

Original Research Article

## Authentic Learning Strategies and Undergraduates' Knowledge in Climate Change in Oyo State

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**Abstract:** This study investigated the impact of authentic learning strategies on undergraduate students' knowledge in climate change education in universities in Oyo State, Nigeria. The study was motivated by the persistent use of conventional lecture-based instructional methods, which have been found inadequate in developing students' practical skills and deeper understanding of environmental issues such as climate change. The study specifically examined the effectiveness of Problem-Based Learning (PBL) and Service Learning (SL) as authentic learning strategies. A quasi-experimental research design was adopted. The population consisted of undergraduate students from selected universities in Oyo State, while a multistage sampling technique was used to select intact classes from two departments each across the three institutions on the basis of science and non-science, in the end a total sample of 286 undergraduate students participated in the study. The participants were assigned to Service Learning, Problem-Based Learning, and Conventional Instructional Method groups. Data were collected using validated instruments measuring knowledge. Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings revealed that authentic learning strategies had a significant effect on students' knowledge of climate change, with Service Learning producing the highest performance, followed by Problem-Based Learning, while the Conventional Method recorded the least performance. However, Gender and field of study had no significant main effects on undergraduates' knowledge in climate change, although a significant interaction effect between treatment and gender was observed. The study concluded that authentic learning strategies are effective in improving students' knowledge of climate change. It was recommended that universities should adopt more student-centered and experiential teaching approaches, particularly Service Learning and Problem-Based Learning, to improve climate change education outcomes.

**Keywords:** Authentic Learning, Problem-Based Learning (PBL), Service Learning (SL), Climate Change Education, Knowledge.

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## INTRODUCTION

Climate change is considered as the most striking challenge of the 21st century, requiring informed and innovative approaches across all sectors. Universities have important roles in preparing future generations with the information, skills, and problem-solving abilities to address complex issues (Clarke-Crespo, Mougán, & Moreno-Gaite, 2021). Climate change is one of the major global environmental problems of the 21st century. Climate Change has been defined as a change in the state of the climate that can be

identified by changes in the mean and/or the variability of its properties (e.g., temperature, precipitation, humidity, incident radiation, isothermality, wind patterns, and that persists for an extended period, typically decades or longer, Field and Barros, *et al.*, (2014). According to NASA, (2020), climate change is a global phenomenon that involves changes in the planet's typical climate (temperature, precipitation, and wind), which are primarily caused by human activities. Natural internal climate system processes, as well as external, natural or human influences, can all contribute to climate change (external variability). Hence, natural human

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influences are the primary causes of climate change. Human factors such as urbanization, deforestation, population growth, industrialization, and greenhouse gas production have been identified as key contributors to the increase in carbon dioxide levels, which have significantly altered climatic conditions in recent decades.

Given the urgency and complexity of these climate challenges, there is a growing need for effective education that equips individuals with the skills to respond appropriately. However, traditional lecture-based learning approaches often fail to encourage critical thinking and real-life application that are required for effective climate action. Instead, as suggested by Hodson and Bryant (2018) that authentic learning strategies provide a more effective alternative by engaging students in practical real-world problem-solving related to environmental issues. Therefore, there is a growing demand to comprehend how much authentic learning methods help undergraduates learn about climate change in Nigeria which happens to be greatly affected by climate change effects. Although studies have examined climate change education in Nigeria (Adeyemo & Ajao, 2013), no specific focus has been on authentic learning strategies and their effect on undergraduate knowledge, innovation, and problem-solving skills within Oyo State. Meanwhile, authentic learning provides students with real world problems and scenarios that are relevant to their lives and interest, making the learning experience more engaging and meaningful.

