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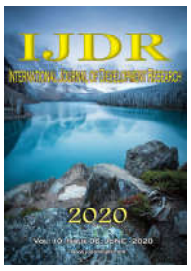

RESEARCH ARTICLE OPENACCESS

COGNITIVE AND AFFECTIVE STRATEGIES FOR THE CONSTRUCTION OF OPTIMAL LEARNING EXPERIENCES IN MODERN PHYSICS IN EBONYI STATE COLLEGE OF EDUCATION, IKWO

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ABSTRACT

This study was carried out to identify the cognitive and affective strategies for improving the teaching and learning of modern physics in Ebonyi State Colleges of Education, Ikwo in southeast Nigeria. Two research questions were developed in line with the purpose of the study. Two null hypotheses were formulated and tested at 0.05 level of significance. The study adopted descriptive survey design. The population of the study is 76 male and 57 female students of departments of physics and integrated science who offer courses in modern physics from the area of study. A sample of 20 male and 20 female students was drawn using simple random sampling technique. A two-cluster 11 item instrument termed "Teaching and Learning of Modern Physics Questionnaire" (TLMPQ) was used for data collection. The instrument was first validated by three experts and reliability was determined using Cronbach Alpha Statistics and the reliability value got was 0.82. The administration and retrieval of instrument were through direct contact and use of research assistants with the respondents. Data collected were analysed using mean and standard deviation for the research questions, while t-test statistics were used for testing the null hypotheses. The findings of the study revealed that all the items presented are the strategies for improving the teaching and learning of modern physics in Ebonyi State Colleges of Education, Ikwo in southeast Nigeria. Findings on the hypotheses tested revealed that there was no significant difference in the mean responses of male and female students of physics on all the items presented. Based on the findings of the study, it was recommended thatteachers and lecturers should adopt learner-centred pedagogical strategies in teaching modern physics by considering and implementing the hierarchical order of cognitive and affective domains of learning. This will not only reduce its abstract nature but make its study relevant to the needs of the society. Secondly, the necessary learning resources should be made available to both teachers and students.

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INTRODUCTION

The amount of knowledge that the student learned is a criterion and goal of effective teaching. These should be the most impressive words to be pre-existing in the mind of every teacher as stated by Ding, [1].When one studies contemporary science teaching theory, it makes one to become aware that it is not the only principle of teaching. In addition to the selection of instructional materials that meet the needs of students, and what the teacher imparts in the classroom, there are several other factors that can influence the students' development in learning, [2]. Among the most important are the teaching strategies, which should fit the teaching and learning environment. For example, most science courses, particularly introductory courses such as modern physicswhich is taught to intermediate level physics students in the country, always emphasizes discipline-centred or instructor-centred teaching, [2]. This means that the students have been exposed to great amounts of scientific information, formulas and concepts which may be unrelated and uninteresting. At the same time, the teacher could not focus on encouraging the students to learn by themselves; instead they rush to cover more and more information in the lessons.In essence, the teacher must now realise that students learn too little of what he teaches if he uses the conventional teaching methods such as teacher-centred, [2]. Therefore, the method of teaching and learning must be changed, and appropriate pedagogical strategies should be adopted for this change in line with the domains of learning.Unfortunately, modern physics is also a subject which most students traditionally find very abstract and difficult, and its teaching has not changed much since it was invented early 20th century, [3]. It is an area which has not, until recently, attracted much pedagogical research and it is timely that college and university teachers should be

investigating ways in which it might be taught more effectively. There are (at least) two difficulties facing such an investigation. First, the subject is shrouded in a highly mathematical formalism, and, though some textbook authors have sought to simplify the demands this makes on students, there is not yet consensus about how it might be taught less abstractly. Second, the subject is in a state of flux — questions of how the formalism should be interpreted are still discussed in the technical literature, [4].

Statement of the problem: Now in the general opinion, the measure of teaching is not the amount of knowledge the students learn from teachers but the learning skills which the students master, [1].Thus, science teaching requires more attention to the teaching and learning process of moving students from their initial state of knowledge and understanding to the desired level, rather than to the content of the course. In fact, studies show that students learn best if they are engaged in active learning. This is even more important in the teaching of highly abstract subjects like modern physics, [1]. Student-centred teaching is a teaching style more effective than others because it is more likely to motivate students by engaging their interest. It is important that in order to help students learn better, the teacher not only manages change, assessment for the future, curriculum design, training the students learning skills needed, but also developing the teaching techniques needed in the classroom, [1].However, studies show that the need for science education and direct reciprocal relationship between technology and science, in the sense that the share of technology through experiments and promoting the best evidence of the achievements of cognitive science, which the technology becomes available to the general population, [5]. This situation has precisely led the education policy makers around the world to the program-implemented curriculum developments in science teaching and learning in order to gain knowledge and skills useful in a wider context, and other sciences, as well as in everyday life [6, 7].In this article, pedagogy of teaching based on cognitive and affective domains of learning, efforts were made to determine suitable strategies and techniques for teaching modern physics to students in colleges of education in southeast Nigeria.

