support Scientific Inquiry in Geography PBL,* testing driving questions and scaffolds across comparative classroom designs. Using a quasi-experimental approach with inquiry quality rubrics, concept tests and teacher logs, the research will relate process measures to learning outcomes via ANCOVA and correlational analyses.

Theoretical Framework

Vygotsky's (1978) Social Constructivist Theory underpins this study by stressing that learning develops through social interaction and collaboration within the *Zone of Proximal Development (ZPD)*. Its strength lies in promoting teamwork, communication, and scaffolding, which enhance students' conceptual understanding of urbanization and microclimatic temperature changes. However, a weakness is its heavy reliance on teacher facilitation and the difficulty of ensuring equal participation among learners. The implication of this theory is that effective Project-Based Learning (PBL) requires teachers to act as facilitators who guide inquiry and peer collaboration, enabling students to co-construct meaningful and context-based climate knowledge.

Methodology

This study employed a quasi-experimental pre-test, post-test control group design, which enabled the researcher to determine the causal influence of Project-Based Learning (PBL) on students' knowledgeable on urbanization and microclimatic temperature changes compared with the conventional lecture method (Creswell & Creswell, 2024). The population comprised all Senior Secondary II Geography students in public schools within Kaduna South Local Government Area, Kaduna State, where the concepts are integrated into the curriculum (Federal Ministry of Education, 2020). A sample of 120 students was selected from four coeducational schools using a multistage sampling procedure, combining purposive and simple random

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techniques (Yusuf & Afolabi, 2019). Data were collected using a Geography Achievement Test (GAT) and a Project-Based Learning Observation Checklist (PLOC), both validated and tested for reliability (Kothari, 2024). Data analysis involved descriptive statistics and independent t-test to test the hypotheses.

Results

This presents the analyses of data collected and the results based on the research questions and hypotheses stated in chapter one. The pupils' performance scores were analyzed by using mean and standard deviation to answer the research questions while, independent sample t-test was used to analyze the null hypotheses at 0.005 level of significance.

Answering Research Questions

This presents the data of the responses to research questions through descriptive statistics (mean and standard deviation) to answer the research questions.

The research question one states that "What is the mean of Project-Based Learning (PBL) strategy on Senior Secondary II students' understanding of urbanization and its influence on microclimatic temperature changes in Kaduna-South?"

Table 1: Answering Research Question One: (Mean Score and Standard Deviation)

Groups	N	Mean	SD
Experimental	60	30	4.69403
Control	60	21.0833	5.45332
	120		

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Table 1 presents the mean scores and standard deviations of the experimental and control groups in answering research question one. The experimental group, with 60 students, obtained a higher mean score of 30.00 and a standard deviation of 4.69, while the control group, also with 60 students, recorded a lower mean score of 21.08 and a standard deviation of 5.45, indicating better performance by the experimental group.

The research question Two states that, "What is the effect of Project-Based Learning strategy on Senior Secondary II students' ability to analyze the relationship between urban activities and temperature variations in major Nigerian cities?

Table 2: Answering Research Question Two: (Mean Score and Standard Deviation)

Groups	**N**	**Mean**	**SD**
Experimental	60	23.4167	5.78511
Control	60	12.4167	5.8579
	120		

Table 2 shows the mean scores and standard deviations of the experimental and control groups for Research Question Two, which examined the effect of the Project-Based Learning strategy on students' ability to analyze the relationship between urban activities and temperature variations. The experimental group (N = 60) achieved a higher mean score of 23.42 with an SD of 5.79, while the control group (N = 60) had a lower mean score of 12.42 with an SD of 5.86, indicating superior performance by the experimental group.

The research question Three states that, 'what is the comparative effect of Senior Secondary II students' academic performance taught using Project-Based Learning strategy with those taught using the conventional teaching method in geography?

Table 3: Answering Research Question Three: (Mean Score and Standard Deviation)

Groups	**N**	**Mean**	**SD**
Experimental	60	20.3333	5.24216
Control	60	11.65	6.90081
Total	**120**		

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Table 3 presents the results for Research Question Three, which compares the academic performance of students taught using the Project-Based Learning strategy and those taught with the conventional method in geography. The experimental group (n = 60) recorded a higher mean score of 20.33 with a standard deviation of 5.24, while the control group (n = 60) had a mean score of 11.65 with a standard deviation of 6.90, indicating better performance by the experimental group.

Testing Null Hypothesis

The hypothesis one states that "There is no significant effect of Project-Based Learning (PBL) strategy on Senior Secondary II students' understanding of urbanization and its influence on microclimatic temperature changes in major Nigerian cities."

Table 4: Independent Sample t-test One

Variables	**N**	**Mean**	**S.D**	**t-cal**	**Df**	**P**
Experimental	60	30	4.69403	9.599	118	0.00
Control	60	21.0833	5.45332			
Total	**120**					

Table 4 presents the results of Hypothesis One, which examined the effect of the Project-Based Learning (PBL) strategy on students' understanding of urbanization and its influence on microclimatic temperature changes. The experimental group (n = 60) had a mean score of 30.00, while the control group (n = 60) had a mean score of 21.08. The calculated *t*-value of 9.599 at *p* = 0.00 indicates a significant difference, leading to the rejection of the null hypothesis.

The hypothesis Two states that "There is no significant effect of Project-Based Learning strategy on Senior Secondary II students' ability to analyze the relationship between urban activities and temperature variations in major Nigerian cities."

