

INVESTIGATING INNOVATIVE TEACHING METHODOLOGIES AND TECHNOLOGIES AMONG UNDERGRADUATE STUDENTS

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ABSTRACT This research work discusses the benefits of blending the old traditional system of teaching physics with the innovative methodologies and technologies in our current age and generation in tertiary institutions in order to stimulate the real essence of studying physics as a course. The descriptive survey and experimental survey research design was adopted for this study. The population of this study comprises of selected physics students in Adeyemi federal university of education, Ondo. A total of 200 students were separated into two groups for the research analysis. First 100 students to serve as the control group while the other 100 students as the experimental group. Tests were administered to both groups before the class and after the class as a means of which the data was collected from the respondents. A data collected was analyzed using t-test. The research hypothesis was tested at 0.05 alpha level using t-tests. Pearson Product Moment Correlation (PPMC) was used to test for relationship between the control group and experimental group. the findings of this study showed the mean score of functional learning model pretest to be 7.7950 ± 1.92550 and that of old traditional posttest method to be 6.000 ± 1.60492 . The mean difference was 1.795. the t-test value ($df = 99$, $t = 7.661$) was found to be significant at 0.05 alpha level ($p < 0.000$) which affirmed that there was significant difference in the two teaching methodologies. this study concluded that innovative teaching methodologies and technologies improve the learning in physics classrooms and laboratories in Nigerian tertiary institutions and it was recommended that all instructors and lecturers should try and keep their selves relevant by improving and working on their area of specialization equipping themselves with innovative methodologies and technologies in their choice of discipline.

KEYWORDS: Classroom, Innovative, Laboratories, Methodologies, Teaching

I. INTRODUCTION

In the teaching profession, the question of suitable teaching techniques is crucial since it determines what and how the subject may be taught (Arisi, 2004). Being innovative means doing or creating something that has never been done, experienced, or made before. Any firm that wants to succeed at the long run needs to be innovative. Every nation can benefit from education in order to further its growth (Heng& Sol, 2022). O'Connell (2014) states that a number of initiatives are being implemented with an emphasis on Inquiry Based Learning (IBL) to improve science education in European countries. Science education centers in several nations provide teachers with the chance to receive training and build their

confidence in instructing science courses and inquiry-based science education (O'Connell, 2014). Most students believe that learning university physics is challenging. Despite its application, the multi-media education method remains inadequate. It is necessary to refine the method and its application, as well as to continue exploring and improving the means, (Liang and Shi, 2012).

Lesson delivery by teachers has a major impact on the quality of education. Methods or approaches used to provide information to pupils are known as instructional methods. These approaches can be divided into two groups: student-centered approaches and teacher-centered approaches. The teacher-centered approach places a heavy emphasis on the teacher's authority, passive students, and limited levels of student choice. While some power sharing is frequently included, a learners- or students-centered approach does not always give students complete control over the learning process; instead, it considers the knowledge, abilities, perspectives, and dispositions that students bring to the classroom (Akpokiniovo, 2022). There isn't a single optimal method for delivering instruction. While student-centered techniques are obviously necessary for some purposes, teacher-centered approaches are clearly more suited for others (Roff, 2012). These days, questioning and discussion, investigation and problem-solving, demonstration and laboratory work methods are used to pass instruction to students, thereby improving the quality of education (Ajaja, 2013).

The notion to look at cutting-edge teaching strategies and technology to enhance physics instruction in classrooms and laboratories was spurred by the fact that the physics teaching and learning process has not been successful in achieving the major goals of taking this course in the university. Developing a healthy school atmosphere, encouraging student participation in the learning process, and raising students' motivation are all critical for an effective teaching and learning. As the facilitator of the educational process, the teacher faces the challenging task of being equipped to manage a variety of interpersonal interactions, adjust to changing demands, and operate in a classroom where there is open, two-way communication. The main task of contemporary schools is to place the students in an active role, and to include innovative teaching/learning methods such as problem-, research- or inquiry-based learning, which are contrary to traditional one-way (frontal) teaching method. The teacher, therefore, must be a collaborator, adviser and educator, the one that organizes the educational process, teaches students, and uses those kinds of teaching methods, which help the students to consciously, actively, and comprehensively learn the teaching contents and the Objectives related to them, while at the same time developing the required skills (Pritchard, 2009; Sharples, et al., 2016). Since the year 2000, radical changes can be observed in the field of education and training and the basic paradigm of technology-supported teaching, which is transitioning from technology oriented learning and teaching to student-centered classrooms (Dolenc and Aberšek, 2015). Active learning, through which students become active participants in the learning process, is an important means for development of student skills. In the process of active learning, students move from being passive recipients of knowledge to being participants in activities that encompass analysis, synthesis and evaluation besides developing skills, values and attitudes. Active learning not only emphasizes the development of students' skills but also their exploration of their own attitudes and values. When active learning is carried out, simulations, discussions, student presentations, games, role-plays, flip Charts and handouts are basic elements of physics lessons. Meyers & Jones have maintained that the active learning consists of three factors, which are interrelated. These are: basic elements; learning strategies; and teaching resources. The basic elements of active learning are speaking, listening, reading, writing and reflecting. These five elements involve cognitive activities that allow students to clarify the question, consolidate and appropriate the new knowledge. The second factor of active learning is the learning strategies that incorporate the above five elements. These are small groups, cooperative work, case studies, simulation, discussion, problem

solving and journal writing. Third factor of active learning is teaching resources that the teacher uses to encourage students to interact and participate.

