



## Effect of Metaconceptual Teaching Approach on Students' Academic Achievement and Interest in Quantum Physics in Enugu Education Zone

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### Abstract

This study investigated the effect of meta-conceptual teaching approach on students' academic achievement and interest in secondary school Physics in Enugu Education Zone. Four research questions and six null hypotheses guided the study. The design was Quasi-Experimental. The population for the study was 3,916 SS2 Physics students in the Zone. Purposive sampling and random sampling were used to select 60 students. The experimental group was taught using a meta-conceptual teaching approach while the control group was taught using the conventional method. The instrument for data collection were 50 Physics Achievement Test (PAT) and Physics Interest Scale (PIS) which were validated by three experts and tested for reliability using Kuder-Richardson's formula-20 and Cronbach alpha which yielded coefficients 0.87 and 0.86 respectively. The data were analyzed using mean, standard deviation, and Analysis of Covariance. The results showed that students in the meta-conceptual teaching approach achieved better than their counterparts. It was recommended that physics teachers incorporate a meta-conceptual teaching approach in teaching.

**Keywords:** Meta-conceptual teaching approach, Academic achievement, Interest, Quantum Physics.

### Introduction

Science education embodies all educational processes aimed at providing unlimited opportunities for learners to understand and utilize the necessary knowledge, skills and attitudes required to operate effectively in a scientific and technological society. Science education is an integral field of study which considers both the subject matter of science discipline such as Biology, Chemistry, Physics, Agriculture, and so on, as well as the process involved in the teaching and learning of science (Okeke, 2014). It is in the attainment of this goal of science education that we hope to produce the required large pool of experts in science and technology, which will help to bring about the much-needed socio-economic development of a nation. These experts can only be produced through a well-organized and efficient science and technology education. Physics education is an aspect of Science Education that deals with the teaching and learning of physical properties of matter in relation to its energy.

Physics is the most fundamental and the root of every field of science (Eryilmaz, 2016). Anyakoha (2016) defined physics as a natural science that involves the study of matter and energy and their interactions. Physics is the study of the natural phenomenon at its most fundamental levels and manner. This is because, physics, being one of the core subjects offered in Nigerian schools forms the

basis for the nation's technological advancement and human resource development (Abubakar, 2012). Physics knowledge has contributed immensely to the production of tools and devices of tremendous advantage to the human race (Sani, 2012). The knowledge of physics according to Udo (2012) offers the learners the opportunity to think critically, reason analytically and acquire the spirit of enquiry. The researcher also stressed that the knowledge of physics develops in students, the scientific and technological knowledge, skills and attitudes which will assist them to make decisions based on the observation and experimentation. Quantum Physics, Geophysics, Medical Physics, Computing Physics, Material Physics, Environmental Physics, Communication, Physics Education, Engineering and Industrial Physics to list but a few are career courses in institutions of higher learning which cannot be undertaken without the knowledge of physics at secondary school level.

Physics is divided into two broad categories: Classical Physics and Modern Physics. Classical physics is the branch of physics that studies the mechanism of a particle of length greater than  $10^{-6}\text{m}$  while Quantum physics is the branch of physics that studies the mechanisms of a particle less than a length of  $10^{-6}\text{m}$  (Okoli, 2019). Quantum Physics is the study of matter and energy at the most fundamental level. Quantum Physics is required to uncover the



properties and behaviours of every building block of nature. Quantum Physics examines very small objects such as electrons and photons. These electrons and photons are all around us acting on every scale. The branches of quantum physics include uncertainty principle, wave-particle duality, energy levels, and the photoelectric effect. The discovery of Quantum Physics led to the discoveries of valuable resources like computers, lasers, transistors etc.