Authentic learning is a learning designed to connect what students are taught in school to real-world issues, problems, and applications; learning experiences should mirror the complexities and ambiguities of real life. Children work towards production of discourse, products, and performances that have value or meaning beyond success in school; this is learning by doing approach. All learning experience should be tailored towards encouraging the students to make meanings from what they are being learnt and to think beyond the school. Any learning experience should aim to instill authenticity into every task, lesson and unit to ensure that 'students are able to develop problem solving skills and confidence in their own learning abilities (Nicaise, Gibney & Crane, 2000). Authentic learning as defined by Lombardi (2007), is a learning that focuses on real-world, complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice. It is through this authentic learning that learning can become more permanent and that the students can boast of becoming problems' solvers. Prominent among the authentic strategies are Problem-based learning (PBL) and Service learning (SL).

Problem-Based Learning (PBL) is a teaching approach that encourages students to engage with real-world problems, enhancing their understanding of

complex topics like climate change. PBL helps students retain information better and develop a deeper understanding of the issue. It fosters creativity and innovation by encouraging students to think outside the box and develop novel solutions (Hmelo-Silver 2004; Savery, 2006; Raman *et al.*, 2024). PBL also enhances students' problem-solving skills by allowing them to analyze data, identify key problems, and develop strategic solutions. Empirical studies support the efficacy of PBL in climate change education, showing significant improvement in students' ability to apply scientific knowledge to real-world problems. Incorporating PBL in undergraduate climate change education significantly enhances knowledge, fosters innovativeness, and develops robust problem-solving skills. Raman *et al.*, (2024) explore the effectiveness of Problem-Based Learning (PBL) in enhancing problem-solving skills in chemistry education, recommending further research in all chemistry areas and the use of Problem-Based Learning for stimulating lesson planning.

PBL has been widely recommended for teaching complex and abstract concepts in science, such as climate change, because it promotes deep understanding, long-term retention, and transfer of knowledge. Studies have shown that PBL improves students' achievement, motivation, collaboration skills, and environmental awareness when compared with traditional lecture-based approaches (Bell, 2010; Thomas, 2000; Blumenfeld *et al.*, 1991).

#### General Steps in PBL

1. Presentation of a real-world problem
2. Formulation of driving questions
3. Planning and investigation by students
4. Development of a project or solution
5. Presentation and reflection
6. Evaluation and feedback

Service learning, a pedagogical approach that combines community service with academic learning can significantly enhance undergraduates' knowledge, innovativeness, and problem-solving skills, particularly in the context of climate change. This method provides students with hands-on experience that bridges theoretical knowledge and practical application, enhancing their educational journey. Service learning deepens undergraduates' understanding of climate change by immersing them in real-world environmental issues, exposing them to diverse perspectives and interdisciplinary approaches. It fosters innovativeness by encouraging creative thinking and developing novel solutions to environmental challenges (Moely *et al.*, 2002; Reeb *et al.*, 2010).

Service Learning Strategy is an educational approach that combines community service with academic learning. In this strategy, learners participate in volunteer work or projects that address real-world issues, while also gaining knowledge and skills related to their

studies. This strategy aims to foster civic engagement, empathy, and critical thinking, as students reflect on their experiences and connect them to course material. Service-learning is a pedagogical strategy in which students engage in community service that will enhance their understanding of course concepts and enable them to make contributions to their communities (Rhodes & Davis, 2001).

In the context of climate change, service learning equips students with the tools and mindset to innovate. Service learning projects related to environmental sustainability develop innovative approaches to reducing carbon footprints and promoting renewable energy. Overall, service learning is a powerful educational tool that significantly enhances undergraduates' knowledge, innovativeness, and problem-solving skills, making them essential for the next generation of leaders tasked with combating climate change and ensuring a sustainable future.

Gbadamosi (2022) determined the effects of service learning as a strategy for preparing economics education undergraduate students at the University of Ibadan for employment. It found that service learning enhances financial literacy, project management, teamwork, and resourcefulness skills in pre-service teachers while Omosunlade and Gbadamosi, (2023) reported Service learning as a teaching method that integrates technical knowledge with personal and social growth, promoting interpersonal skills, critical thinking, problem-solving, self-esteem, competence, and social responsibility. Gbadamosi (2024) determined the impact of Service Learning (SL) on female academic lecturers' professional development found that SL can enhance female lecturers' capabilities, but its planning and execution must adhere to procedural principles for human development. However, none of the available reports has documented the impacts of these authentic strategies on undergraduate' knowledge, innovativeness and problem-solving in climate change in Oyo state, Nigeria.

