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Innovative pedagogical approaches for classroom delivery: The Science teachers' perspective

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ABSTRACT

The irrefutable relevance of science to humanity and national development through its applications in solving 21st-century global problems compelled the researchers to investigate science teachers' awareness and utilization of innovative pedagogical approaches (IPA) for effective teaching of science in a 21st-century science classroom in Anambra State, Nigeria. The study which adopted a descriptive survey research design, was guided by four research questions and two null hypotheses. A total of 316 secondary school science teachers (131 biology, 98 chemistry, and 87 physics) were sampled using proportionate stratified simple random sampling technique. Data were collected using a 62-item structured questionnaire, developed by the researchers from teaching experiences and reviewed literature, with a reliability coefficient of 0.71 established using Cronbach Alpha. The data were collected through direct (face-to-face) administration of the questionnaire and analyzed using frequency counts, percentages, mean, and standard deviation to answer the research questions. Additionally, one-way Analysis of Variance (ANOVA) was used to test the null hypotheses at a 0.05 alpha level. The findings of the study revealed that science teachers utilize only 7 out of the 14 IPA they are aware of. This limited utilization is due to various challenges, including a lack of funds, insufficient time allocated to teaching science subjects, and resistance to change among teachers. In light of the results, it was established that science teachers only employ a few of the IPA they are familiar with. In line with the respondents' suggestions to address this issue, the study recommended that the government, in collaboration with other educational stakeholders, should provide funds, organize and sponsor educators to seminars, conferences and workshops to acquaint them with IPA and effective ways to incorporate them into teaching practices.

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INTRODUCTION

In every organized educational process, the desire of every teacher at the end of any lesson, is to achieve the stated objectives through effective classroom delivery. Classroom delivery, according to Uwatt (2019), refers to the process in which teachers deliver lessons for the purpose of achieving their pedagogical objectives effectively. It is a multi-dimensional activity that involves planning, developing and implementation of skills, techniques and strategies to achieve positive learning outcomes (Ushie and Daniel, 2022). Ushie and Daniel maintained that in any effective classroom delivery, the teacher strives to achieve stated objectives through getting a deeper understanding of the learners, the material to be taught, its scope and organization, the techniques to be used, the reinforcers to employ, the learning environment, and the evaluation practices to be implemented. To achieve the premise, Kolling and Shumway-Pitt (2022) stated that the teacher must equip oneself with pertinent comprehension of the material to be taught and organize the information (lesson) in a way that makes it easier for both the teacher and the students to teach and learn: from simple to complicated, familiar to unfamiliar.Inyang-Abia (2015) noted that each lesson has its own unique method of delivery and it is crucial that educators in the 21st century apply the appropriate pedagogical approaches to promote learning and help students acquire the necessary values, norms, attitudes, and skills needed to thrive in the global competitive society.

Pedagogical, teaching or instructional approaches, according to Samba et al (2010), simply refer to a strategy, a process, or a set of thoughtfully planned classroom activities that can be rigorously adhered to in order to teach a subject, idea, or concept. They are a set of principles, beliefs, or ideas employed by teachers to help students acquire knowledge and develop skills (Hoque, 2016). Hence, pedagogical approaches may simply be referred to as a set of techniques or strategies employed by teachers during classroom instruction to foster information dissemination between teachers and students and among students. In any teaching and learning process, Mbia and Nsungo (2019) asserted that pedagogical approaches employed have been categorically classified into two: Teacher-centred (conventional) and student-centred (Innovative).

Teacher-centred approaches or traditional teaching approaches are defined as methods of instruction where the instructor is in front of the students, sharing knowledge and having the students take notes (Nwuba et al., 2022a). These approaches, according to Paris (2014), have drawn criticism for their inability to meet the lesson's stated objectives, despite being widely acknowledged and used by teachers in the classroom due to their many benefits, which include covering a large amount of content quickly and being useful in teaching a large population. These drawbacks of teacher centred approaches have inspired stakeholders in education to search for other strategies that could be used to improve classroom delivery, ushering in the era of student-centred pedagogical approaches.

Student-centred or innovative pedagogical approaches (IPA), according to Nwuba et al (2022a), are methods of instruction and learning that prioritize students and work to make learning accessible to them. Mbia and Nsungo (2019) described them as teaching strategies that offer practical activities that serve to lessen the emphasis on rote memorizing of scientific ideas and principles by motivating students to actively engage in their education and develop science process skills. Hence, IPA are simply novel or new methods, strategies or techniques of instruction that enables learners actively participate during the course of instruction and learning