Students often view physics as too abstract and difficult, which makes it difficult for them to perform well in both internal and external examinations. These poor academic results, among other things, are related to the traditional physics teaching method that is commonly used by most physics teachers. This traditional method of instruction typically emphasizes memorization: teachers give lectures, students take notes, and students are tested on the material. However, this approach does not work for every student, which leads to poor performance and damages students' creativity and power of imagination. In order to treat this ailment, this research was conducted to investigate novel methodologies and technologies to enhance physics classroom learning. There are still gaps in university physics education that might be linked to the physics teaching process, despite the fact that numerous studies have been conducted to move physics from an abstract to a tangible learning process. In order to enhance learning in physics classrooms and laboratories, this effort focuses on cutting-edge teaching approaches and technologies.

II. REVIEW OF RELATED LITERATURE

The landscape of physics education in Nigeria faces a critical challenge: ensuring students truly grasp the intricacies of physics concepts beyond rote memorization or formulaic application. Traditional assessment tools often fall short, failing to capture the multifaceted nature of conceptual understanding and hindering the identification of potential misconceptions or reasoning patterns. Due to this cause, Gbamaja (1999) pointed that content, methodology, and techniques are some of the basic element of teaching and concluded that good teaching requires sound and deep knowledge of pedagogical principles of conveying that knowledge to the learners. This chapter embarks on a journey through the landscape of existing research, seeking a map – a transformative tool – that can bridge this gap and illuminate the intricate pathways of students' physics conceptualization. Our destination: concept mapping, a versatile technique poised to ignite a deeper understanding of physics in Nigerian classrooms.

A. THE QUEST FOR CONCEPTUAL UNDERSTANDING

While existing assessment tools, such as multiple-choice tests and algorithmic problem sets, offer some insights, they are frequently plagued by limitations that obscure the true depths of students' understanding:

- (a). Surface-level Knowledge: Traditional methods often reward rote memorization and algorithmic procedures, failing to reveal the intricate web of connections and reasoning processes that underpin genuine conceptual understanding.
- (b). Cultural and Linguistic Disconnect: Current tools often reflect Western cultural norms and language, potentially disadvantaging Nigerian students from diverse backgrounds. This bias overlooks the richness of students' prior knowledge and local contexts, hindering meaningful connection with physics concepts.
- (c). Inadequate Assessment of Reasoning and Application: Existing methods primarily focus on factual recall and algorithmic calculations, neglecting to assess critical thinking, reasoning skills, and the ability to apply physics principles to real-world scenarios. This overlooks a crucial aspect of understanding – the ability to adapt and utilize knowledge in diverse contexts.
- (d). Limited Scope and Accessibility: Many existing tools suffer from a narrow focus on specific concepts or rely on specialized equipment or technological resources, limiting their applicability in diverse classroom settings and potentially excluding students from marginalized communities.

These limitations highlight the urgent need for a new assessment tool that transcends existing methods and embraces a holistic approach to measuring conceptual understanding in the Nigerian context. Enter concept mapping, a versatile tool poised to illuminate the hidden pathways of students' physics knowledge.

B. CONCEPT MAPPING: ILLUMINATING THE INTERCONNECTEDNESS OF KNOWLEDGE

Concept mapping, rooted in the work of Ausubel (1968) and Novak (1977), offers a dynamic and visual approach to representing knowledge structures. Students actively organize concepts, build relationships between them using connecting words, and create a personalized map of their understanding. This process fosters multiple benefits for physics education:

- (a). **Holistic Assessment:** Concept maps encourage students to move beyond surface-level knowledge and delve into the intricate connections between concepts. This allows for assessment of reasoning processes, the ability to identify relationships, and the application of knowledge to real-world scenarios, painting a more complete picture of conceptual understanding.
- (b). **Cultural Sensitivity:** Concept maps can be readily adapted to reflect local contexts and languages, empowering students to build upon their prior knowledge and cultural perspectives. This fosters inclusion and promotes meaningful connections with physics concepts.
- (c). **Accessibility and Scalability:** Concept mapping requires minimal resources and can be readily implemented in diverse classroom settings. Students can generate maps using readily available materials like paper and pencils, or leverage mobile technology for digital map creation.

C. THEORETICAL FRAMEWORK

Understanding physics isn't simply memorizing formulas or solving equations; it's a profound voyage through the intricate network of forces, motions, and energy. Navigating this labyrinthine terrain requires traversing the landscape of existing knowledge, encountering new concepts, and continuously evolving mental models. To support this intellectual odyssey, we need a map – a theoretical framework that illuminates the mechanisms of learning and understanding. This section delves into two prominent theories - Ausubel's assimilation theory and DiSessa's p-prims – offering invaluable insights into how students integrate new knowledge and navigate misconceptions, paving the way for the development of our novel assessment tool.

Ausubel's Assimilation Theory: Anchoring New Knowledge in Familiar Shores. David Ausubel (2000) proposed the seminal assimilation theory, emphasizing the crucial role of existing cognitive structures in learning new information. He distinguished between rote learning – the shallow memorization of facts without connection – and meaningful learning – the anchoring of new concepts to relevant preexisting knowledge. Imagine a student with an intuitive understanding of pushing forces; this becomes a sturdy anchor point for them to assimilate the concept of Newton's Third Law and grasp the notion of equal and opposite reaction forces. In contrast, presenting this law without considering the student's existing knowledge might lead to rote memorization without deeper understanding. Ausubel's theory further highlights the process of subsumption, where new information modifies and expands existing cognitive structures. Think of this process as shaping: a new concept refines and enriches the pre-existing framework, leading to a richer and more nuanced understanding. For example, a student with the p-prim that "force=push" might encounter situations where forces pull objects, prompting them to revise their p-prim to encompass both pushing and pulling forces. This ongoing subsumption allows students to progressively build a more comprehensive and interconnected mental model of the physical world.