To implement Service learning, National Youth Leadership Council, 2020 put forward the some steps which are summarized thus:

These steps can be summarized as follows:

1. Identify community needs and align them with curriculum goals
2. Partner with local organizations or community groups for service projects
3. Prepare students through orientation, training, and clear expectations.
4. Facilitate reflective activities, such as discussions or presentations.
5. Monitor progress, provide feedback, and assess student outcomes.
6. Evaluate the service learning strategy impact on student.

As regards the climate change education which is a focus of this study, the overall steps can be shaped to suit for learning of climate change education in the following ways:

1. Community projects: Students work on local environmental initiatives like tree planting, clean-ups, promoting recycling
2. Climate research: This involves students investigating climate issues in the community and presenting findings.
3. Advocacy: Students engage in awareness campaigns, writing letter to organizing events
4. Sustainability workshops: Teach community members about eco-friendly practices through hands-on workshops.
5. Reflection and Action: Students reflect on their service experiences, connecting them to climate change concepts and inspiring future actions.

These authentic strategies are far better than the conventional strategy that only encourage rote learning. Conventional Instructional Strategy (CIS) is a one-way method of disseminating information to students. Student in this situation has to listen and jot down some necessary information as summary if need be and organize into reading contents (Farroq, 2012). This is a traditional, teacher-centered approach where the instructor delivers information (lectures, chalk-talk) to passively receiving students, focusing on textbook knowledge and memorization for tests, often criticized for lack of interaction but still valued certain learning styles (e.g. visual/verbal). The students through the teacher passively received instructional contents or elements and lay strong emphasis on the given information in the examination (Chopper, 2010). Lindsay (2011) opines that bulk of instructional contents are taught to the large number of students within a short time frame, making some concepts in science with their skills and principles look theoretical abstraction for understanding. Some studies argued that, conventional instructional strategy don't actively engaged students, as deep learning and ability to retain for long in the memory some concepts which are abstracts are discouraged (Ahmed and Abimbola, 2011; Umar, 2011).

#### **Characteristics of Conventional Instructional Strategy (CIS)**

- i. Teacher-Directed: The teacher controls the flow of information, standing at the front of the class.
- ii. Passive Learning: Students primarily listen, read a memorize content from notes and textbook.
- iii. "Chalk-Talk": Often involves the teacher writing and speaking at the board (traditional lecture style).
- iv. Assessment-Focused: Aims to cover content for exams, sometimes leading to rote rather than deep understanding.

Gender differences also shape problem-solving approaches in climate change. United Nations Development Programme (2016) notes that women often adopt community-based and adaptive problem-solving strategies, particularly in resource management. Furthermore, Leiserowitz Anthony *et al.*, (2014) found that gender influences environmental attitudes and decision-making, which in turn affects problem-solving engagement. Cultural norms, however, may limit women's participation in formal scientific and policy-driven problem-solving processes.

Field of study plays a crucial role in determining the knowledge. Students in science-related disciplines tend to demonstrate stronger analytical and innovative skills due to their exposure to technical knowledge. According to National Research Council (2012), interdisciplinary learning enhances creativity and innovation in solving complex environmental problems. Similarly, Sterling Stephen (2010) argues that education for sustainability requires integrating multiple disciplines to foster innovative thinking.

Theoretically, this study is anchored on the constructivism learning theory whose its major proponents include: Jean Piaget and Vygotsky. The general believe of the constructivists is that learners construct knowledge rather than just passively take in information. As people perceive the environment around them, they reflect upon those experiences and build their representations and incorporate new information into their pre-existing knowledge. This theory is germane to the topic under investigation as it tends provide insight on how authentic learning (problem-based and service learning) can support students in developing the skills and knowledge required to address the pressing climate change.