Interestingly, as important as physics is, students' academic achievement and interest in the subject at secondary school and institution of higher learning has not been encouraging. In Nigeria, there has been recurring unacceptable attainment of students in physics. Record of students' performance at Senior School Certificate Examination (SSCE) in physics conducted by West African Examination Council (WAEC) according to Adolphous (2018) shows that between 2001 and 2009 (except in 2006), less than 50% of the students who enrolled for physics obtained credit level pass and above to secure admission into the university in order to pursue courses that require physics. The researcher also stressed that the failure rate continued from 2007 to 2009 (42.9%, 47.1% and 46.2%) and in 2013 (46%) with an improved achievement in 2010, 2011 and 2012 (50.2%, 62.6% and 67.2%). The failure trends continued in 2015, 2017; and 2020 (47.83%, 41% & 36% respectively) with an improved achievement in 2016, 2018; and 2019 (71%, 87% & 80% respectively). In general, this cannot be considered an acceptable achievement as many have lamented that the achievement of Nigerian students in physics at the Senior School Certificate Examination (SSCE) has been generally not so good (Adaramola & Obomanu, 2011; FME, 2009). Even the WEAC chief examiner's report in physics specifies areas of students' weakness and the way forward to better achievement in the subject. They stated that many students cannot properly draw physics diagrams, give correct definitions of some concepts or solve some problems, using mnemonics to master some physics equations. The Chief examiners also reported that there are challenges in Nigerian students' understanding of concepts such as wave-particle duality of photons. They opined that the wave-particle duality was poorly understood among upper secondary students in Nigeria, and some students demonstrated misconceptions rooted in a classical physics worldview. They suggested as well that teachers should teach students rules guiding physics diagrams

and should provide teaching aids and models to help students understand physics concepts.

The students' poor achievement in physics in particular and sciences, in general, has been attributed to many factors. These include; poor methods of physics instruction by the teachers, insufficient number of qualified physics teachers, lack of indigenous textbooks, inadequate apparatus in the physics laboratory, poor classroom management by physics teachers, teacher's belief and attitude towards physics, physics teacher's inability to improvise, inadequate instructional materials and aids, educational background and parental expectations on the learners and finally students' related-factors or variables like students' academic anxiety, academic self-efficacy, academic locus of control, academic motivation and more ( Adedayo & Jegede, 2013). This study therefore, is set to find out the effect of the meta-conceptual teaching approach on students' academic achievement and interest in physics.

Meta-conceptual is derived from a Greek word meaning "beyond comprehension". Metaconceptual Teaching Approach (MTA) according to Nwankwo, Achufusi and Offiah (2019) is a metacognitive knowledge and processes that are acting on and related to one's conceptual system that enables the learner to conceptually understand the concepts taught. The metaconceptual teaching approach was first suggested by Thorley (1990); though it was Yuruk (2005) who used the approach first to test run its efficacy. MTA involves Practices designed to facilitate students' engagement in Metaconceptual Knowledge (MK), Metaconceptual Awareness (MA), Metaconceptual Monitoring (MM) and Metaconceptual Evaluation (ME) and Metaconceptual Application (MAP) (Yuruk, 2007 in Nwankwo, Achufusi and Offiah, 2019). Metaconceptual Knowledge is one's stable knowledge about concept learning and factors influencing concept formation and acquisition; Meta-conceptual Awareness is one's awareness of and reflection on existing and past concepts, one's interpretation of experiences, ontological and epistemological presuppositions and the context in which a concept is used; Metaconceptual Monitoring involves processes that generate information about one's cognitive state or thinking process and Metaconceptual Evaluation deals with making judgmental decisions about the validity of competing conceptions. Metaconceptual Application deals with the application of the concepts that are well



articulated into reality. These include such practices as poster drawings, journal writing, class and group discussions as well as quantitative problem-solving (Nwankwo, Achufusi and Offiah (2019). These processes demand learners to engage in higher level of thinking about the concepts taught. These practices are designed to help students to understand and have a full grasp of the scientific concepts taught and therefore register improved academic achievement.

Interest is the kind of awareness inclination for understanding the world and acquiring cultural and scientific knowledge (Eze, 2016). As students are interested in a certain field, they may pay special attention to it, observing carefully, memorizing well and thinking actively. Only by arousing students' interest in learning physics can we enhance students' enthusiasm for learning physics; help them master physics conceptual knowledge and techniques better, and form the scientific spirit and attitude. Therefore, physics teachers should try to identify a teaching method that can motivate or arouse students' interest, (Zengyan & Chem, 2012).