IPA employed in a 21st century classrooms are vast and wide. Revathi et al. (2019) noted that innovative methodologies used in classroom instruction include all, but are not restricted to: Cooperative learning approach (CLA), Experiential based learning (EBL), Project based teaching approach (PBTA), Research based teaching learning (RBTL), Computer assisted instruction (CAI), Flipped classrooms, Peer tutoring, Problem solving teaching (PST), Use of digital tools and reusable learning objects, blended learning, Z to A approach, Mind-mapping approach (MMA) and Activity-based approach (ABA). Similarly, Obikezie et al (2022), in their study, identified them as computer assisted instruction (CAI), ethno-science instruction (EI), computer supported collaboration (CSC), multimedia integrated instruction (MII), inquiry-based learning (IBL), quick response codes (QRC), project-based learning (PBL), wisely managed classroom technology (WMCT), jigsaws strategy (JS), and projected video packaged instruction (PVPI) among others. Some of these innovative pedagogical approaches are briefly explained as thus;

Computer assisted instruction (CAI) according to Egbo et al. (2020) is a novel instructional technique in which contents to be taught are meticulously organized, composed, and programmed in a computer so that several computer units may operate them simultaneously, allowing interaction between user and computer with immediate feedback. It is an innovative approach that employs 6 (Drill and practice, tutorial, simulation, discovery, gaming and problem solving) modes of instruction to foster learning (Ekundayo, 2022).

Cooperative instructional approach are Innovative methods of instruction that include small, diverse groups, typically consisting of four or five people, collaborating to complete a group activity where each person is responsible for a portion of the result that can only be achieved by the group as a whole (Sani, 2015). Olaya and González-González (2020) posited that there are numerous variations of the cooperative instructional approach, consisting: Reciprocal teaching, Quiz-quiz, STAD (Students Team Achievement Division), Prairie fire Jigsaw, Think-Pair Share approach, Numbered Heads Together, and Group investigation.

Experiential learning approach (ELA) which is basically "gaining knowledge by practicing" encourages learning that is practical oriented. Nwuba et al (2022b) described it as an activity-based teaching strategy that gives students the chance to actively participate during the course of instruction, developing their capacity for solving problems and judgment. To effectively implement ELA in a classroom, Kolb (1984) identified four stages associated with the approach which instruction must follow: Concrete experience, reflective observation, abstract and active experimentation.

Guided inquiry based instructional approach (GIBIA) refers to learning by discovery. Nwuba et al (2024) defined it as an active learning approach where students, with the help of an instructor, gain knowledge about specific phenomena on their own. Ike (2016) noted that GIBIA in order to promote the acquisition of knowledge through exploration, experience, and conversation, encourages small-group discussion, experiential learning, and cooperative learning, allowing students explore materials, ask questions, and share ideas rather than memorizing facts and materials as they study. Hence, in this approach, students create information rather than absorb it while teachers serve as facilitators rather than providers.

Mind-Mapping Instructional Approach (MMIA), introduced by Tony Buzan, a psychologist, in 1974, is an innovative instructional approach that uses diagrammatic non-linear illustrations (graphic tools) in representing knowledge; assisting teachers in explaining complex structures, relationships between concepts and integrating graphically new knowledge with existing knowledge (Awosika & Okoli, 2023). Kanelechi et al (2018) stated that mind maps are hierarchical and show relationships among the whole concept being represented.

Problem-based learning (PBL) is an innovative learning technique introduced in McMaster University, Canada in 1969. It is a student-centred approach wherein, as opposed to just presenting knowledge and ideas, complicated actual-life situations. are used as tools to help students comprehend concepts and theories. (Pius & Okoli, 2021). In implementing PBL, Students are presented with an open-ended topic and given guidance on how to undertake research, combine theory and practice, and use their knowledge and skills to create a workable solution.

Generative learning model (GLM) according to Obikezie et al (2023) is a constructivist form of instruction that emphasizes mental processes, as it substantially provides opportunities for learners to re-evaluate their preconceptions in the light of new ideas and learning experiences. In using GLM, Okeke and Okigbo (2021) posited that four instructional phases which aims at correcting existing misconceptions and accommodating new ideas for meaningful learning are implemented. That is, the preliminary phase, focus phase, challenge phase and application phase.

Crossover instructional Approach (CIA) denotes an exhaustive knowledge of instruction which incorporates both structured and unstructured learning settings. It is a cutting-edge method of training that uses the principles of both the official and casual classroom settings to enhance learning (Nwuba et al., 2023b). In implementing CIA, Srinivasa et al (2022) recommended that prior to the academic visit to the informal learning environment, the teacher should clearly state the concept to be learnt and the goals to be achieved. Srinivasa et al., opined that these specific learning goals are meant to direct and motivate learners to investigate, gather images or written materials as proof, and afterwards turn in their answers to the teacher in groups or individually.

A thorough review of the principles underlying these IPA have shown that these approaches enhance student learning by making science more interactive and relevant to real-world applications. Nwaeze et al (2016), in their study, noted that IPA not only create long lasting memory but also help instill in learners a sense of accountability, success, and maturity since they are ultimately in charge of every choice they make. Supporting the premise, Wabuke et al (2017) asserted that these methods in many cases create an immersive, hands-on learning environment that helps students draw connections between what they are learning in the classroom and real-world situations, promoting STEM (Science, Technology, Engineering and Mathematics) skills of creativity, problem-solving, cooperation, and critical thinking. In addition, Puranik (2020) claimed that when these cutting-edge teaching strategies are applied correctly, they provide links between theory and real-world applications that aid students in understanding course material, adjusting to technological changes in the environment, and solving challenging challenges. Summarizing these benefits, Oyelekan et al (2017) stated these practically oriented learning strategies help to reduce the emphasis on rote memorization of scientific concepts and principles, promote the acquisition of knowledge and skills, as well as improve students' acquisition of science process skills.