Purpose of the study:The main purpose of this study is to determine innovative strategies based on cognitive and affective domains of learning that could be appliedfor the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwoin southeast Nigeria.Specifically this study sought to determine if adoption of various hierarchies of the cognitive and affective domains of learning with appropriate teaching methodology would improve the learning of modern physics among students of Ebonyi State College of Education, Ikwo.

Scope of the Study:The content scope of this study is focused on finding innovative strategies based on cognitive and affective domains of learning for improving the teaching and learning of modern physics in the college of education. The study covers the students of Physics and Integrated Science departments of Ebonyi State College of Education, Ikwo who offer courses in modern physics.

Significance/Justification of the study:The findings of this study would reveal the possible things to do to improve the teaching and learning of modern physics in Ebonyi State Colleges of Education, Ikwo and other colleges of education in Nigeria. This will be achieved through the application of recommendations of this study. Achieving this feat through this study will make students' achievement in modern physics to improve for better as the highly abstract nature of subject contents would be highly reduced. This would go a long way improving the science and technology status of the country.The result of the study will be beneficial to the teachers and curriculum planners. This is in the area of helping them to develop a realizable educational goal in the subject.

Research Questions

The following research questions will guide the study:

1. What are the cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo?
2. What are the affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo?

Hypotheses

The following hypotheses will be tested at 0.05 level of significance:

1. Male and female students will not differ significantly in their mean ratings on cognitivestrategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo
2. Male and female students will not differ significantly in their mean ratings on affective strategies for strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

Literature Review

Modern physics is a division of the entire NCE level physics with a foundation of general physics knowledge. The content of this subject usually consists of two parts: quantum physics, and atomic and nuclear physics, [8]. It is full of information and concepts which may confuse the students. However, it is a useful course, especially for students in the 21st century who will develop and apply contemporary science and technology throughout their careers.

The characteristics of the learners and conventional teaching methods:When considering the learning beliefs and behaviours of our students, it may be that they are following the customs of the cultural environment rather than creating new rules, which may be the same when they are learning physics or other science discipline. People are familiar with the idea that 'knowledge can change one's destiny', but they usually don't know how to get the knowledge except from books or teachers. This is the result of a long term teacher-centred practice in the traditional education system, [1]. So, physics lessons, at the NCE level as well as universities in Nigeria, usually use a teaching approach based on a lecture format with a few laboratory activities restricted to verification of some physical laws. In fact, the students after graduation would transfer perceived methods and learned contents to classrooms when employed as teachers or lectures, and the recycling continues.

Consequently, in the 21st century, there is a growing dissatisfaction with the quality of physics teaching and learning. It called for physics teachers to have an in-depth knowledge of physics discipline. There must also be widespread changes of teaching strategies in order to promote the students enjoying the physics better. Namely, the teacher should 'transform himself/herself from being a "dispenser" of knowledge to being a "coach" managing the evolution of student skills' [9].In order to solve the specific teaching and learning problems, science teachers should first know what the students want to meet the society needs, and their career focus and what the teachers' responsibilities for the students are at present, [10].

It is pertinent according to Ding, [1] to know that physics students in the tertiary level may expect the following:

i. High-quality teaching with clear goals and outcomes.
ii. Better quality feedback and more appropriate assessment.
iii. Better computer-based resources to support their learning, less onerous workloads in some but not all units-of-study.
iv. Worthwhile, high-quality tutorials and laboratory classes.
v. Appropriate tasks that improve the students' ability to solve problems, interpret data, write reports and interact with others.
vi. Having identified the most important things students require during the process of learning, Ding [1] concludes that quality learning is most likely to happen when it is:
    (i) student-centred, because that is where the responsibility lies;
    (ii) cooperative in nature rather than competitive because people do not learn things best at the expense of others;
    (iii) a social act, shared with peers and validated by the whole learning environment, because learning is essentially a human activity.
vii. At the same time, Ding [1] also concluded that the teachers are responsible for the following:
    (i) the curriculum: what to be taught;
    (ii) the teaching strategies used: how it should be taught ; and
    (iii) the learning context.