Gender has been noted by researchers over the years as having an impact on achievement in Physics and its related disciplines (Akumah, 2013). Longe and Adedeji (2003) even stressed that science, technology, and their related disciplines are male-reserved while Art and Humanities are female reserved. This belief makes boys appear to have a naturally positive attitude towards science and technical subjects while girls show more inclination to Arts and Humanities. The problem is even compounded by the fact that most science educators give a masculine outlook to science subjects such as chemistry and physics (Babajide, 2010); encouraging females to go rather for biology, agricultural science and home economics which they consider to be more female-friendly science subjects. Some other researchers (Nwankwo & Okoye, 2015; Orefor, 2016) opined that gender has no influence on students' achievement in the sciences. All these and related treatments make girls have phobia for science and science-related subjects which definitely affect their future career-choice and eventual achievement. Due to lack of consensus regarding the issue of gender and science and more importantly to capture the interest of girls, and consequently improve their achievement in physics and other science-related carriers, there is a need therefore, to try such innovative strategy as meta-conceptual teaching approach to see what effect

it will have on achievement and interest of male and female students in the sciences especially Physics.

### Statement of the Problem

In Nigeria, emphasis has been placed on secondary school students' academic achievement and interest because of its direct positive impact on national development. Young students in secondary schools today are expected to be leaders of tomorrow and the quality of manpower the nation can boast of in the future. Also, students' academic achievement is a measure for gaining admission into institutions of higher learning. More so, students advance in the understanding of quantum physics leads directly to the development of new products such as televisions, computers, domestic appliances, and nuclear weapons that have dramatically transformed modern-day society. Advances in quantum physics led to the development of industrialization and advances in mechanics inspired the development of calculus. Physics thus makes significant contributions through advances in new technologies that arise from theoretical breakthrough. In view of the positivisms of physics to mankind, many researchers in recent time are interested in the factors affecting academic achievement and interest in physics in particular and sciences in general with a view to finding solutions to the problems of poor academic achievement and interest. Studies on students' academic achievement and interest have mostly pointed out that effective and innovative teaching approaches are the major variable that enhances academic achievement and interest, yet they have received very little attention if any, in the literature of Enugu Education Zone. In view of the on-going, the present study identifies meta-conceptual teaching approach whose effects on academic achievement and interest have not been so much reported in the literature of Enugu Education Zone and hence deemed it very important to find out the Effect of meta-conceptual teaching approach on students' academic achievement and interest in quantum physics students in the Zone.

### Purpose of the Study

The main purpose of the study is to investigate the effect of metaconceptual approach on students' academic achievement and interest in quantum physics in Enugu Education Zone of Enugu State. Specifically, the study seeks to find the:

1. Difference between the mean achievement scores of students taught quantum physics

using metaconceptual approach and that of those taught using conventional method.

2. Difference between the mean interest scores of students taught quantum physics using metaconceptual approach and that of those taught using conventional approach.
3. Difference between the mean achievement scores of male and female students taught quantum physics using metaconceptual approach and those taught using conventional teaching approach.
4. Difference between the mean interest scores of male and female students taught quantum physics using metaconceptual approach and those taught using conventional teaching approach.
5. Interaction effect of teaching approaches and gender on students' achievement in quantum physics.
6. Interaction effect of teaching approaches and gender on students' interest in quantum physics.

### Research Questions

The following research questions were designed to guide the study

1. What is the difference in the pretest and posttest mean achievement scores of physics students taught using metaconceptual approach and those taught using conventional instructional approach?
2. What is the difference in mean interest scores of physics students taught using metaconceptual approach and those taught using conventional instructional approach?
3. What is the difference in the mean achievement scores of male and female students taught Physics using metaconceptual approach and those taught using conventional teaching approach?
4. What is the difference in the mean interest scores of male and female students taught Physics using metaconceptual approach and those taught using conventional teaching approach?