DiSessa's p-prims: Unmasking the Shadows of Misconceptions. While Ausubel's theory sheds light on building upon existing knowledge, we must also acknowledge the persistent presence of pre-existing misconceptions. Aaron DiSessa (2014) introduced the concept of p-prims – persistent, implicit frameworks individuals utilize to explain physical phenomena. These p-prims, shaped by everyday experiences and intuitive reasoning, can sometimes conflict with scientific concepts, leading to misunderstandings and entrenched misconceptions. For instance, the common "force-equals-push" p-prim can hinder students' understanding of forces acting at a distance, like gravity. Similarly, the "velocity-equals-position" p-prim can create confusion when introducing concepts like acceleration and relative motion. DiSessa emphasizes that these p-prims are not simply errors to be eradicated but rather ingrained structures that require careful attention and reinterpretation.

(a). Assessment as a Catalyst for Deeper Understanding: Beyond the Factual Shallows.

Assessment plays a crucial role in understanding students' existing knowledge structures, identifying potential p-prims and misconceptions, and ultimately promoting their conceptual understanding. Traditional assessments, heavily reliant on formulaic problem-solving and factual recall, often fail to delve into the depth of students' conceptual frameworks. As argued by Tai and Sadler (2014), such assessments can reward students with well-developed p-prims that align with the test format, even if these p-prims don't reflect genuine understanding of the underlying concepts.

Therefore, effective assessment for conceptual understanding needs to transcend mere factual accuracy and probe deeper into students' reasoning and explanatory frameworks. This aligns with the constructivist view of assessment, which emphasizes the importance of understanding how students construct their own meaning from their experiences and prior knowledge (Popham, 2017). By employing appropriate assessment strategies, we can gain valuable insights into students' p-prims, assess their progress in subsumption, and ultimately tailor our teaching interventions to address gaps and misconceptions.

(b). Bridging the Theory with Practice: Designing an Assessment Tool that Illuminates Understanding.

Guided by the principles of Ausubel's assimilation theory and DiSessa's p-prims, a new assessment tool seeks to move beyond the limitations of traditional methods. By employing a diverse range of item formats, we aim to tap into students' underlying reasoning and reveal the nature of their cognitive frameworks.

i. **Open-ended prompts:** Imagine presenting students with a scenario like two skaters pushing away from each other and asking them to explain the forces at play. This encourages them to engage their p-prims and articulate their understanding, allowing us to identify common misconceptions and address them through targeted instruction.

ii. **Concept maps:** A visual representation of students' understanding of concepts like force, motion, and energy can reveal fragmented knowledge structures and highlight areas where subsumption needs to occur. Analyzing these maps provides insights into the connections students make between concepts, allowing us to identify misconceptions that arise from conflicting p-prims. For example, a student connecting "force" only to arrows representing pushing forces might reveal a need for interventions addressing pulling forces.

iii. **Carefully crafted multiple-choice questions:** Going beyond simple recall, these questions can act as probes to uncover p-prims. By including distractors that reflect common misconceptions, we can analyze student choices and gain valuable diagnostic information. For instance, a question about

Newton's Third Law with distractors like "forces always cancel each other out" or "reaction forces act only on stationary objects" can reveal the presence of specific p-prims hindering understanding.

iv. **Performance-based tasks and simulations:** Engaging students in hands-on activities and simulations allows them to apply their understanding in real-world contexts. Analyzing their interactions and explanations during these tasks can further illuminate their p-prims and how they apply them to novel situations. For example, observing students manipulating forces in a simulation might reveal p-prims related to the direction or magnitude of forces.

(c). 2.2.2 Embracing the Journey: Towards a Collaborative Exploration of Conceptual Understanding

Understanding the theoretical undercurrents of learning like Ausubel's assimilation theory and DiSessa's p-prims equips us with a powerful lens through which to view both teaching and assessment. By acknowledging the dynamic interplay between existing knowledge, misconceptions, and new information, we can move beyond rote memorization and foster a collaborative exploration of the physical world.

Our new assessment tool, informed by these theoretical frameworks, strives to be a valuable partner in this exploration. By providing a multifaceted platform for students to showcase their reasoning, reveal their p-prims, and demonstrate their progress in subsumption, it offers teachers and students alike a deeper understanding of conceptual development. This paves the way for more effective and meaningful physics education, where learning becomes a transformative journey – a shared quest for understanding the intricate tapestry of the universe around us.

D. EXISTING ASSESSMENT TOOLS: CHARTING A COURSE THROUGH STRENGTHS AND LIMITATIONS

Measuring and nurturing genuine conceptual understanding of physics in Nigerian classrooms requires tools that go beyond the surface of memorized formulas and regurgitated facts. While familiar assessment methods exist, we must critically examine their limitations to pave the way for more nuanced and effective approaches.

(a). 2.3.1 Traditional Methods: The Familiar but Flawed - A Deeper Dive

While familiar and convenient, traditional physics assessment methods in Nigerian classrooms often fail to capture the true essence of students' conceptual understanding. Let's delve deeper into their limitations, understanding why we need to move beyond mere "checking boxes" and towards assessments that truly illuminate the intricacies of student learning.