### Statement of the Problem

Undergraduate climate change education programs in Oyo State Universities largely rely on traditional lecture-based methods. While these approaches may facilitate the transmission of basic knowledge, they often fail to actively engage students or foster the critical thinking and practical skills required to effectively address climate challenges. As a result, students may lack the competencies to analyze real-world environmental issues, propose innovative solutions, and participate meaningfully in climate change mitigation and adaptation efforts. This limitation in educational strategies restricts the development of informed, skilled, and empowered graduates who can contribute to sustainable environmental practices in Oyo State and beyond. Therefore, there is a critical need to investigate the effectiveness of incorporating authentic learning strategies within undergraduate climate change education programs in Oyo State Universities. In response to this gap, the research aims to explore how the implementation of authentic learning strategies (problem-based and service learning) will affect the

undergraduates' knowledge in climate change education programs in Oyo State universities.

### Objectives of the Study

The main objective of this study is to determine the impact of authentic learning strategies on undergraduates' knowledge in climate change within the universities located in Oyo State, Nigeria. In particular, the research seeks to:

- i. Determine the impact of authentic learning strategies on the extent to which undergraduates can comprehend climate change science and its effects.
- ii. Determine the main and interaction impacts of gender on undergraduates' knowledge, in climate change, and
- iii. Evaluate the main and interaction impacts of fields of study on undergraduates' knowledge, in climate change

### Hypotheses

The following null hypotheses were formulated to guide the study.

**Ho1:** There are no significant impacts of authentic learning strategies (problem-based and service learning) on undergraduates' knowledge in climate change education programs at universities in Oyo State, Nigeria.

**Ho2:** There are no significant impacts of gender on undergraduates' knowledge in climate change education programs at universities in Oyo State, Nigeria.

**Ho3:** There are no significant impacts of fields of study on undergraduates' knowledge in climate change education programs at universities in Oyo State, Nigeria.

**Ho4:** There are no significant interaction impacts of authentic learning strategies (problem-based and service learning) and gender on undergraduates' knowledge in climate change education programs at universities in Oyo State, Nigeria.

**Ho5:** There are no significant interaction impacts of authentic learning strategies (problem-based and service learning) and fields of study on undergraduate's knowledge in climate change education programs at universities in Oyo State, Nigeria.

**Ho6:** There are no significant impacts of gender and fields of study on undergraduate's knowledge in climate change education programs at universities in Oyo State, Nigeria,

**Ho7:** There are no significant impacts of authentic learning strategies (problem-based and service learning) gender and fields of study on undergraduate's knowledge in climate change education programs at universities in Oyo State, Nigeria.

### Significance of the Study

Nigeria's future is gravely threatened by climate change, and Oyo State is especially at risk. It is crucial to provide undergraduates with the information, they need to handle this situation. The purpose of the study is to evaluate how well realistic learning strategies promote critical thinking, deeper comprehension, and the capacity

to apply knowledge to real-world situations. This can help Oyo State to create climate change education initiatives that are more successful. Teachers may design learning experiences that go beyond rote memorization and equip students to become active participants in climate solutions by identifying effective tactics.

The study could provide upcoming generations with the knowledge and resources they need to address the challenges posed by climate change. By giving students, a solid grounding in climate science, creative thinking, and problem-solving skills, they may take the lead in creating and putting into practice mitigation and adaptation plans tailored to Oyo State's unique circumstances.

The results of this study can help curriculum creators and policymakers in Oyo State universities create and execute evidence-based procedures and policies for teaching about climate change. This may cause a systemic change in favour of more meaningful and captivating educational opportunities that equip graduates to handle the realities of climate change.

Future national research initiatives can benefit from this, and it may even spark the creation of best practices for efficient climate change teaching in Africa. Oyo State is the focus of this research, however, the results may apply to other parts of Nigeria and potentially to other developing nations dealing with comparable climate-related issues.

The knowledge gathered from this study can be modified and used to develop more successful climate change education initiatives in a variety of settings. All things considered, this research has the potential to greatly enhance Oyo State's climate change education, empower the next generation, and provide important insights into the field of climate change education worldwide.