### Hypotheses

The following null hypotheses were formulated for the study; which which was tested at 0.05 level of significance

1. There is no significant difference in the pretest and posttest mean achievement scores of physics students taught quantum physics using metaconceptual approach and those taught using conventional approach as a method of teaching.
2. There is no significant difference in the mean interest scores of physics students taught quantum physics with metaconceptual approach and those taught using conventional approach.
3. There is no significant difference in the mean achievement score of male and female students taught quantum physics using metaconceptual approach and those taught using conventional approach.
4. There is no significant difference in the mean interest score of male and female students taught quantum physics using metaconceptual approach and those taught using conventional approach.
5. There is no significant interaction effect of gender and teaching methods on students mean achievement scores in physics.
6. There is no significant interaction effect on gender and teaching methods on students mean interest score in physics.

### Method

A pretest-posttest quasi-experimental research design, specifically non-equivalent control groups design was used for the study. Sixty (60) SS 2 physics students (31 males & 29 females) drawn through a purposive sampling approach from which two co-educational secondary schools in Enugu North Local Government Area of Enugu State were used for the study. In stage one, simple random sampling technique was used to select Enugu North Local Government Area. In second stage, purposive sampling was used to select two co-educational schools in the local government area based on the existence in those schools of well-equipped physics laboratories and experienced physics teachers with teaching qualification. Simple random sampling technique (precisely balloting) was next used to assign experimental and control treatments to the schools. The technique was used so as to provide classes where boys and girls work



together under the same classroom environment. Intact classes were used in the sampled schools so as not to disrupt the normal school activities. Four weeks were used for the experiment. Each week had two periods (double periods each) of 40 minutes per period. The control group was taught using the conventional method which involves content-rich activities such as demonstrations, lecture, experiments and quantitative problem-solving which does not involve the students in metaconceptual processes. For the experimental class, the same set of activities for the control group was carried out for both double periods; but in addition to discussing and writing down their observations, students were engaged in such meta-conceptual activities as:

- a) Mind Maps: Mind mapping is a visual technique that enables students to express their ideas and share their knowledge freely. This helps the students to link what they already know to what is been taught.
- b) Poster production which helped students to engage in meta-conceptual awareness and monitoring.
- c) Conceptual Change Texts: In conceptual change texts, firstly students are given the misconceptions related to the subject and then they are scientifically explained why those misconceptions are wrong. This helps the students to dissociate the alternative conception from correct information.
- d) Journal writing in which students kept record of their observations as well as what they understood all through the process of any group-based activity.

e) Group discussions where students were arranged in groups of 3-4 members to discuss their ideas about a given situation; like why our cell phones unlock its screen when brought close to our faces.

f) Class discussions: Class discussions were constantly held especially after each group-based activity.

The instrument used for data collection was the Physics Achievement Test (PAT) adopted from WAEC past Questions between 2015-2020 comprised 50 multiple-choice items with four options and Physics Interest Scale (PIS) adopted from Okafor (2020). The instruments were face and content validated by three experts and tested for reliability using Kuder Richardson 20 (KR-20) and Cronbach Alpha which yielded a coefficient of 0.87 and 0.86 respectively. The instrument was first administered as a pre-test, scored and kept without any feedback to the students. After the treatment, the same test with the same contents was reshuffled and given as a post-test. Both tests were scored by the researcher to avoid bias. The results obtained were used for analysis. Research questions were answered using mean and standard deviation (SD) while the hypothesis was tested using ANCOVA.