Science, in recent times, has been appraised as an essential tool for scientific and technological advancements owning to its recognition as the foundation for economic growth, societal health, and the overall development of nations. Nwuba et al (2023a) defined science as an organized body of information acquired via a scientific process of observation and experimentation, with the ultimate objective of comprehending the nature of the world and universe. In his study, Mankilik (2017) asserted that science is integral to a nation's knowledge base and economy, making it indispensable for both individual and societal progress. It is a catalyst for the development of any civilization as it transmits information, skills and values, promoting human capacity building that fosters, propels, and sets the tempo for technical innovation and national economic prosperity (Akanwa et al., 2019). Considering the premise, Udu (2018) summarized that education in science is paramount to survival as it equips students with the cognition and expertise necessary for advancement in science and technology, that drives innovation and economic growth.

In light of these benefits of science, and a drive towards achieving them, Oyelekan et al (2017) noted that competent and well-trained science teachers, who are well aware of the expectations placed on science education globally in instilling scientific and technological values in learners, are required. Udu (2018) stressed that these qualified and experienced teachers are expected to transform science instruction into an engaging activity and academic endeavor that can spark students' interest and encourage them to stick with science rather than giving up on it. Bolstering the premise, Nwuba et al. (2023a) stressed that it is essential that science classes be exciting and fun for students rather than a burden or a source of boredom, in order to maintain and grow their interest. Considering these benefits of science to man, nation and capacity building, there is need for teachers not only to be aware of pedagogical approaches for teaching science but also learn and know how to utilize them effectively in the classroom. In light of this backdrop, the study aimed to ascertain science teachers’ awareness and utilization of IPA for effective classroom delivery in a 21st century science classroom, in Anambra State, Nigeria.

Objectives of the Study

The primary goal of the study is to investigate innovative pedagogical approaches employed science teachers for classroom delivery in a 21st century classroom. Specifically, the study sought to identify innovative pedagogical approaches science teachers' are aware of for classroom delivery in a 21st century science classroom, determine innovative pedagogical approaches science teachers' utilize for classroom delivery in a 21st century science classroom, investigate the challenges mitigating against effective implementation of IPA in a 21st century science classroom, as well as proffer solutions to challenges encountered by science teachers' during implementation of IPA in a 21st century science classroom.

Theoretical Framework

This study is anchored on the Technological Pedagogical Content Knowledge (TPACK) framework, developed by Matthew J. Koehler and Punya Mishra in 2009. The TPACK framework posits that effective teaching, especially with the integration of technology, requires a blend of three core types of knowledge: technological knowledge, pedagogical knowledge, and content knowledge. It emphasizes the importance of understanding digital tools and technologies, teaching methods and practices, and the subject matter, as well as how these knowledge domains intersect and influence one another in the classroom.

By applying the TPACK framework, this study aimed to explore how the interplay between science teachers' knowledge of technology, pedagogy, and content influences their awareness and utilization of innovative pedagogical approaches. The framework provided a foundation for understanding the complex interactions between these areas and helped identify where teachers may need additional support or training to successfully integrate these methodologies into their educational practices.

Materials and Methods

Research Design

The study employed a descriptive survey research design, which is a widely accepted approach for gathering data from a large population to describe current conditions, practices, or attitudes (Nworgu, 2015). This design was chosen because it allows for the collection of detailed information from a representative sample of the population using structured questionnaires. The methodology is suitable for the study's objective of exploring science teachers' awareness and utilization of innovative pedagogical approaches.

Participants

The study population comprised all 1,516 science teachers (specializing in biology, chemistry, and physics) from the 263 public secondary schools in Anambra State, Nigeria, during the 2023/2024 academic year. The population was distributed across the six educational zones of the state: Aguata (294), Awka (382), Nnewi (288), Ogidi (247), Onitsha (163), and Otuocha (142). This population was carefully selected because these teachers play a crucial role in the application of innovative instructional strategies in science instruction.

Sample and Sampling Techniques

Due to the large population size, Taro Yamane's (1967) formula was used to calculate a sample size of 316 science teachers. Taro Yamane's formula was employed because it suits the research design adopted and also, because the population, and level of significance, of the study is known). To ensure the sample was representative of the population, a proportionate stratified random sampling technique was employed to determine the number of respondents expected from each of the six educational zones in the state: Aguata (61), Awka (80), Nnewi (60), Ogidi (51), Onitsha (34), and Otuocha (30). After stratification, a simple random sampling technique was applied to select the respondents from each school in the zones. This approach ensured that every science teacher had an equal chance of being included in the sample. The final sample included 131 biology teachers, 98 chemistry teachers, and 87 physics teachers, representing the diversity of science specializations.