Multiple-choice tests (MCQs) have long been the workhorses of physics assessment, offering standardized formats and ease of scoring. Yet, their allure often conceals their shortcomings: Feasting on Formulas, Starving Understanding: MCQs often reward the ability to recall and apply formulas rather than truly comprehending the underlying concepts. Students can ace tests by rote memorizing solutions without grasping the deeper principles at play. The Guessing Game: The limited answer choices offered in MCQs can introduce an element of chance. Lucky guesses can inflate scores, masking genuine understanding and creating a false sense of mastery. Nuances Lost in Translation: Complex ideas and subtle distinctions within a concept can easily be lost in the binary world of right and wrong answers. MCQs often overlook the richness of student reasoning and the diverse pathways to understanding. Cultural Biases Linger: Standardized MCQs, often developed in Western contexts, may

not resonate with the lived experiences and cultural knowledge of Nigerian students. This can lead to misinterpretations, unfair advantages for some, and ultimately, inaccurate reflections of their true understanding. While MCQs offer a quick and efficient way to gauge basic knowledge recall, they fall short when it comes to assessing genuine conceptual understanding. In the diverse classrooms of Nigeria, relying solely on MCQs risks overlooking the potential and unique learning styles of students, ultimately hindering their true development in physics.

Problem-solving exercises, another staple of physics assessment, may appear to necessitate understanding. However, they too have their limitations: Algorithmic Aptitudes, Not Conceptual Grasp: Many traditional problems sets present well-defined steps and procedures to reach a solution. Students' adept at following these algorithms can excel without truly understanding the underlying principles or being able to apply them to novel situations. Standardized Solutions, Diverse Pathways: The "one right answer" approach inherent in many problem sets fails to acknowledge the diverse ways students may arrive at a solution. This overlooks creative thinking, alternative reasoning strategies, and the valuable insights these offer into individual understanding. Limited Scope, Bounded by Numbers: Focusing solely on numerical calculations and prescribed problem formats restricts the assessment of broader conceptual understanding. Students may grasp the mechanics of solving specific problems without possessing a holistic view of the underlying concepts and their real-world implications. The Pressure of Performance Anxiety: High-stakes problem-solving assessments can induce test anxiety, hindering students' ability to demonstrate their true understanding. This can further exacerbate existing inequalities and create an unfair playing field for students from diverse backgrounds. While problem-solving exercises can play a valuable role in developing procedural skills, they must be carefully designed and balanced to avoid masking or misjudging conceptual understanding. In the Nigerian context, a more nuanced approach to problem-solving assessment is needed, one that celebrates diverse thinking, recognizes alternative solutions, and goes beyond the tyranny of the singular "correct" answer. By critically examining the limitations of traditional assessment methods, we pave the way for the development of more effective tools that truly illuminate the landscape of student understanding in physics classrooms across Nigeria. Our journey towards holistic and culturally relevant assessment requires moving beyond the familiar but flawed methods and embracing innovative approaches that capture the richness and diversity of student learning.

(b). Exploring Existing Conceptual Understanding Tools

While traditional assessment methods provide some information, they are often insufficient for gauging true conceptual understanding of physics. Therefore, several dedicated tools have emerged to delve deeper into student thought processes and uncover misconceptions. Let's examine some of these existing options, recognizing their strengths and limitations within the Nigerian context:

Concept Inventories: Force and Motion Conceptual Inventory (FCMI) and Force Concept Inventory (FCI): These widely used inventories are designed to identify common alternative frameworks and misconceptions students hold about force and motion. They employ multiple-choice questions along with free-response items to probe deeper than surface knowledge. Concept inventories offer standardized assessments, allowing for comparisons across different studies and institutions. They efficiently reveal widespread misconceptions held by students, providing valuable information for targeted instruction. The static nature of these inventories can limit their ability to capture the full spectrum of student understanding. Cultural biases may exist in the language and context of certain items, requiring sensitive adaptation for the Nigerian context. Additionally, they primarily focus on specific concepts, overlooking other aspects of understanding.

Open-Ended Assessments: Concept maps, essays, and interviews: These tools allow students to express their understanding in their own words and reveal their reasoning process. Concept maps visually represent conceptual connections, while essays can delve into explanations and justifications. Interviews provide a platform for in-depth exploration of student thinking. Open-ended assessments offer flexibility and cater to diverse learning styles, allowing students to demonstrate understanding in ways that resonate with them. They provide insights into reasoning patterns and potential misconceptions that may go unnoticed in standardized tests. Scoring can be subjective and time-consuming, requiring skilled educators with a deep understanding of physics concepts and student thinking. Standardizing scoring procedures and training educators are crucial for consistent interpretation. Additionally, bias can creep in depending on the interviewer's expectations and prompting techniques.

Performance-Based Assessments: Simulations, experiments, and design projects: These assessments engage students in actively applying their understanding to real-world scenarios. Simulations offer virtual manipulation of variables, while experiments allow practical exploration of physical phenomena. Design projects encourage students to apply their knowledge to solve problems and create tangible solutions. Performance-based assessments foster critical thinking, collaboration, and problem-solving skills while motivating students through hands-on experiences. They help bridge the gap between theoretical concepts and practical applications, making physics more meaningful and relevant. Logistical challenges can arise with limited resources and laboratory facilities in some Nigerian schools. Safety concerns and time constraints may restrict the scope and frequency of certain experiments. Additionally, scoring can be complex, requiring consideration of both the final product and the underlying reasoning process.