### Results

Answer research questions and hypotheses are presented in table below

**Table 1: Mean and Standard deviation of achievement scores of students taught Quantum Physics using meta-conceptual teaching approach and those taught using the conventional approach**

Teaching Method	N	Pre-test		Post-test		$(\bar{x})$ gain
		$(\bar{x})$	SD	$(\bar{x})$	SD	
Meta-conceptual teaching Approach	30	26.13	13.88	63.73	14.48	37.60
Conventional method	30	25.60	10.31	36.00	11.50	11.40

Table 1 shows the pretest and posttest mean achievement scores of students taught Quantum Physics using meta-conceptual teaching approach were 26.13 and 63.73 while the gain in mean score was 37.60. Their counterpart taught using the conventional approach, on the other hand, had 25.60, 36.00 and 10.40 as pre-test, post-test and gain in mean scores respectively. This shows a 27.20 difference in gain in mean scores between the two

groups in favor of the students taught with meta-conceptual teaching approach. The result also shows a remarkable difference in mean gain scores between students taught quantum physics using meta-conceptual teaching approach. These students had higher post-test mean achievement score and greater gain in mean score in achievement than students taught using conventional approach.

**Table 2: Mean and Standard deviation of interest scores of students taught quantum physics using meta-conceptual teaching approach and those taught using conventional approach**

Teaching Method	N	Pre-test		Post-test		$\bar{(x)}$ gain
		$\bar{(x)}$	SD	$\bar{(x)}$	SD	
Meta-conceptual teaching Approach	30	45.00	14.42	68.80	8.57	23.00
Conventional method	30	46.20	10.41	56.00	9.190	7.80

Table 2 shows the pretest and posttest mean interest scores of students taught quantum physics using meta-conceptual teaching approach were 45.00 and 68.00 while the gain in mean score was 23.00. Their counterpart taught using conventional approach, on the other hand, had 46.20, 56.00 and 9.80 as pretest, posttest and gain in mean scores respectively. This shows a 13.20 difference in gain in mean scores between the two groups in favor of the students taught with meta-conceptual teaching approach. The result also shows a remarkable difference in mean gain scores between students taught quantum physics using meta-conceptual teaching approach. These students had higher posttest mean interest scores and greater gain in mean score in interest scores than students taught using the conventional approach.

**Table 3: Mean and Standard deviation of achievement scores of male and female students taught quantum physics using meta-conceptual teaching approach and those taught using conventional teaching approach**

Gender	N	Pre-test		Post-test		$\bar{(x)}$ gain
		$\bar{(x)}$	SD	$\bar{(x)}$	SD	
Male	31	25.16	9.53	50.19	16.68	25.03
Female	29	26.62	14.90	49.52	21.74	22.90

Table 3 shows the pretest and posttest mean achievement scores of male students (25.16 and

50.19) and their female counterpart (26.62 and 49.52) taught quantum physics using meta-conceptual teaching approach and those taught using conventional teaching approach. The gain in mean score for male students was 25.03 while that of the female counterpart was 22.90. This indicates a mean difference of 2.13 in favor of the male students.

**Table 4: Mean and Standard deviation of interest scores of male and female students taught quantum physics using meta-conceptual teaching approach and those taught using conventional teaching approach**

Gender	N	Pre-test		Post-test		$\bar{(x)}$ gain
		$\bar{(x)}$	SD	$\bar{(x)}$	SD	
Male	31	45.71	12.51	63.74	9.50	18.03
Female	29	45.48	12.67	60.14	11.71	14.66

Table 4 shows the pretest and posttest mean interest scores of male students (45.71 and 63.74) and their female counterpart (45.48 and 60.14) taught quantum physics using meta-conceptual teaching approach and those taught using conventional teaching approach. The gain in mean score for male students was 18.03 while that of the female counterpart was 14.66. This indicates a mean difference of 3.37 in favor of the male students

**Table 5: Summary of Analysis of Covariance of effect of meta-conceptual teaching approach on students' achievement in quantum physics by Treatment and Gender**

Dependent Variable: posttest						
Type II Sum of						
Source	Squares	df	Mean Square	F	Sig.	
Corrected Model	11889.530 <sup>a</sup>	4	2972.3983	16.865	.000	
Intercept	21712.171	1	21712.171	123.194	.000	
Pretest	350.321	1	350.321	1.988	.164	
Approach	11421.870	1	11421.870	64.807	.000	
Gender	.029	1	.029	.000	.990	
Interaction	.403	1	.403	.002	.962	
Error	9693.403	55	176.244			
Total	170784.000	60				

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Corrected Total	21582.933	59
a. R Squared = .551 (Adjusted R Squared = .518)		

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Table 5 shows that at .05 level of significance, there was a significant main effect of the teaching method on students' academic achievement in Physics,  $F(1, 55) = 64.807, P(.000) < .05$ . Therefore, the null hypothesis was rejected. Thus, there is significant

difference in mean achievement scores of students taught Quantum Physics using meta-conceptual teaching approach and those taught using conventional teaching approach.