Instrument for Data Collection

A 62-item structured questionnaire titled "Innovative Pedagogical Approaches for Classroom Delivery" (IPACD) was used to collect data. The IPACD was developed by the researchers based on their extensive classroom experiences, participation in seminars, conferences, workshops, and thorough literature reviews. IPACD comprised two sections:
Section A focused on the respondents' personal data, specifically their subject specialization.
Section B addressed the research questions with four distinct parts:

Research Question 1: A checklist of 20 items with two response options, Aware (A) and Not Aware (NA).
Research Question 2: The same checklist of 20 items, but with response options of Utilized (U) and Not Utilized (NU).
Research Questions 3 and 4: Five items each with a 4-point response options (Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD)).

Validation of Instrument

The structured questionnaire was subjected to face and content validation by three curriculum experts from Nnamdi Azikiwe University, Awka. The experts, specializing in Science Education, Educational Psychology, and Measurement and Evaluation, reviewed the instrument for appropriateness, coverage, clarity of language, and expression. Based on their feedback, the instrument was refined to ensure it accurately captured the necessary data.

Reliability of Instrument

The reliability of the questionnaire was tested through a pilot study involving 50 science teachers in Enugu State, Nigeria, which is a different location to avoid bias. The Cronbach Alpha technique was used to assess the internal consistency of the instrument, resulting in a reliability coefficient of 0.71. This value indicates that the instrument has a satisfactory level of reliability, making it suitable for the study. The choice of Cronbach Alpha formula was because the instrument was polychotomously scored (each response option has a score) and the instrument was administered once.

Data Collection

Data collection was conducted by the six researchers, each assigned to one of the six educational zones in the state (Anambra), under study. On visiting the sampled schools, an ethical letter seeking permission, to collect data from science teachers, was presented to the school principals, for approval. Once approval was given, the researchers visited the staff rooms, where they explained the purpose of the study and assured the respondents of the confidentiality of their responses. A face-to-face administration method was chosen to facilitate direct interaction, allowing researchers to clarify any items that the respondents might find difficult to understand, particularly regarding the innovative pedagogical approaches listed in the questionnaire.

Data Analysis

Data analysis was conducted using frequency counts, percentages, weighted mean, and standard deviation to address the research questions. These descriptive statistical tools were employed to help organize,

summarize and interpret the collected data, to give readers a clear understanding of information collected. Additionally, bar charts were also used to give a simple pictorial representation of the data collected. To test the null hypotheses, at 0.05 level of significance, Analysis of Variance (ANOVA) was employed. The researchers' choice of ANOVA for inferential statistics was because the study sought to compare the means of three groups, for significant difference. On decision making, the following criteria were adopted:
Research Questions 1 and 2: A response rate of 50% and above was categorized as "Aware (A)" or "Utilized (U)," while responses below 50% were categorized as "Not Aware (NA)" or "Not Utilized (NU)."
Research Questions 3 and 4: A mean score of 2.50 and above was considered "Agreed on (A)" by respondents, while a mean score below 2.50 was considered "Disagreed (D)."
Hypothesis Testing: The null hypothesis was rejected if the p-value was less than or equal to the alpha level of 0.05; otherwise, it was not rejected.

RESULTS AND DISCUSSIONS

Science Teachers' Awareness of IPA

Table 1: Frequencies and percentages of IPA science teachers are aware of for classroom delivery

S/N	Item	Aware		Not Aware		Decision
		F	%	F	%	
1	Competitive Instructional Approach	256	81.0	60	19.0	Aware
2	Computer Aided Instruction	301	95.3	15	4.7	Aware
3	Guided Inquiry Instructional Approach	316	100	0	0.0	Aware
4	Jigsaw cooperative Learning Method	199	63.0	117	37.0	Aware
5	Scaffolding Instructional Approach	204	64.6	112	35.4	Aware
6	Google Classroom	182	57.6	134	42.4	Aware
7	Use of Analogy approach	237	75	79	25	Aware
8	Individualized Instructional Approach	259	82	57	18	Aware
9	Think pair share Cooperative Approach	197	62.3	19	37.7	Aware
10	Generative learning method	94	29.7	222	70.3	Not Aware
11	Experiential Instructional Approach	174	55	142	45	Aware
12	Peer Teaching Instructional Approach	246	77.8	70	22.2	Aware
13	Z to A Instructional approach	74	23.4	242	76.6	Not Aware
14	Multimodal Learning	87	27.5	229	72.5	Not Aware
15	Gamification	94	29.7	222	70.3	Not Aware
16	Blended Learning	142	45	174	55	Not Aware
17	Flipped Classroom	124	39.2	192	60.8	Not Aware
18	Constructivist Instructional Approach	211	66.8	105	33.2	Aware
19	Cross Over Learning Strategy	81	25.6	235	74.4	Not Aware
20	Reflective Instructional Approach	54	17.1	262	82.9	Not Aware
21	Reciprocal Teaching Approach	145	45.9	171	54.1	Not Aware
22	Mind Mapping Instructional Approach	71	22.5	245	77.5	Not Aware
23	Conceptual Instructional Approach	195	61.7	121	38.3	Aware
24	Contextual Instructional Approach	143	45.3	173	54.7	Not Aware
25	Problem solving Instructional Approach	216	68.4	100	31.6	Aware