## METHODOLOGY

### Research Design

This study adopts pretest and posttest quasi-experimental in a quantitative approach using Test. The design is 3\*2\*2 factorial matrix.

**Table 1: 3\*2\*2 Factorial Matrix of Treatments, Undergraduates' Fields of Study and Gender.**

		Gender	
		Male (C1)	Female (C2)
Treatments	Field of Study		
Problem-Based (A1)	Science-based (B1)	A1B1C1	A1B1C2
	Non Science-based (B2)	A1B1C1	A1B1C2
Service Learning (A2)	Science-based (B1)	A2B1C1	A2B1C2
	Non Science-based (B2)	A2B1C1	A2B1C2
Conventional strategy (A3)	Science-based (B1)	A3B1C1	A3B1C2
	Non Science-based (B2)	A3B1C1	A3B1C2

### Variables of the Study

#### I. Independent Variables: Instructional Strategies at 3-Three Levels, Namely,

1. Problem-Based instructional Strategy;
2. Service Learning strategy; and
3. Conventional Instructional Strategy.

#### II. Dependent Variables:

1. Undergraduates' knowledge of climate change;

#### III. The Moderator Variables:

1. The Undergraduates field of study
2. The Undergraduates gender.

### Population of the Study

All the 200 level undergraduate students in universities in Oyo state constituted the population of the study.

### Sample and Sampling Technique

This study adopted multi-stage sampling approach. At the first stage, a purposive sampling technique was used to select three public Universities in Oyo state. At the second stage, stratified sampling technique was employed to select two departments each

from each of the three universities based on field of study (science and non-science disciplines). Finally, cluster sampling was used to select the intact classes from each department, making a total of six intact classes across the three institutions. At the end, a total of two hundred and eighty six (286) respondents constituted the sample for the study.

### Instrumentations

Six research instruments (one response and five stimulus instruments) were constructed and validated for use in the study.

The instruments for the study are:

#### I. Stimulus Instruments:

1. Problem-Based Instructional Guide (PBIG);
2. Service Learning Instructional Guide (SLIG);
3. Conventional Instructional Guide (CIG);
4. Validation Sheets for the Instructional Guides (VSIG);
5. Assessment Sheets for the Treatments (AST).

#### II. Response Instruments:

1. Undergraduates' Knowledge of Climate Change Test (UKCCT);

All the research instruments were validated and their corresponding reliability determined accordingly.

**Validation of Instruments**

To ensure face and content validity, each of the six instruments used in the study were validated. Both of the instruments which include response and stimulus were given to two experts in the Department of Integrated Science Education, Emmanuel Alayande University of Education, Oyo. The experts carefully reviewed the instruments and made necessary corrections which were duly and thoroughly effected.

**Reliability of the Instruments**

A pilot study was conducted using 20 respondents who were not part of the main study but shared similar characteristics with the target population. The instruments, UKCCT were administered to the participants and their responses were analysed using Kuder-Rechardson to determine the internal consistency of the instrument. The reliability coefficient of 0.80 was obtained. This value indicates that the instrument possessed acceptable internal consistency as reliability coefficients above 0.70 are considered adequate for research purposes.

**Procedure for Data Collection**

The researchers secure ethical approval from the Heads of the each of the department that were selected for the study to conduct the research. After the approval, research assistants were trained for four weeks. A pre-test was administered via Google Forms, followed by a six-week treatment period where the SL and PBL groups were exposed to authentic learning guides, while the control group used the conventional method. A post-test was administered in the final week.

**Method of Data Analysis**

The data were analysed using frequency counts and percentages for the socio-demographic variables of the respondents, while Analysis of Covariance (ANCOVA) with the pretest scores as covariates to test the hypotheses at 0.05 level of significance. Analysis of covariance was used to single out the initial group differences. Also, the ANCOVA’s Estimated Marginal Mean (EMM) was used to detect the magnitude and direction of differences.