(c). The Need for a New Approach: A Tailored Nigerian Solution

While existing assessment tools offer valuable insights, none perfectly captures the multifaceted nature of conceptual understanding in the Nigerian context.

i. Functional Learning Model

The functional learning model is an advanced active learning strategy that could enhance effective teaching and learning processes, it is a combination of different relevant strategies and how they can be synchronized to achieve a brilliant academic performance of students. This model tends to reveal the secret and relationship between different strategies in order to make teaching and learning enjoyable for both teacher and learner, it implies the confluence in the teaching-learning process. Functional learning model is good for classroom instruction and Physics laboratories. One of the features of this Learning model is Peer learning which refers to a strategy wherein students not only learn from educators but also with each other, in both formal as well as informal ways. Under this instructional teaching mechanism, people belonging to similar group tend to work together and help each other for gaining some knowledge. Activities like classroom discussions, blogs, or online discussion forums, are example of peer learning strategies. This form of teaching not only provides the information to the students about the education related concepts but also improve the social cognitive skills (Wessel, 2015; Pauletal, 2018).

How the component works together to form a Functional Learning Model

In this part of the paper, we are going to look at how these components work together to form functional learning model.

Step 1: Teacher considers the choice of study of the learner by introducing the course content and ask for individual to pick their choice at first, which is expected of the student to work on their choice of learning and consult the teacher with difficult problem next class.

Step 2: The teacher is expected to prepare him/herself for the next class as a consultant, the teacher is also expected to pick a movie or short clip that portray the problem that require the learning of such content.

Step 3: the teacher gives general test in the class to evaluate, to discover mastery of subject matter. Once every aspect is covered or the teacher discovered the aspect left behind by the student.

Step 4: the teacher recommends the student to present on what aspect he chooses. (Peer-peer-teaching)

Step 5: the teacher gives student relevant materials on each course to study outside the classroom, and solve difficult problem only in classroom (flipped classroom).

Step 6: the teacher recommends inventive personal ideas project from each student to explore their creativity from the lesson so far. (This might serve as a reward for the student being an inventor or developing the potency in learning physics)

Step 7: practical exam as evaluation

ii. Traditional Method of Teaching

In traditional teaching teacher is being the controller of the learning environment. Power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (in regard to curriculum content and specific outcomes). Traditional teaching methods focused on the teacher as the only source of information in the classroom. It embraces the idea of a teacher-centered method involving face-to-face interaction, mainly from the teacher to the student. In the traditional method of teaching, teaching happens within the four walls of the classroom. Here, the teacher is the sole source of knowledge. It's a teacher-centric method that promotes the supremacy of the teacher within the classroom setup. Also, every aspect of learning proceeds as per their will. The teacher has full control over the learning environment, decides the teaching methodology, and determines the course curriculum. In the traditional method of teaching, teachers followed the drill and rote method of memorization. In this method, children learn through repetition and memorization. There is little or no scope for critical thinking. (<https://graphy.com/blog/traditional-method-of-teaching/>)

III. METHODOLOGY

A. THE SAMPLE SIZE OF THIS STUDY

This study employed the experimental research design. This method was adopted because it gives room for a researcher to test for the cause and effect. The population of this study comprises some selected physics students in Adeyemi Federal University of Education, Ondo. The sample size of this study Comprises two hundred students; 100 for experimental and 100 for control group. The instrument for data collection in this study was a structured test. It contained the pre-test and the post-test. The tests consisted of structured questions on "wave motion". It contained four (4) theory questions to tests students' knowledge of wave motion having been taught with two different methods which were Functional Learning Model (FLM) and Traditional method of Teaching (TMT). The test was practically a written exam which was exhibited after the implementation the model to be evaluated. A data collected was analyzed using t-test. The research work doesn't apply any questionnaire that might require yes/no answer or strongly agree or disagree, is pure experimental research that has to do with written exam and scoring based on the question given. The same questions were given to both groups so as to define a

good judgment while evaluating the models. To establish reliability of the research, instruments, test-retest technique was used, where by the researcher administered the test to the pilot study respondents at an interval of one week. The two sets of tests were scored separately then the correlation co-efficient was computed using the Pearson's Product Moment Correlation (PPMC). According to Mugenda and Mugenda (1999), a correlation coefficient, r , of 0.7 is considered appropriate. The study achieved a reliability coefficient of 0.78 for the test. Which confirmed that the instruments used yielded reliable information? After the functional learning model has been applied to the experimental group, a post-test was conducted on both the experimental group and the control group. Data collected were collated, coded and computed and the hypothesis was tested at 0.05 alpha level using t-tests. Pearson product movement correlation (PPMC) was also used to test for the relationship.

B. MODEL EVALUATION

PPMC is a statistical measure that quantifies the linear relationship between two continuous variables.

PPMC was used for Model Evaluation

(a). Scoring Consistency:

- i. A high positive correlation (closer to +1) indicates a strong positive relationship between the two sets of scores. This suggests that the two scoring methods are highly consistent and produce similar results.
- ii. A low correlation (closer to 0) or a negative correlation suggests that the two scoring methods may not be consistent and may produce different results.

(b). Model Validity:

- i. If the two sets of scores are based on different models or methods, a high correlation can suggest that the two models are measuring the same underlying construct or phenomenon.
- ii. However, it's important to note that correlation does not imply causation. A high correlation simply means that the two variables are related, but it doesn't necessarily mean that one causes the other.

C. INTERPRETING THE RESULTS

To effectively interpret the PPMC results, these factors were considered:

- i. Magnitude of the Correlation Coefficient: A higher absolute value indicates a stronger relationship.
- ii. Statistical Significance: The correlation coefficient should be statistically significant to ensure that the observed relationship is not due to chance.
- iii. Practical Significance: Even if the correlation is statistically significant, it may not be practically significant if the effect size is small.
- iv. Contextual Understanding: The interpretation of the correlation coefficient was based on the specific context of the study, including the nature of the variables and the research question.