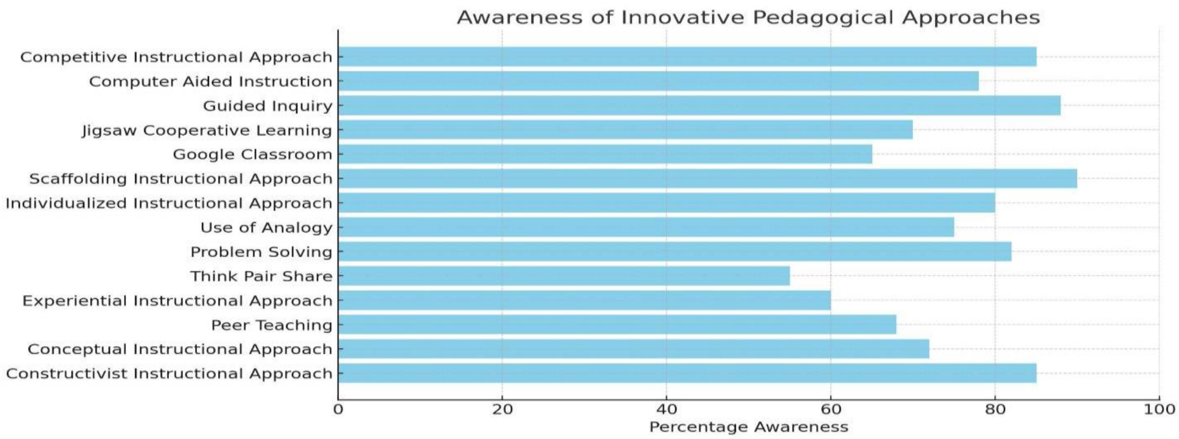

Figure I: Respondents Awareness of innovative pedagogical approaches

Table 1 and its bar chart shows that most teachers are aware of 14 out of the 25 innovative approaches identified, with particularly high awareness of approaches like scaffolding, competitive instruction, and guided inquiry. This awareness may be attributed to conferences, seminars, social media and E-learning platforms, teachers are exposed to.

Science Teachers' Utilization of IPA

Table 2: Frequency counts and percentages of IPA science teachers utilize for classroom delivery

S/N	Item	Utilized		Not Utilized		Decision
		F	%	F	%	
1	Competitive Instructional Approach	196	62	120	38	Utilized
2	Computer Aided Instruction	54	17.1	262	82.9	Not Utilized
3	Guided Inquiry Instructional Approach	284	89.9	32	10.1	Utilized
4	Jigsaw cooperative Learning Method	127	40.2	189	59.8	Not Utilized
5	Scaffolding Instructional Approach	174	55.1	142	44.9	Utilized
6	Google Classroom	2	0.6	314	99.4	Not Utilized
7	Use of Analogy approach	187	59.2	129	40.8	Utilized
8	Individualized Instructional Approach	210	66.5	106	33.5	Utilized
9	Think pair share Cooperative Approach	133	42.1	183	57.9	Not Utilized
10	Generative learning method	31	9.8	285	90.2	Not Utilized
11	Experiential Instructional Approach	124	39.2	192	60.7	Not Utilized
12	Peer Teaching Instructional Approach	210	66.5	106	33.5	Utilized
13	Z to A Instructional approach	21	6.6	295	93.4	Not Utilized
14	Multimodal Learning	14	4.4	302	95.6	Not Utilized
15	Gamification	5	1.6	311	98.4	Not Utilized
16	Blended Learning	64	20.3	252	79.7	Not Utilized
17	Flipped Classroom	46	14.6	270	85.4	Not Utilized
18	Constructivist Instructional Approach	103	32.6	213	67.4	Not Utilized

19	Cross Over Learning Strategy	36	11.4	280	88.6	Not Utilized
20	Reflective Instructional Approach	19	6	297	94	Not Utilized
21	Reciprocal Teaching Approach	94	29.7	222	70.3	Not Utilized
22	Mind Mapping Instructional Approach	45	14.2	271	85.8	Not Utilized
23	Conceptual Instructional Approach	150	47.5	166	52.5	Not Utilized
24	Contextual Instructional Approach	78	24.7	238	75.3	Not Utilized
25	Problem Solving Instructional Approach	196	62	120	38	Utilized