**Table 6: Summary of Analysis of Covariance of effect of meta-conceptual teaching approach on students' interest in quantum physics by Treatment and Gender**

Dependent Variable: posttest					
Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2940.307 <sup>a</sup>	4	735.077	10.640	.000
Intercept	10267.675	1	10267.675	148.623	.000
Pretest	604.973	1	604.973	8.757	.005
Approach	2246.012	1	2246.012	32.511	.000
Gender	146.982	1	146.982	2.128	.150
Interaction	50.795	1	50.795	.735	.395
Error	3799.693	55	69.085		
Total	237380.000	60			
Corrected Total	6740.000	59			
a. R Squared = .436 (Adjusted R Squared = .395)					

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Table 6 shows that at .05 level of significance, there was a significant main effect of the teaching method on students' Interest in Physics,  $F(1, 55) = 32.511, P(.000) < .05$ . Therefore, the null hypothesis was rejected. Thus, there is significant difference in mean interest scores of students taught Quantum Physics using meta-conceptual teaching approach and those taught using conventional teaching approach.

**Hypothesis 3:**

Table 5 shows that at .05 level of significance, there was no significant main influence of gender and the effect of teaching method on students' academic achievement in physics,  $F(1,55) = .000, P(.990) > .05$ . Therefore, the null hypothesis was accepted. Thus, gender has no significant influence on the academic achievement of students in quantum physics.

**Hypothesis 4:**

Table 6 shows that at .05 level of significance, there was a significant main influence of gender and the effect of the teaching method on students' Interest in Physics,  $F(1, 55) = 2.128, P(.150) > .05$ . Therefore, the null hypothesis was accepted. Thus, there is no significant difference in mean interest scores of male and female students taught Quantum Physics using

meta-conceptual teaching approach and those taught using conventional teaching approach.

**Hypothesis 5:**

Table 5 further showed that at .05 level of significance, there was no significant interaction effect of gender and the teaching method on students' academic achievement in Physics,  $F(1, 55) = .002, P(.962) > .05$ . Therefore, the null hypothesis was accepted. Thus, there is no significant interaction effect of gender and the teaching method on students' academic achievement in physics.

**Hypothesis 6:**

Table 6 further showed that at .05 level of significance, there was no significant interaction effect of gender and the teaching method on students' Interest in Physics,  $F(1, 55) = .735, P(.395) > .05$ . Therefore, the null hypothesis was accepted. Thus, there is no significant interaction effect of gender and the teaching method on students' interest in physics.

**Discussions**

The result of this study as shown in Table 1 revealed that students taught quantum Physics using a meta-conceptual teaching approach and those of the control group taught with conventional method were similar



in terms of their achievement scores in the pretest. However, after the experiment, the experimental group performed better in achievement score test than those taught using conventional approach. From Table 5, a significant difference existed between the academic achievement scores of the experimental and control groups in favor of the experimental group. This result is consistent with the findings of Nwankwo, Achufusi and Offiah (2019). In that study, they observed that the meta-conceptual teaching approach had a significant positive effect in promoting students' conceptual understanding when compared with the effect of lecture method of instruction.