**RESULTS**

**Table 2: Demographic Distribution of Participants**

Gender			
	Male	Female	Total
<b>Service learning</b>			
Science	10	48	58
Non-science	2	16	18
<b>Problem-based learning</b>			
Science	22	88	110
Non-science	2	8	10
<b>Conventional learning</b>			
Science	8	34	42
Non-science	16	32	48
<b>Total</b>	<b>60</b>	<b>226</b>	<b>286</b>

The table 2 above reveals that the sample is predominantly female with Two hundred and twenty six (226) participants representing approximately 79% of the sample and sixty (60) male participants representing approximately 21% of total sample. Out of this, Problem-Based Learning has the highest representation with One hundred and twenty participants (120) representing approximately 42% of total sample, follow by Conventional Learning group with ninety(90)

participants representing approximately 31% of sample and the least is Service Learning group with seventy-six (76) participants representing approximately 27% of sample size. Based on field of study, the table reveals that sample largely composed of science students with two hundred and ten (210) science students representing approximately 73% of sample and seventy-six (76) non-science students representing approximately 27% of total sample.

**Table 2: Analysis of Covariance (ANCOVA) of Post-Knowledge by Treatment, Gender and Field of Study**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6960.143	12	580.012	25.939	.000	.705
Intercept	492.034	1	492.034	22.005	.000	.145
Pre knowledge	1073.140	1	1073.140	47.993	.000	.270
Treatment	359.316	2	179.658	8.035	.001*	.110
Field of Study	49.862	1	49.862	2.230	.081	.017
Gender	1.474	1	1.474	.066	.702	.001

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Treatment × Field of Study	111.767	2	55.883	2.499	.086	.037
Treatment × Gender	262.499	2	131.249	5.870	.001*	.083
Field of Study × Gender	30.086	1	30.086	1.345	.248	.010
Treatment × Field of Study × Gender	22.499	2	11.249	.503	.606	.008
Error	2906.849	130	22.360			
Total	56153.844	286				
Corrected Total	9866.991	285				

R Squared = .705 (Adjusted R Squared = .678) \* denotes significant p < 0.05

**H01a:** There are no significant main effects of authentic learning strategies on undergraduates’ knowledge of climate change.

accounted for 11.0% of the total variation in students’ knowledge of climate change in this model. Therefore, Hypothesis 1a was rejected.

Table 2 indicates that there is a significant main effect of treatment on undergraduate knowledge of climate change ( $F_{(2, 273)} = 8.04$ ;  $p < 0.05$ ; partial  $\eta^2 = 0.11$ ). The effect size of 11.0% shows that the treatment

To determine the degree of difference across treatment groups, estimated marginal means were calculated, and the results are shown in Table 3.1

**Table 2.1: Mean Difference in Post-Knowledge by Treatment and Control Group**

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Service Learning	20.450	1.384	17.712	23.188
Problem-based learning	18.402	1.489	15.456	21.349
Conventional method	13.574	1.034	11.529	15.620

According to Table 2.1. undergraduate students who were exposed to the Service-Learning strategy had the highest adjusted mean score in their post-knowledge of climate change (20.45), followed by those in the Problem-Based Learning group (18.40), while students in the Conventional Method group recorded the lowest mean score (13.57). The order is represented as Service

Learning > Problem-Based Learning > Conventional Method.

To determine which of the groups is the source of the significant main effect of treatment, a Bonferroni post-hoc test is carried out across the groups. The results of this analysis are presented in Table 2.2.

**Table 2.2: Pairwise Comparison of Post-Knowledge by Treatment and Control Group**

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Sig.
Service Learning	Problem-based learning	2.048	.933
	Conventional method	6.876*	.000
Problem-based learning	Service Learning	-2.048	.933
	Conventional method	4.828	.050
Conventional method	Service Learning	-6.876*	.000
	Problem-based learning	-4.828	.050

\*denotes significant p<0.05

According to Table 2.2, the post-knowledge mean scores of undergraduate students who were taught through the Service Learning strategy did not differ significantly from those taught using the Problem-Based Learning strategy ( $p > 0.05$ ), but differed significantly from those taught using the Conventional Method ( $p < 0.05$ ). As also shown in Table 2.2, students who were exposed to the Problem-Based Learning strategy and those in the Conventional Method group showed a marginal difference in their post-knowledge mean scores ( $p = 0.05$ ), which is at the threshold of significance. These findings indicate that the significant difference observed in the ANCOVA results is largely due to

differences between the treatment groups and the control groups, rather than between the treatment groups themselves.