The contemporary teaching strategies in modern physics

Ding, [1] identified the following important contemporary science teaching techniques to include:

i. Development of list and constructivist learning theories in science teaching and learning;
ii. Problem-based learning technique in science teaching and learning;
iii. Case study and contextual learning approaches in science;
iv. Group tasks and collaborative learning;
v. E-learning strategies and computer-based information searching method;
vi. Curriculum developments in contemporary science teaching and learning.

Undoubtedly, these teaching strategies when adopted in line with the various hierarchies of cognitive and affective domains of learning cannot only enhance the learning experience but also make the student become an active learner who has developed a range of learning skills, including lifelong learning skills, problem solving skills which are essential to physics, technical and cognitive skills and personal skills.Then since the contents and concepts in modern physicsare very abstract, boring and hard to learn, thestudents might lose interests even if they use a contemporarybut simple teaching method in the classroom. Therefore, itis important and efficient to combine several modernteaching approaches according to the basic principles ofmodern teaching methods, which is 'Quality teachingshould be aimed at promoting deep level processing ofinformation in the mind of the learner [11].

The challenges in teaching and learning modern physics

Teachers must think of how to make the students participate in the learning process, to think and learn more actively. However it is realistic enough to know that it is not going to be easy, no matter which strategy one applies in the future, because of a number of perceived difficulties. These difficulties include the following;

(i) Knowing the students and the teacher and students knowing each other.
(ii) In colleges of education in southeast Nigeria, the number of students studying physics is not large but are entangled with a large number of courses (GSE,Education,etc.), and moreover, different students have different needs. It is difficult for the teacher to be certain what the students want and what skills and attributes he wishes the students to have. The teacher should not therefore imagine that he can adopt the optimal strategies without considering the background of students' knowledge, the difference between learners and the analysis of the discipline in what he will teach, [12].
(iii) Therefore, no matter how difficult it is, the teacher still needs to think about it, because only once he knows what he wants to achieve and what skills he wants the students to have, can he address teaching strategies which might achieve this.
(iv) More real demonstration in the classroom.
(v) In order to help the students in conceptualising physics models and gaining the prospective abilities, the teacher should supply the students with appropriate pedagogical tools and hand-on demonstrations during the lectures or in the workshops. At present in colleges of education in Nigeria, it is difficult due to some widely recognised problems such as time of lecture, ability of teachers, shortage of equipment and limitation of discipline.

The Domains of learning

Cognitive Domain

The cognitive domain involves the development of the mental skills and the acquisition of knowledge. Bloom, Krathwohl and others, [13]identified and classified six categories under this domain to include:

1. Knowledge: the ability to recall data and/or information.
2. Comprehension: the ability to understand the meaning of what is known.
3. Application: the ability to utilize an abstraction or to use knowledge in a new situation.
4. Analysis: the ability to differentiate facts and opinions.
5. Synthesis: the ability to integrate different elements or concepts in order to form a sound pattern or structure so that a new meaning can be established.
6. Evaluation: the ability to come up with judgments about the importance of concepts.

Affective Domain

The affective domain involves our feelings, emotions and attitudes. This domain is categorized into five subdomains according to Bloom and Krathwohl, [14], and include following:

1. Receiving Phenomena: the awareness of feelings and emotions as well as the ability to utilize selected attention.
2. Responding to Phenomena: active participation of the learner.
3. Valuing: the ability to see the worth of something and express it.
4. Organization: ability to prioritize a value over another and create a unique value system.
5. Characterization: the ability to internalize values and let them control the person`s behaviour.

RESEARCH METHOD

Research Design:A cross-section descriptive survey research design is adopted for this study. This is used to study a sample of population at a single point in time. This design was adopted because according to Ezeh, [15] it enables the researcher to use reliable techniques to collect data from a well-defined population or systematically selected segments of a population for the purpose of determining the attributes of the population. Ezeh, [15]also explained that in survey research design, the purpose is usually to identify the characteristics of a defined population with respect to specific variables.

Population of the Study: The population is made up of133 students (76 males and 57 females) of both Physics and Integrated Science departments who offer some courses in modern physics.This population for the study comprised the entire first, second and third year students of Physics and Integrated Science departments in Ebonyi State College of Education, Ikwo in Southeast Nigeria

.