By carefully considering these factors, I use PPMC to effectively evaluate the consistency and validity of the models.

IV. RESULTS AND DISCUSSION

A. DEMOGRAPHIC DATA OF STUDENTS

Table 1. Frequency and Percentage Showing the Demographic Information of Respondents

Variable	Description	Frequency	Percentage	Cumulative percentage
Designation	Students	200	100	100.0
Gender	Male	120	60	40.0
	Female	80	40	100.0
Level	200	98	49	49.0
	300	102	51	100.0
Department	Physics	100	100	100.0

The results in Table 3.1 reveal that 100% of the respondents were students. It further reveals that 60% of the students were male while 40% were female. The results also show that 49% of the students were from 200 Level while the rest were from 300 Level. Finally, the result reveals that all the participated students were 100% physics students.

Table 2: Comparative Analysis of Functional Learning Model and Old Traditional Method

Variables	Mean	SD	N	df	Mdf	t-test values	Sig	Remark	Decision
FLM	7.7950	1.92550	100	99	1.795	7.661	0.000	Significant	Refused to uphold hypothesis
OTM	6.0000	1.60492	100						

$P < 0.05$

The result in Table 1 shows the mean score of functional learning model posttest to be 7.7950 ± 1.92550 and that of old traditional posttest method to be 6.000 ± 1.60492 . The mean difference was 1.795. The t-test value ($df = 99, t = 7.661$) was found to be significant at 0.05 alpha level ($P < 0.000$). Therefore, the null hypothesis which stated that there is no significant difference between the use of functional learning model and old traditional method was refused to be upheld while the alternatives hypothesis which stated that there was significant difference in the two teaching methodologies was upheld.

Table 3: Descriptive Analysis of Functional Learning Model and Academic Performance of the Physics Students?

Variables	Mean	SD	N	Df	Mdf	t-test values	Sig	Remark	Decision
FLM	7.7950	1.92550	100	99	4.5750	18.227	0.000	significant	Refused to uphold hypothesis
Academic performance	3.2200	1.49970	100						

$P < 0.05$

The results in Table 4.2 shows the mean score of functional learning model to be 7.7950 ± 1.92550 and that of academic performance of the physics students to be 3.2200 ± 1.49970 . The mean difference was 4.57500. The t-test value (DF=99, $t=18.227$) was found to be significant at 0.05 alpha level ($P=0.000$). Therefore, the null hypothesis which stated that there is no significant relationship between the use of functional learning model and academic performance of physics students was refused to be upheld while the alternative hypothesis which stated that there was significant relationship between the use of functional learning model and academic performance of the physics students was upheld.

B. Research Hypothesis

- i. There is no significant difference between the use of functional learning model and old traditional method
- ii. There is no relationship between the uses of functional learning model and academic performance of the Physics students.

Test of Hypothesis using PPMC

Research Question One: There is no significant difference between the use of functional learning model and old traditional teaching method. Pearson product moment correlation showing the significant difference between the use of functional learning model and old traditional method.

Table 3: Correlations Analysis Table

		Ex-posttest	Ex-pretest
Ex-posttest	Pearson correlation	1	.968**
	Sig.(2-tailed)		.000
	N	100	100
Ex-pretest	Pearson correlation	.968**	1
	Sig. (2-tailed)	.000	
	N	10	10

**Correlation is significant at the 0.01 level (2-tailed)

Pearson product moment correlation of experimental group post-test and experimental group pre-test was found to be moderately and statistically significant ($r = .97, P < 0.001$) hence, H_1 was not supported. This shows that the null hypothesis which stated that there is no significant difference between the use of functional learning model and old traditional teaching method was refused to be upheld while the alternative hypothesis which stated that there is significant difference between the use of functional learning model and old traditional teaching method was upheld.

Table 4: Pearson product moment correlation showing the relationship between the use of functional learning model and academic performance of the physics students.

		Experimental posttest	group-	Control group-pretest
Ex-posttest	Pearson correlation	1		.788**
	Sig. (2-tailed)			
	N	100		.007
				100
Con-posttest	Pearson correlation	.788**		1
	Sig. (2-tailed)		.007	
	N	100		100

*Correlation is significant at the 0.01 level (2-tailed)

Pearson product moment correlation of experimental group posttest (FLM) and went control group pretest (OTM) was found to be moderately positive and statistically significant ($r = .688^{**}$, $p < 0.007$) hence H2 was not supported. This implies the null hypothesis which stated that there is no relationship between the use of functional learning model and academic performance of the physics students was refused to be upheld while the hypothesis which stated that there is significant relationship between the use of functional learning model and academic performance of the physics students.

CONCLUSION

One could argue that the teaching and learning process of physics will become outdated without the advancement of the antiquated traditional teaching methods, which could be upgraded by cutting-edge teaching methodologies and technologies. This could have an impact on students' academic performance and limit their ability to think critically about the true purpose of studying physics.

According to the study's findings, cutting-edge instructional strategies and technological advancements enhance physics lab and classroom instruction. Owing to the importance of appropriate teaching of physics in classrooms and laboratories that could enhance concurrent learning validity, the following recommendations were made:

- (a). it is imperative for a physics lecturers to adopt an acceptable innovative methodologies and technologies, to make learning process effective, since it makes an impact in the educational system.
- (b). the students should be given a voice in the classroom in order to phase out in some student the belief of not being confident.
- (c). every instructor should keep themselves relevant by improving and working on their area of specialization equipping themselves with innovative methodologies and technologies in their endeavors.
- (d). the government should provide adequate financial support and facilities to enhance the exploration of the hidden resources in our country through effective learning of physics.