**H02:** There are no significant main effects of gender on undergraduates’ knowledge of climate change.

Table 2 showed that there are no significant main effect of gender on undergraduate knowledge of climate change ( $F_{(1, 273)} = 0.07$ ;  $p > 0.05$ ; partial  $\eta^2 = 0.001$ ). Therefore, Hypothesis 2 was not rejected. This implies that students’ knowledge of climate change did not influence by gender.

**H03:** There are no significant main effects of field of study on undergraduates’ knowledge of climate change.

Table 2 showed that the field of study has no significant main effect on undergraduate knowledge ( $F_{(1, 273)} = 2.23$ ;  $p > 0.05$ ; partial  $\eta^2 = 0.017$ ). Hence, Hypothesis 3 was not rejected. This suggests that students’ knowledge of climate change does not differ significantly based on their field of study.

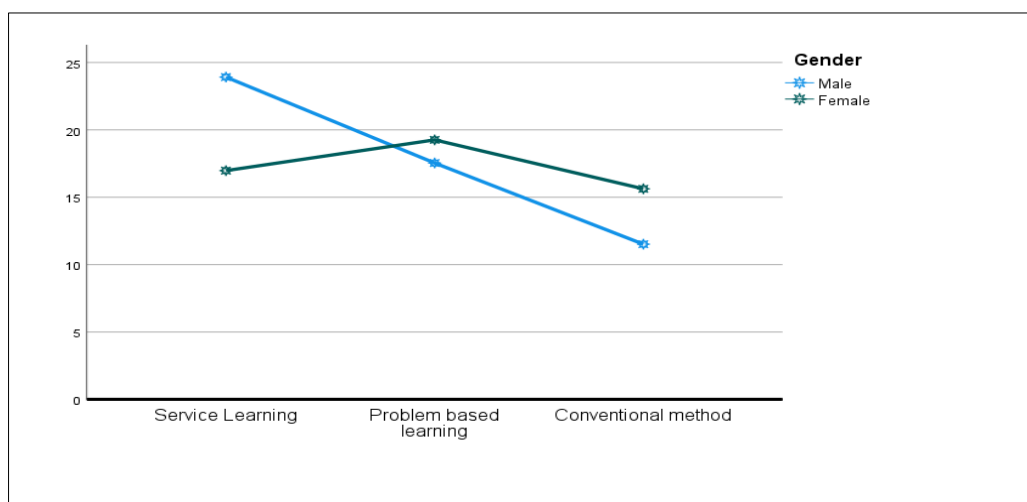
**H04:** There are no significant interaction effect of treatment and gender on undergraduate knowledge in climate change.

Table 2 indicates that there is a significant interaction effect of treatment and gender on undergraduate knowledge of climate change ( $F_{(2, 273)} = 5.87$ ;  $p < 0.05$ ; partial  $\eta^2 = 0.083$ ). The effect size of 8.3% shows the proportion of variance explained by this interaction. Therefore, Hypothesis 4 was rejected. This implies that the effectiveness of treatment varies across gender.

The mean scores for the interaction effect of treatment and gender are presented in Table 3 and illustrated in Figure 3.1.