Sample and Sampling Techniques:The sample size of the study is 40 respondents comprising 20 male students and 20 female students representing 30% of the population.Purposive sampling technique was used with percentage to reduce the number of selection of the population.

Instrument for Data Collection:A questionnaire developed by the researcher from literature, consultation with stakeholders in education and personal observation based on the research questions and hypotheses was used for data collection. The instrument is titled "Teaching and Learning of Modern Physics Questionnaire" (TLMPQ).

Validation of the Instrument:The face and content validity of the instrument weredetermined. To ascertain this, the researcher presented copies of the questionnaire together with the topic and purpose of the study, research questions and hypotheses to three experts for validation. Their comments and suggestions guided the construction of the instrument.

Reliability of the Instrument:The reliability of the instrument was determined by administering copies of the questionnaire on some selected students of physics departments of Federal Colleges of Education in Obudu, Cross River state of Nigeria. The scores obtained from the respondents were collated to determine the internal consistency of the instrument in each section. This was done using Cronbach Alpha. The reliability co¬efficient of 0.70 and 0.72 were obtained for clusters 1 and 2 of the TLMPQrespectively. The overall mean coefficient of 0.71 was obtained for the instrument. In line with Nworgu, [16] who stated that if the co-efficient obtained in an instrument is up to 0.60 and above, the instrument should be considered good enough to be used for a study. Therefore, the instrument was deemed reliable. The choice of Cronbach Alpha is in line with Howith and Cranner, [17] who recommended Cronbach Alpha as a proper statistical tool for determining the internal consistency of an instrument for a descriptive survey. Internal consistency was measured because the instrument is homogenous in nature.

Method of Data Collection: The researcher together with the help of three research assistants administered the instrument directly to the respondents in the Ebonyi State Colleges of Education, Ikwoin southeast Nigeria. The research assistantswereproperly instructed on how to distribute and collect copies of the questionnaire from the respondents.

Method of Data Analysis:Mean scores and standard deviation were used to answer the research questions while t- test statistics were used to test the hypotheses at 0.05 level of significance. In analysing the data, mean ratings of 4 was regarded as Strongly Agree (SA), 3 for Agree (A), 2 for Disagree (D) and 1 for Strongly Disagree (SD). In analysing the data for the hypotheses, the t- test was used to test the hypotheses at the 0.05 level of significance.

PRESENTATION AND ANALYSIS OF DATA

Research Question 1

What are the cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo?

Table 1 is used to answer research question 1, which sought to find out the cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.The results on the table show that the items were all accepted as cognitive strategies because they all have mean values above 2.50 for both male and female student respondents.

Research Question 2

What are the affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo?

Table 1: Meanresponses on the cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

Responses		Males				Females			
S/N	Item Statement	ΣFX	Ẍ	SD	Decision	ΣFX	Ẍ	SD	Decision
1	Developing the ability to acquire knowledge of the various concepts in modern physics and being able to recall such information.	60	3.0	1.22	Accepted	62	3.1	1.27	Accepted
2	Developing the ability to comprehend (understand) the concepts in modern physics through both teacher and student-centred learning methods.	58	2.9	1.19	Accepted	62	3.1	1.27	Accepted
3	Developing the ability to utilize abstraction or to use knowledge in a new situation relating to the concepts in modern physics.	70	3.5	1.41	Accepted	66	3.3	1.37	Accepted
4	Developing analytical ability. The ability to differentiate facts and opinions as they relate to concepts in modern physics.	64	3.2	1.32	Accepted	66	3.3	1.37	Accepted
5	Developing the ability to integrate different elements or concepts of modern physics in order to form a sound pattern or structure so as to establish a new meaning.	60	3.0	1.22	Accepted	62	3.1	1.27	Accepted
6	Developing the ability of evaluation which involves creating a variety of ways of solving a problem and then with an established criteria the best solution method can be selected.	68	3.4	1.43	Accepted	62	3.1	1.27	Accepted

Table 2: Meanresponses on the affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo

Responses		Males				Females			
S/N	Item Statement	ΣFX	Ẍ	SD	Decision	ΣFX	Ẍ	SD	Decision
1	Developing the willingness, acceptance and necessary attention to the various stimulations associated with the concepts in modern physics.	64	3.0	1.22	Accepted	62	3.1	1.27	Accepted
2	Developing the desire for reaction to ideas, objects or system of values in relation to the learning of modern physics.	68	3.4	1.43	Accepted	64	3.2	1.32	Accepted
3	Developing the understanding of value of respect for a belief or a feeling of assumption attached to the learning of the concepts in modern physics.	64	3.2	1.32	Accepted	66	3.3	1.37	Accepted
4	Developing organizational ability to show interconnectedness between values there in the learning of modern physics and determine their existing relationship.	66	3.3	1.37	Accepted	62	3.1	1.27	Accepted
5	Developing characterization ability in which practical association with organizing and integrating the values is made into a personal value system.	70	3.5	1.41	Accepted	72	3.3	1.39	Accepted

Table 2 is used to answer the research question, which sought to find out theaffective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo. The results on the table show that the items were all accepted as the affective strategies. This is because they all have mean values above 2.50 for both male and female student respondents.

Hypotheses:

HO_1: There is no significant difference in the mean rating of the responses of male and female students on cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

The data for testing the hypothesis are presented in table 3.

The data presented in table 3 revealed that each of the 6 items in the table had calculated t-values less than the table value of 1.96 (two tailed test) at 0.05 significance and 39 degrees of freedom. This indicates that there is no significant difference in the mean ratings of the responses of the two groups of respondents (male and female students) oncognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo. With this result the null hypothesis of no significant difference was upheld for the 6 items.

HO_2: There is no significant difference in the mean rating of the responses of male and female studentsonaffective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

Table 3: T-test analysis of the responses of two groups of respondents (male and female students) on cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo

S/N	Item statement	Male students N = 20		Female students N = 20		t-cal	t-tab	Remark
		X_1	S_1^2	X_2	S_2^2	t-cal	t-tab	Remark
1	Developing the ability to acquire knowledge of the various concepts in modern physics and being able to recall such information.	3.0	1.50	3.1	1.61	-0.253	1.96	Not significant
2	Developing the ability to comprehend (understand) the concepts in modern physics through both teacher and student-centred learning methods.	2.9	1.41	3.1	1.61	-0.515	1.96	Not significant
3	Developing the ability to utilize abstraction or to use knowledge in a new situation relating to the concepts in modern physics.	3.5	2.00	3.3	1.89	0.453	1.96	Not significant
4	Developing analytical ability. The ability to differentiate facts and opinions as they relate to concepts in modern physics.	3.2	1.74	3.3	1.89	-0.235	1.96	Not significant
5	Developing the ability to integrate different elements or concepts of modern physics in order to form a sound pattern or structure so as to establish a new meaning.	3.0	1.50	3.1	1.61	-0.253	1.96	Not significant
6	Developing the ability of evaluation which involves creating a variety of ways of solving a problem and then with an established criteria the best solution method can be selected.	3.4	2.06	3.1	1.61	0.700	1.96	Not significant

df = 39

Table 4: T-test analysis of the responses of two groups of respondents (male and female students) on affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

S/N	Item statement	Male students N = 20		Female students N = 20		t-cal	t-tab	Remark
		X_1	S_1^2	X_2	S_2^2	t-cal	t-tab	Remark
1	Developing the willingness, acceptance and necessary attention to the various stimulations associated with the concepts in modern physics.	3.0	1.50	3.1	1.61	-0.159	1.96	Not significant
2	Developing the desire for reaction to ideas, objects or system of values in relation to the learning of modern physics.	3.4	2.04	3.2	1.74	0.460	1.96	Not significant
3	Developing the understanding of value of respect for a belief or a feeling of assumption attached to the learning of the concepts in modern physics.	3.2	1.74	3.3	1.88	-0.425	1.96	Not significant
4	Developing organizational ability to show interconnectedness between values there in the learning of modern physics and determine their existing relationship.	3.3	1.88	3.1	1.61	0.479	1.96	Not significant
5	Developing characterization ability in which practical association with organizing and integrating the values is made into a personal value system.	3.5	1.99	3.3	1.93	0.451	1.96	Not significant

df = 39

The data for testing the hypothesis are presented in table 4.

The data presented in table 4 show that each of the 5 items in the table had calculated t-values less than the table value of 1.96 (two tailed test) at 0.05 significance and 39 degrees of freedom. This indicates that there is no significant difference in the mean ratings of the responses of the two groups of respondents (male and female students) onaffective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.With this result the null hypothesis of no significant difference was upheld for the 5 items.

Finding of the study

Cluster 1: The cognitive strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.The respondents agreed that for there to be optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo, the following cognitive strategies shall be adopted.