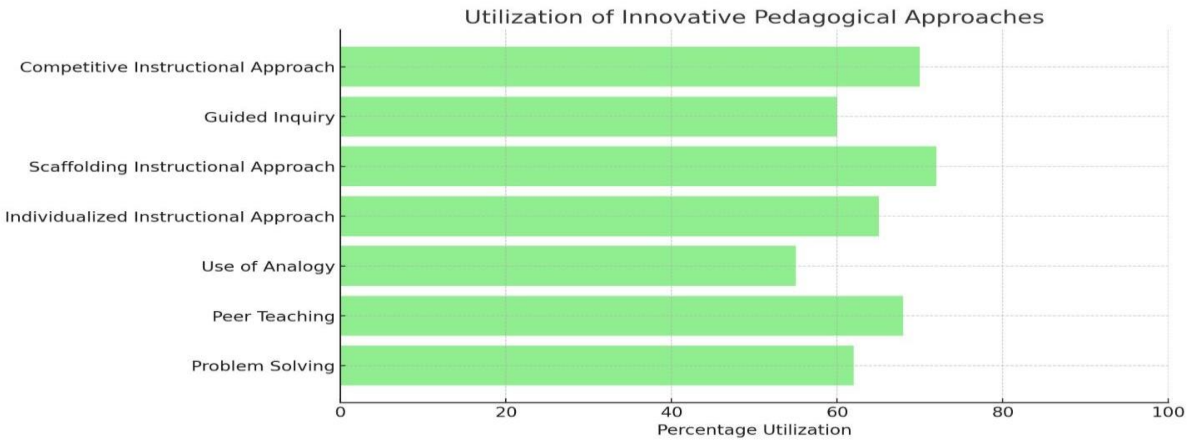

Figure II: Respondents utilization of innovative pedagogical approaches

The chart above highlights that fewer approaches are commonly utilized compared to those that teachers are aware of. This suggests a gap between awareness and practical application. This gap, in utilization, may be attributed to the nature of the approach, its implementation principles and requirements as well as the teachers' in-depth knowledge of the subject matter.

Challenges Mitigating against Science Teachers' Utilization of IPA

Table 3: Mean and standard deviation scores of the challenges to effective implementation of IPA in a 21st century science classroom

S/N	Item	Mean	SD	Decision
1	Limited time allotted to the science subject curriculum.	3.18	0.99	Agreed
2	Unavailability of equipped laboratories, technology and educational materials.	3.65	0.69	Agreed
3	Lack of Finance for technology driven learning	3.82	0.54	Agreed
4	Resistant to change due to familiarity with traditional teaching methods	3.06	1.08	Agreed
5	Teachers may require specialized training and professional development, to acquire skills and knowledge necessary, to effectively implement innovative pedagogical approaches.	3.44	0.81	Agreed
6	Teachers may face challenges in developing appropriate assessment strategies to evaluate student learning accurately.	2.81	1.02	Agreed

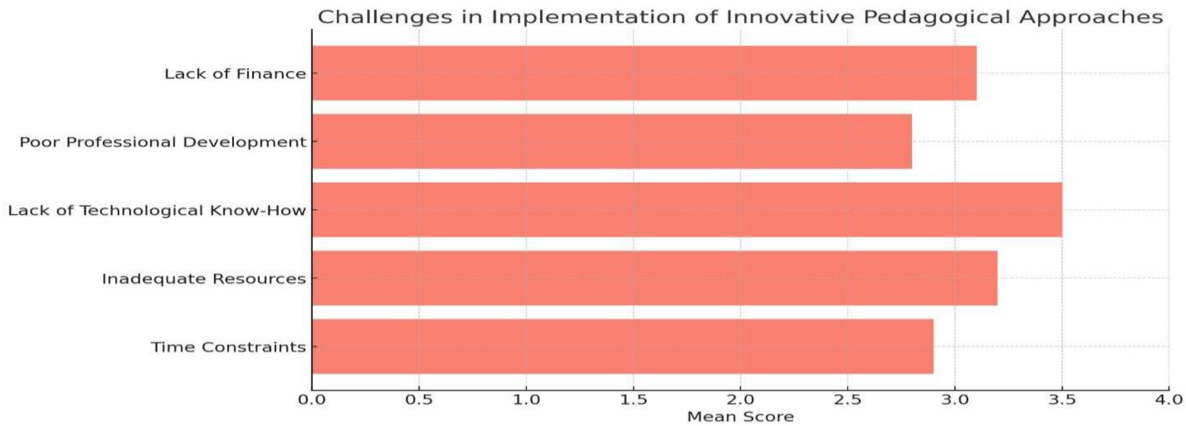

Figure III: Respondents challenges in implementation of innovative pedagogical approaches

The chart above demonstrates that lack of technological know-how and financial constraints are the most significant challenges teachers face in implementing innovative approaches.