- (e). innovative teaching strategies such as team teaching, brainstorming, peer tutoring etc. should be reflected in Physics teacher education curriculum to enable new graduate teachers to be fully equipped for teaching and learning of the subjects.
- (f). Conferences, workshops, and seminars should be organized by government for the practicing and serving science teachers to update their knowledge/skills in the application of these strategies which will enhance quality teaching and rebuilding the interest of the learners in Physics and other science subjects.

REFERENCES

- [1] Adeyemo, S.A. (2010) The Relationship between Students' Participation in School Based Extracurricular Activities and Their Achievement in Physics, *International Journal of Science and Technology Education Research*, 1, 111-117. Accessed on 08/10/2023
- [2] Adeyemo, S.A. (2010). Teaching/learning physics in Nigerian secondary school: The curriculum transformation, issues, problems, and prospects. *International journal of education Research and Technology*, 1(1),99. Accessed on 05/11/2023. *American Journal of Physics*, 66, 64. <http://dx.doi.org/10.1119/1.18809>. Accessed on 05/11/2023.
- [3] Agbaje, E.O., Adeneye, A.A. and Daramola, A.O. (2009) Biochemical and Toxicological Studies of Aqueous Extract of *Syzgium aromaticum* (L.) Merr. & Perry (Myrtaceae), in rodents. *Africa Journal of Traditional Medicine in Cameroun*, 6, 241-254. <https://doi.org/10.4314/ajtcam.v6i3.57162>. Accessed on 08/10/2023
- [4] Agommuoh, P. C. (2015). Enhancing the teaching of physics through the use of ICT in Senior secondary schools. *Science Teachers Association of Nigeria Annual Conference Proceedings* 274-283. Accessed on 08/10/2023
- [5] Agommuoh, P. C. (2004) Effects of videotaped instruction on secondary school students' physics. An unpublished MED thesis, University of Nigeria, Nsukka, 2010. [16]. Accessed on 08/10/2023.
- [6] Agommuoh, P.C. (2010). Effects of prior knowledge, exploration, discovery, dissatisfaction with prior knowledge (pedda) and the learning cycle (tlc) constructivist instructional models on students' conceptual change and retention in physics. An unpublished Ph.D. thesis, University of Nigeria, Nsukka, 2010. [16]. Accessed on 05/11/2023.
- [7] Best, J.W. and Kahn, J.V. (1993) *Research in Education*. 2nd Edition, Pearson Education Inc., Cape Town. Accessed on 05/11/2023.
- [8] Bloom, B.S (1956), *Taxonomy of educational Objectives, Handbook: The Cognitive Domain*, David McKay, New York. Accessed on 05/11/2023.
- [9] Bob Goddard (making a difference, 2012). Accessed on 08/10/2023
- [10] Bonwell CC, Eison JA. *Active learning: creating excitement in the classroom*, ASHEERIC Higher Education Report No. 1, George Washington Uni., Washington, DC. Accessed on 08/10/2023
- [11] Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom*. ASHE-ERIC Higher Education Report, Washington DC: School of Education and Human Development, George Washington University. Accessed on 08/10/2023
- [12] Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.) (1999). *How people learn: Brain, mind, experience and school*. Committee on Developments in the Science of Learning, Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, DC: National Academy Press. Accessed on 15/10/2023
- [13] Bransford, J. D., Brown, A. L. & R. R. Cocking R.R. (2000). *How people learn: brain, mind, experience and school*. Washington D. C. National Academy Press. Accessed on 24/10/2023
- [14] Brown, G & Atkins, M. (1988). *Effective Teaching in Higher Education*, vol 4, Science and Education publishing, Ghana. Accessed on 12/10/2023
- [15] Carr, R., Palmer, S. & Hagel, P. (2015). *Active Learning: The Importance of Wessel*,