1. Developing the ability to acquire knowledge of the various concepts in modern physics and being able to recall such information.

2. Developing the ability to comprehend (understand) the concepts in modern physics through both teacher and student-centred learning methods.
3. Developing the ability to utilize abstraction or to use knowledge in a new situation relating to the concepts in modern physics.
4. Developing analytical ability. This is the ability to differentiate facts and opinions as they relate to concepts in modern physics.
5. Developing the ability to integrate different elements or concepts of modern physics in order to form a sound pattern or structure so as to establish a new meaning.
6. Developing the ability of evaluation which involves creating a variety of ways of solving a problem and then with an established criteria the best solution method can be selected.

Cluster 2: The affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo.The respondents agreed that for there to be optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo, the following affective strategies shall be adopted.

1. Developing the willingness, acceptance and necessary attention to the various stimulations associated with the concepts in modern physics.
2. Developing the desire for reaction to ideas, objects or system of values in relation to the learning of modern physics.
3. Developing the understanding of value of respect for a belief or a feeling of assumption attached to the learning of the concepts in modern physics.
4. Developing organizational ability to show interconnectedness between values there in the learning of modern physics and determine their existing relationship.
5. Developing characterization ability in which practical association with organizing and integrating the values is made into a personal value system.

Findings on Hypotheses

The findings on the hypotheses tested showed that there is no significant difference in the mean ratings on the responses of male and female students on the two hypotheses tested with the corresponding items which are cognitive and affective strategies for the construction of optimal learning experiences in modern physics in Ebonyi State College of Education, Ikwo. This implies that both male and female students agreed that all the listed cognitive and affective strategies if adopted, there will be the construction of optimal teaching and learning experiences in modern physics in Ebonyi State College of Education, Ikwo.

Conclusion

Modern physics is an area of physics which is, above all others, of immense importance in modern technology - lasers, transistors and semiconductors are but a few applications. Students who are studying physics for professional reasons need to know this subject well, [4].However, the concepts involved in it are complex and counter-intuitive. They need a lot of time and reflection to be absorbed properly. Therefore it would be desirable for students to meet these ideas early in their career, even in high school if possible. Unfortunately, modern physics is also a subject which most students traditionally find very abstract and difficult, and its teaching has not changed much since it was invented early this century, [6].It is an area which has not, until recently, attracted much pedagogical research and it is timely that university teachers should be investigating ways in which it might be taught more effectively. There are (at least) two difficulties facing such an investigation. First, the subject is shrouded in a highly mathematical formalism, and, though some textbook authors have sought to simplify the demands this makes on students, there is not yet consensus about how it might be taught less abstractly. Second, the subject is in a state of flux-questions of how the formalism should be interpreted are still discussed in the technical literature. The project reported here proposes a line of enquiry that seeks to answer two fundamental questions.

(i) Is it possible to identify the most important concepts that students need to understand in order to learn quantum mechanics 'successfully'?
(ii) What is it about the way students conceptualize the ideas of quantum mechanics which makes them particularly 'difficult'?

To make students choose and progress in this subject and put the nation on a path of sustainable scientific and technological development there is the need to adopt the identified cognitive and affective strategies in this study. This if addressed by the relevant stakeholders could enhance a better understanding of the subject. The study therefore made the following contributions to knowledge;

(i) It has provided information to the stakeholders in physics education on strategies to adopt to reduce the abstract nature of modern physics and enhance its teaching and learning in colleges and other tertiary institutions.
(ii) The study provided information to the curriculum planners on how to redesign the modern physics curriculum to become more relevant to the needs of the society.
(iii) The study also provided information to the school administrators and other stakeholders in education sector on the need to train teachers to adopt relevant strategies in teaching abstract subjects.

Limitations of the Study

Limitation in this context means any area not covered by the study but still considered important for the quality and effective teaching of practical physics in Nigeria. They are:

(i) Identification of material resources required for teaching and learning of modern physics.
(ii) Curriculum reforms to enhance the teaching and learning of highly abstract subjects like modern physics.
(iii) Improving the teachers' competence in teaching highly abstract subjects like modern physics through appropriate trainings.

Recommendations for Improvement

Based on the findings of the study, the following recommendations are made.

(i) Teachers and lecturers should adopt learner-centred pedagogical strategies in teaching modern physics by considering and implementing the hierarchical order of cognitive and affective domains of learning. This will not only reduce its abstract nature but make its study relevant to the needs of the society.

(ii) The necessary learning resources should made available to both teachers and students.

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