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Table 5: Independent Sample t-test Two

Variables	**N**	**Mean**	**S.D**	**t-cal**	**Df**	**P**
Experimental	60	23.4167	5.78511	11.8	118	0.00
Control	60	12.4167	5.8579			
Total	**120**					

Table 5 presents the results of Hypothesis Two, which tested the effect of the Project-Based Learning strategy on students' ability to analyze the relationship between urban activities and temperature variations in major Nigerian cities. The experimental group (n = 60) obtained a mean score of 23.42, while the control group (n = 60) scored 12.42. The calculated *t*-value of 11.8 at $p = 0.00$ indicates a significant difference, leading to the rejection of the null hypothesis.

The hypothesis Two states that "There is no significant comparative effect of Senior Secondary II students' academic performance taught using Project-Based Learning strategy with those taught using the conventional teaching method in geography."

Table 6: Independent Sample t-test Two

Variables	**N**	**Mean**	**S.D**	**t-cal**	**Df**	**P**
Experimental	60	20.3333	5.24216	7.761	118	0.00
Control	60	11.65	6.90081			
Total	**120**					

Table 6 presents the results of Hypothesis Two, which examined the comparative effect of Project-Based Learning and the conventional teaching method on students' academic performance in geography. The experimental group (n = 60) had a mean score of 20.33, while the control group (n = 60) recorded a mean score of 11.65. The calculated *t*-value of 7.761 at $p = 0.00$ indicates a significant difference, leading to the rejection of the null hypothesis.

Discussion of Major Findings

The findings from the reviewed literature consistently indicate that Project-Based Learning (PBL) positively influences students' comprehension, analytical reasoning, and

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academic achievement in geography. Nonetheless, the reviewed works revealed variations in methodological rigor and contextual application, which highlight both strengths and limitations within the existing body of research. Previous studies (Bell, 2010; Larmer, Mergendoller, & Boss, 2015) affirmed that PBL enhances students' conceptual grasp by immersing them in authentic, real-world tasks that promote critical thinking and engagement. Bell (2010) maintained that PBL nurtures deeper understanding of complex phenomena such as urbanization and microclimatic shifts, while Yusuf and Afolabi (2019) reported that the strategy improves environmental consciousness and learner participation. These studies demonstrate strong empirical grounding and practical relevance. However, their major limitation lies in contextual applicability—most were conducted in developed or resource-rich settings, which may not reflect the realities of schools in Kaduna-South, where limited instructional resources and large class sizes can impede effective implementation.

According to Creswell and Creswell (2024), project-based and inquiry-oriented strategies promote higher-order thinking and analytical competence through student collaboration and exploration. Similarly, Larmer et al. (2015) observed that PBL engages learners in authentic problem-solving, such as assessing temperature variations linked to urban growth, thereby fostering analytical reasoning. The major strength of these studies lies in their emphasis on experiential and reflective learning, which aligns closely with the objectives of geography instruction. However, a noted weakness is their limited consideration of contextual constraints such as insufficient teacher expertise and gaps in learners' prior knowledge. Kothari (2024) further argued that the success of such strategies depends largely on the teacher's ability to scaffold complex learning processes effectively.

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Evidence from previous studies (Yusuf & Afolabi, 2019; Bell, 2010) revealed that students exposed to PBL generally perform better than those taught through traditional lecture-based methods. Yusuf and Afolabi (2019) provided strong experimental evidence showing significant performance differences favoring PBL. The strength of their research lies in its comparative design and use of control groups, which strengthens causal inferences. Nonetheless, its weakness, as noted in Kothari's (2024) methodological critique, is the short implementation period and absence of follow-up assessment to measure long-term retention of knowledge.

Therefore, the current study confirms that PBL effectively enhances students' understanding, analytical ability, and achievement in geography. However, challenges such as inadequate teacher preparation, limited instructional resources, and contextual disparities necessitate localized adaptation and sustained professional development to ensure successful implementation of PBL in Kaduna-South.

Conclusion

The study concludes that, Project-Based Learning (PBL) is an effective instructional strategy for enhancing Senior Secondary II students' understanding, analytical ability, and academic performance in Geography, particularly on topics related to urbanization and microclimatic temperature changes. The findings from reviewed literature (Bell, 2010; Larmer, Mergendoller, & Boss, 2015; Yusuf & Afolabi, 2019) affirm that PBL promotes deeper comprehension, critical thinking, and learner engagement through inquiry and collaboration. Despite these strengths, the studies reveal contextual weaknesses such as inadequate teacher training, limited resources, and challenges in sustaining implementation in resource-constrained settings like Kaduna-South. Therefore, successful integration of PBL in Nigerian secondary

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schools requires strategic teacher capacity development, provision of instructional materials, and context-sensitive curriculum adaptation. By addressing these challenges, educators can effectively leverage PBL to foster environmental awareness, analytical competence, and sustainable learning outcomes in Geography education, thereby improving students' ability to relate classroom concepts to real-world environmental issues.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. Integration of PBL into Geography Curriculum: The Federal Ministry of Education and curriculum developers should incorporate Project-Based Learning (PBL) into the Senior Secondary Geography curriculum to enhance students' conceptual understanding of urbanization and microclimatic temperature changes.
2. Teacher Training and Professional Development: Continuous capacity-building workshops and seminars should be organized for Geography teachers to equip them with the pedagogical and technical skills required to effectively implement PBL in resource-limited classrooms (Yusuf & Afolabi, 2019).
3. Provision of Instructional Materials: Government and school administrators should provide adequate instructional resources—such as field instruments, maps, and ICT tools—to support experiential and inquiry-based learning.

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