In the present study, meta-conceptual teaching approach was used to highlight the intelligibility and the usefulness of the selected Physics concepts

Quantum Physics and so promoted achievement scores in students by getting them actively involved in constructing their own knowledge through active involvement in meta-conceptual processes. The result also agreed with the findings of Zubeyde and Omer (2011), Yuruk-Selvi and Yakisan (2011) and Mesut and KattyCabe (2016). More so, the meta-conceptual teaching processes used in the present study gave the students in the experimental group opportunity to interact among themselves and with the more knowledgeable others especially during group discussions, creating cognitive conflict in students which led to dissatisfaction alternative conceptions. Resolving these dissatisfactions result in conceptual understanding as well, which in turn promoted their academic achievement. This type of interaction also helped the students to share their ideas with each other and ponder those ideas in depth. Engagement in poster production and group discussion created enthusiasm in students which encouraged conceptual understanding in them which is evident in students as they restructure their initial concepts having found the new ones more meaningful. On the other hand, the conventional approach which was used on the students in the control group comprised lecture, use of textbooks, and only explanation of important concepts where, according to Ceylan & Geban (2010), teachers' major task was to transfer knowledge to students. The conventional teaching approach does not engage students in meta-conceptual processes like poster drawings, mind mapping and so, did not have enough quality to

eliminate students' alternative conceptions and bring about conceptual understanding in students.

The data presented in Table 2 revealed that students taught quantum Physics using a meta-conceptual teaching approach and those of the control group taught with conventional method were similar in terms of their interest scores in the pretest. However, after the experiment, the experimental group performed better in the interest score test than those taught using conventional approach. From Table 6, a significant difference existed between the academic interest scores of the experimental and control groups in favor of the experimental group. The finding was consistent with Eze (2016), Zengyan and Chem (2012), and Offor (2018).

Tables 3 and 4 showed that gender has no influence on students' achievement and interest on Physics concepts (Quantum Physics) using a meta-conceptual teaching approach. This is because, no significant difference existed between the achievement and interest scores of male and female students in the experimental group. The result agrees with Piraksa, Srisawasdi and Koul (2013), Orefor (2016); and Nnorom (2015). On the other hand, the study disagrees with Nworgu, Ugwuanyi and Nworgu (2013) and Nwankwo and Madu (2014) who noted a gender difference with a teaching method.

From the Data displayed in Tables 5 and 6, there is no significant interaction between instructional approach and gender on students' academic achievement and interest scores in Physics was observed. This result agreed with the findings of Nwankwo and Madu (2014), who discovered no significant interaction between gender and instructional analogy on students' conceptual change in physics, agreed with the present finding. On the other hand, Baser and Durmus (2010) noted a significant interaction between gender and instructional treatment on students' academic achievement and interest in current electricity. It is obvious that there is no agreement in the research community concerning the interaction effect of gender and instructional strategies have on students' conceptual understanding of science especially physics concepts. The differences in observation by different researchers could be attributed to the influence of location and some other extraneous threats to the experiment. There is therefore a great need to embark on more studies in order to shed further light on this issue.





### Conclusion/ Recommendations

Use of Meta-conceptual teaching approach in science instruction is effective in increasing Physics students' academic achievement and interest. This is because, the students performed significantly better in posttest scores, when taught quantum physics using meta-conceptual teaching approach than when taught same concepts using conventional teaching approach. The study however, showed there is no significant gender difference in students' academic achievement and interest scores.

Based on the findings of the study, the following recommendations were made:

- 1) Teacher educators in Universities and Colleges of education should be focused on preparing Physics teachers to acquire appropriate skills and competence needed for a meta-conceptual instructional approach.
- 2) Federal Ministry of Education should incorporate a meta-conceptual teaching approach based on the information collected here as a basis for deciding on the best instructional approaches to be adopted in the Nigerian secondary school physics curriculum as opposed to using lecture teaching approach. This is so, as activity-based approaches are aimed at making science (especially Physics) learning interesting and exciting which in turn improves academic achievement.
- 3) Teacher-training programme designers should include in their curriculum a course on the meta-conceptual teaching approach, while practicing teachers should be re-trained in the approach through seminars, workshops, conferences, in-service trainings, annual teacher vacation courses, and refresher courses.
- 4) Curriculum should be reviewed by curriculum planners to reflect the approach while textbook authors should be encouraged to incorporate the approach in Physics textbooks.

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