Solutions to challenges encountered by science teachers' during implementation of IPA

Table 4: Mean and standard deviation scores of solutions to the challenges encountered by science teachers' in effective implementation of IPA in a 21st century science classroom

S/N	Item	Mean	SD	Decision
1	Sustainable and Increased funding should be provided by the government and education stakeholders for schools	3.58	0.62	Agreed
2	Adequate time should be allotted to science teaching	3.91	0.36	Agreed
3	Science teachers should be sponsored to conferences, seminars and workshops organized by professional bodies for acquisition of necessary skills and knowledge	3.72	0.53	Agreed
4	Incentives and motivators should be given to teachers who use innovative pedagogical approaches to encourage them and motivate others to key into the paradigm shift	3.89	0.36	Agreed
5	Government should provide educational technologies (ICT tools) and install them in the classrooms for frequent use by science teachers	3.90	0.40	Agreed
6	Curriculum planners should restructure the science subjects' curriculum to include activities and also recommend science texts that promotes the application of innovative pedagogical approaches	3.48	0.76	Agreed

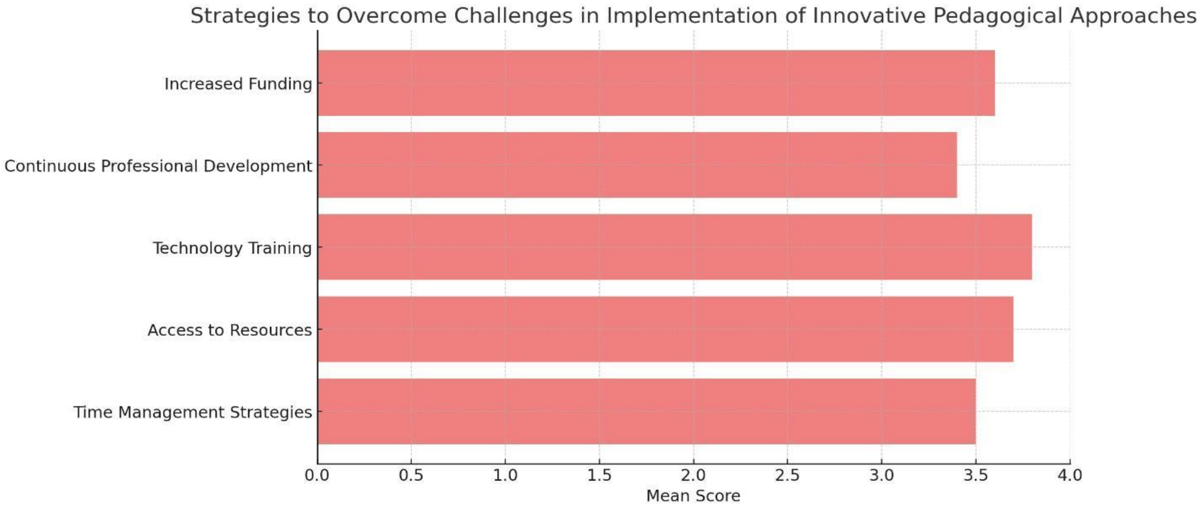

Figure IV: Respondents strategies to overcome challenges in implementation of IPA

This visualization indicates that strategies like technology training and continuous professional development are seen as effective solutions to the challenges identified.

Hypothesis One: No discernible difference exists among the average responses of biology, chemistry and physics teachers on their awareness of IPA for effective classroom delivery in a 21st century science classroom.

Table 5: ANOVA Test on Average Responses of Science Teachers' on Awareness of IPA for Effective Classroom Delivery

	Sum of Squares	Df	Mean Square	F	P-value	Decision
Between Groups	24.485	2	12.243	1.048	0.35	Not sig.
Within Groups	3657.123	313	11.684			
Total	3681.608	315				

Table 5 data analysis shows that at F-value of 1.048, 0.35 is recorded as P-value. Hence, the null hypothesis is not rejected, since the P-value is greater than 0.05 alpha levels at df of 2 and 313, indicating no discernible difference in the average responses of science (biology, chemistry and physics) teachers on their awareness of innovative pedagogical approaches

Hypothesis Two: No discernible difference exists among the average responses of biology, chemistry and physics teachers on their utilization of IPA for effective classroom delivery in a 21st century science classroom

Table 6: ANOVA Test on Average Responses of Science Teachers' on Utilization of IPA for Effective Classroom Delivery

	Sum of Squares	Df	Mean Square	F	P-value	Decision
Between Groups	29.146	2	14.573	2.855	0.06	Not Sig.
Within Groups	1597.791	313	5.105			
Total	1626.937	315				

Table 6 analysis reveals that at an F-value of 2.855, 0.06 P-value is obtained. Hence, the null hypothesis is not rejected, since the P-value is greater than 0.05 alpha levels at df of 2 and 313, indicating no discernible difference in the average responses of science (biology, chemistry and physics) teachers on their utilization of innovative pedagogical approaches.

Discussions

Science Teachers' Awareness of IPA in Teaching Science Subjects

The results reveal that science teachers are aware of only 14 out of the 25 listed innovative pedagogical approaches (IPA). These include methods such as competitive instructional approach, computer-aided instruction, guided inquiry, jigsaw cooperative learning method, Google Classroom, scaffolding instructional approach, individualized instructional approach, analogy approach, problem-solving method, think-pair-share, experiential instructional approach, peer teaching, conceptual instructional approach, and constructivist instructional approach. However, they are not aware of methods such as generative learning, multimodal learning, gamification, flipped classroom, Z-A approach, blended learning, crossover learning strategy, mind mapping, contextual approach, reciprocal approach, and reflective method. The null hypothesis, tested in table 5, confirmed no discernible difference in the awareness levels of biology, chemistry, and physics teachers regarding IPA. This finding implies that the level of awareness of IPA by science teachers across subject areas (biology, chemistry and physics) is the same.