**Table 3.0: Mean Score for the Interaction Effect of Treatment and Gender**

Treatment	Gender	Mean
Service Learning	Male	23.920
	Female	16.980
Problem-based learning	Male	17.544
	Female	19.261
Conventional method	Male	11.521
	Female	15.628



**Figure 3.1: Treatment and Gender on Undergraduate Students' Knowledge of Climate Change**

Figure 3.1 revealed higher post-knowledge mean scores in climate change (23.92) for male undergraduate students exposed to the Service-Learning strategy. This is followed by female students in the Problem-Based Learning group (19.26), female students in the Service-Learning group (16.98), and male students in the Problem-Based Learning group (17.54). Furthermore, female students in the Conventional Method group recorded a higher mean score (15.63) compared to their male counterparts (11.52), while male students in the Conventional Method group had the lowest mean score overall. The pattern of results indicates that the interaction is disordinal, as the effectiveness of the treatment varies across gender groups. Specifically, Service Learning appears to enhance the knowledge of male students more, whereas Problem-Based Learning and the Conventional Method

appear to favour female students. This suggests that the impact of instructional strategies on undergraduate students’ knowledge of climate change differs depending on gender, thereby confirming the presence of an interaction effect between treatment and gender.

**H05:** There are no significant interaction effect of treatment and field of study on undergraduates’ knowledge of climate change.

Table 2 shows that there is no significant interaction effect of treatment and field of study ( $F_{(2, 273)} = 2.50$ ;  $p > 0.05$ ; partial  $\eta^2 = 0.037$ ). Thus, Hypothesis 5 was not rejected. This implies that treatment and field of study had no effect on undergraduate knowledge of climate change.

**H<sub>06</sub>:** There are no significant interaction effect of gender and field of study on undergraduates' knowledge of climate change.

Table 2 revealed that the interaction effect of gender and field of study on undergraduates' knowledge of climate change was not significant ( $F_{(1, 273)} = 1.35$ ;  $p > 0.05$ ; partial  $\eta^2 = 0.010$ ). Therefore, Hypothesis 6 was not rejected. This implies that gender and field of study had no effect on undergraduates' knowledge in climate change.

**H<sub>07</sub>:** There are no significant interaction effect of treatment, gender, and field of study on undergraduates' knowledge of climate change.

Table 2 revealed that the three-way interaction is not significant ( $F_{(2, 273)} = 0.50$ ;  $p > 0.05$ ; partial  $\eta^2 = 0.008$ ). Hence, Hypothesis 7 was not rejected. This implies that treatment, gender and field of study had no effect on undergraduates' knowledge of climate change.

## DISCUSSION

The findings support the constructivist learning theory, which posits that learners build knowledge more effectively through active engagement. The superiority of Service Learning (SL) suggests that hands-on community involvement such as tree planting or waste management projects helps students internalize scientific concepts better than passive listening. While PBL also showed improvement over traditional methods, the community-based orientation of SL provided a more profound impact on knowledge retention. The finding is consistent with earlier studies e.g. (Hmelo-Silver, 2004; Raman et al., 2024) which reported that authentic learning strategies improve knowledge retention and application. However, the non-significant difference between Service Learning and Problem-Based Learning suggests that both strategies are effective, although Service Learning may offer slight advantages due to its community-based orientation.

However, the results showed that gender and field of study had no significant main effect on students' knowledge of climate change. This implies that both male and female students, as well as science and non-science students, benefited equally in terms of knowledge acquisition. This implies that authentic learning strategies are inclusive and effective across different student demographics, supporting the idea that active learning environments provide equal opportunities for engagement and understanding. This findings against the claim of United Nations Development Programme (2016) and Leiserowitz Anthony et al., (2014) who in their separate studies upheld that Gender differences also shape problem-solving approaches in climate change with emphasis that women often adopt community-based and adaptive problem-solving strategies, particularly in resource management.

## CONCLUSION

Based on the findings of this study, it can be concluded that authentic learning strategies significantly enhance undergraduate students' knowledge of climate change. In particular, Service Learning emerged as the most effective approach followed by Problem-Based Learning strategy, while the conventional instructional method proved to be the least effective. This indicates that engaging students in real-life, practical experiences improves their understanding of complex environmental issues such as climate change.

## Recommendations

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

1. **Curriculum Integration:** Universities in Oyo State should integrate Service Learning and PBL into their environmental science curricula.
2. **Community Engagement:** Institutions should partner with local organizations to create practical environmental projects for students.
3. **Capacity Building:** Workshops should be organized to train lecturers on the implementation of authentic learning guides to move beyond "chalk-and-talk" pedagogy.

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