- [16] M. and Quist-Wessel, F.P.M. (2015) Cocoa Production in West Africa, a Review and Analysis of Recent Developments. *NJAS Wageningen Journal of Life Sciences*, 74-75, 1-7. <https://doi.org/10.1016/j.njas.2015.09.001>. Accessed on 08/10/2023
- [17] Cohen, L., Manion, L., & Morrison, K. (1998). *Research Methods in Education*. Routledge. <https://doi.org/10.4324/9780203720967>. Accessed on 16/10/2023
- [18] Craswell, Richard & Calfee, John E, 1986. "Deterrence and Uncertain Legal Standards," *The Journal of Law, Economics, and Organization*, Oxford University Press, vol. 2(2), pages 279-303, Fall. Accessed on 17/11/2023
- [19] Daramola, S.O. (2009). Factors influencing enrolments in physics in the upper forms secondary schools in Kwara State. *Ann Arbor, University Micro Films International*, 2(3). 22-26.1991. Accessed on 08/10/2023
- [20] Developing a Comprehensive Measure. *Active Learning in Higher Education*, 16, 173-186. <https://doi.org/10.1177/1469787415589529>. Accessed on 08/10/2023
- [21] Dolenc, K & Aberšek, B. (2015). TECH8 intelligent and adaptive e-learning system: Integration info Technology and Science classrooms in lower secondary schools. *Computers and Education*, 82 (0), 354-365. Accessed on 03/10/2023.
- [22] Esiobu, G.O. (2005) Genre Issues in Science and Technology Education Development. In: Uwowi, U.M.O., Ed., *Science and Technology Education for Development*, NERDC Press, Lagos, 137-156. Accessed on 25/09/2023
- [23] Federal Republic of Nigeria (2004): *National Policy on Education*. NERDC Lago <https://www.edsys.in/16-innovative-ideas-make-teaching-methods-effective/>. Retrieved 01 Dec 2018. Accessed on 25/12/2023
- [24] Fink, L. D (2003) *Creating significant learning, experience; An integrated Approach to designing college course*, jossey-Bass, San Francisco. Accessed on 06/09/2023
- [25] Fitzpatrick, 2012. *Flipping the Classroom*, Center for Teaching Vanderbilt. ; *The Chronicle of Higher Education* , cft.vanderbilt.edu retrieved on 24-08-2014. Accessed on 25/09/2023
- [26] Fredrick, Otiike, Refried on 25th of July (2011), *Cultivation and its promotion among Pupils, Kenya*, <https://www.interestjournal.com>. Accessed on 19/10/2023
- [27] Freeman, A., Becker, S. A., & Cummins, M. (2017). *NMC/CoSN Horizon Report: 2017 K . The New Media Consortium*. Accessed on 12/09/2023
- [28] Freeman F.A. 2015. The challenges in teaching and learning introductory physics. Web.physics.ucsb.edu/-airboy/challenge.html retrieved on 22-04-2015. Accessed on 14/09/2023
- [29] Freeman, S. et al. (2014). Active Learning Increases Student Performance in Science, Engineering, and Mathematics. *PNAS*, 111, 8410-8415. <https://doi.org/10.1073/pnas.1319030111>. Accessed on 07/11/2023
- [30] Fullan, M. (1991). *The new meaning of educational change*. New York: Teachers College Press. Accessed on 30/10/2023
- [31] Gwyneth, O .J (2013). *Debates in Design and Technology education*; Routledge U.K Accessed on 25/09/2023
- [32] Hake, R. R. (1998). Interactive-Engagement vs. Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. Accessed on 16/10/2023
- [33] Hansen, B.E. (1994) Autoregressive Conditional Density Estimation. *International Economic Review*, 35, 705-730. <https://doi.org/10.2307/2527081>. Accessed on 25/09/2023
- [34] Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses related to achievement*. London: Routledge. Accessed on 25/09/2023
- [35] Jegede, S.A. & Adedayo, J. O. (2013): Enriching Physics Education in Nigeria towards enhancing a sustainable technological development. *Greener Journal of Educational Research*. 3(2) 80-84. Accessed on 08/09/2023
- [36] J. Komenský, *Great Didactic*, University Press “St.KlimentOhridski”, Sofia, 2008. Accessed on 25/09/2023
- [37] J. Cohen *Statistical power analysis for the behavioral sciences* (1988)

- [38] Yee Wan Kwan & Angela F. L. Wong (2015): The constructivist classroom learning environment and its associations with critical thinking ability of secondary school students in liberal studies. Accessed on 08/09/2023
- [39] Miller, R.D. (2015) Miller's Anesthesia. 8th Edition, Churchill Livingstone, San Diego, 31. Accessed on 07/10/2023
- [40] Mugenda, O.M. and Mugenda, A.G. (1999) Research Methods: Quantitative and Qualitative Approaches. Acts Press, Nairobi Accessed on 12/09/2023.
- [41] National Academies of Sciences, Engineering, and Medicine. 2019. Science and Engineering for Grades 6-12: Investigation and Design at the Center. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25216>. Accessed on 10/09/2023
- [42] Olson Matthew. O & Hegenhahn B.R, 2012, an Introduction to the theories of learning, 9th edition, <https://DOI.ORG/10.4324/9781315664965>, New York. Accessed on 25/09/2023
- [43] Prince M. Does active learning work? A review of the research, J Eng Educ 2004;93:223231. Accessed on 11/09/2023
- [44] Pritchard, A. (2009). Ways of learning: learning theories and learning styles in the classroom (2nd edition). London: David Fulton. Accessed on 30/09/2023
- [45] Rahman, S.A. (2004) The Place of Organic Manure in Sustaining Agricultural Development in Nigeria. Science Technology and Society National Workshop, Lafia, 11 July 2004. Accessed on 25/09/2023 Accessed on 25/09/2023
- [46] S. A. Adeyemo, (2010). "Teaching/Learning of Physics in Nigerian Secondary Schools: The Curriculum Transformation, Issues, Problems and Prospects" International Journal of Educational Research and Technology, Vol1, Issue 1, pp. 99 – 111, 2010. Accessed on 25/09/2023
- [47] Screeden, P. S & M. A. Sudhir, M A. (2011) Innovative strategies for science teaching: International Journal of Educational Science and Research. 1 (1), 1 – 10. Accessed on 25/09/2023
- [48] Trowler, V. Reprived (2010), Student Engagement literature, the higher Education Academy, New York. Accessed on 25/09/2023
- [49] Vygotsky, L. (1978). Interaction between Learning and Development. Readings on the Development of Children, 23, 34-41. Accessed on 25/09/2023
- [50] Udoh, A.U. (2012). Refocusing physics education in Nigeria: Issues and Challenges in Teacher Education. Mediterranean Journal of Social Sciences: 3 (13). 1119. Accessed on 25/09/2023.
- [51] Yee Wan Kwan & Angela F. L. Wong (2015): The constructivist classroom learning environment and its associations with critical thinking ability of secondary school students in liberal studies. DOI: 10.1016/j.ijer.2015.02.006. Accessed on 08/09/2023.