The awareness of various IPA aligns with the TPACK framework's emphasis on integrating technological tools with pedagogical strategies and content knowledge. While the awareness of certain approaches (e.g., computer-aided instruction and Google Classroom) supports TPACK's integration of technology, the lack of awareness regarding other methods (e.g., gamification and flipped classroom) highlights potential gaps in teachers' understanding of how emerging technologies can enhance pedagogical practices. The findings support and extend the previous research of Obikezie et al (2022), Nwachukwu and Ile (2023) and Christian-Ike et al (2024) but however contrasts with Samba et al. (2010), who found significant differences in awareness levels among different science subjects. TPACK suggests that awareness alone is not sufficient; effective implementation requires a deeper understanding of how these pedagogical approaches can be integrated with content knowledge and technology.

Science Teachers' Utilization of IPA in Teaching Science Subjects

In terms of utilization, the results indicate that science teachers use only 7 out of the 14 IPA they are aware of. The most utilized methods include competitive instructional approach, guided inquiry, scaffolding instructional approach, individualized instructional approach, analogy approach, peer teaching, and problem-solving method. The hypothesis confirmed no discernible difference in the utilization levels of biology, chemistry, and physics teachers. This by implication means that students are probably still being exposed to most concepts in science using only 7 of the identified approaches. This would most definitely not be an effective way to teach some science concepts, particularly the abstract ones that are harder for students to understand.

The utilization patterns observed align with TPACK's focus on the practical integration of pedagogical methods and technology. The frequent use of certain methods (e.g., problem-solving and peer teaching) suggests that teachers are applying their pedagogical knowledge effectively but may lack comprehensive integration with advanced technological tools. This supports findings by Apochi and Okpaje (2022) and aligns with previous research (Obikezie et al., 2022; Oyeleka et al., 2017; Samba et al., 2010). TPACK emphasizes that effective integration requires not only the awareness but also the ability to blend content, pedagogy, and technology in practice.

Challenges and Prospects

The study identified several challenges hindering the effective utilization of IPA, such as limited time, inadequately equipped laboratories, insufficient materials, inappropriate assessment strategies, resistance to change, and limited access to training. Recommendations include increasing time for science instruction, restructuring the curriculum, providing resources, and offering professional development.

These challenges reflect issues in integrating TPACK components effectively. Limited resources and inadequate training highlight gaps in teachers' technological and pedagogical knowledge. Addressing these challenges aligns with TPACK's call for comprehensive support systems to enhance the integration of technology with pedagogy and content. The recommendations to provide resources and professional development echo TPACK's emphasis on continuous support for teachers to adapt and effectively utilize innovative approaches in their teaching practice. This aligns with similar suggestions by Aminu (2019), Nwachukwu and Ile (2023), Obikezie et al. (2022), and Udu (2018).

STUDY LIMITATIONS AND FUTURE RESEARCH

Despite its contributions, this study has several limitations. First, it was limited to government-owned secondary schools in Anambra State, which may not fully represent the situation in private schools or other regions. Additionally, the study relied on self-reported data, which could be subject to biases such as social desirability or recall bias. Thirdly, the study was delimited to only biology, chemistry and physics teachers, excluding other areas of science specializations (mathematics, Geography, Agriculture etc). Future research should consider including a broader range of schools and employing mixed methods, including classroom observations, to validate the findings. Furthermore, longitudinal studies could explore how science teachers' awareness and utilization of IPA evolve over time and how these changes impact student learning outcomes.

CONCLUSIONS AND RECOMMENDATIONS

This study explored science teachers' awareness and utilization of innovative pedagogical approaches (IPA) in Anambra State, Nigeria. It was found that while most science teachers are aware of some of the IPA identified in the study, a significant number of these approaches, they are aware of, are not utilized in the classroom due to challenges such as inadequate resources, lack of finances, insufficient teaching time, resistance to change, and limited knowledge of implementation. Recognizing the solutions agreed upon by the respondents, the following recommendations were made:

1. Profession bodies such as STAN (Science Teachers Association of Nigeria) in conjunction with the government should organize conferences, workshops and seminars for intensive in-service training of science teachers to get them acquainted with these innovative approaches as well as on how to effectively implement them during science lessons.
2. Curriculum planners and developers should consider reviewing and restructuring the science subjects' curriculum to include activities that advocates for the use of innovative pedagogical approaches as well as give detailed information on how to implement them.
3. In addition to providing sufficient funds, material resources, and a conducive learning environment to support the implementation of these innovative teaching methods, the government and other education stakeholders should also provide teachers with incentives to encourage them to adopt these unique techniques.
4. Teacher training institutions, such as colleges of education and universities, should ensure that science teachers in training are educated on how to use various innovative teaching strategies, during their preservice training programmes.

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