International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Effect of Metaconceptual Teaching Intervention on Students' Conceptual Understanding in Physics

***NWANKWO, Madeleine Chinyere**
*ACHUFUSI, Ngozi
*OFFIAH, Francisca Chinelo

Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

Abstract: ***In this study, the effect of metaconceptual teaching intervention on students'conceptual understanding in physics was examined using a quasi-experimental non-randomized non-equivalent control group research design. The study was guided by two research questions and three hypotheses. Sixty-eight SS2 physics students selected using a multi-stage sampling approach from two intact classes of four co-educational secondary schools in Onitsha-South Local Government Area of Anambra State was used for the study. The relevant data for the study was collectedusinga Thermal Concept Evaluation (TCE) adapted from Zadnik and Yeo (2001) which was re-validated by three experts. The reliability of the instrument was established using Kendall's W Test which yielded a coefficient of concordance of .94.Mean and standard deviation were used in answering the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings of the study showed significant positive effect of metaconceptual teaching intervention (MTI) on students' conceptual understanding in physics. Based on the findings of the study, recommendations were made which included among others, that MTI should be incorporated in teaching of sciences especially physics in Nigerian secondary schools by physics teachers.***

1. Introduction

Countries all over the world crave for sustainable development through qualitative science, but especially physics education of its citizenry. This is because science subjects, particularly physics, helps to analyze the cause of events and develop a set of general principles and laws underlying natural phenomena. Physics, one of the basic sciences taught in Nigerian secondary school system has a very important role to play in the development of any nation. This is because; knowledge of physics, its laws, principles, theories and facts permeates every fabrics of human endeavor ranging from daily living to more complex applications in technology (Mankillik & Agal, 2014). Despite its importance in national development and students' awareness of this obvious fact, very few students go for physics at school certificate level, how much more embracing physics as a course of study in institutions of higher learning. The few that venture into physics often do so because it is a basic requirement for other science-related careers. Many who opt for physics also perform abysmally in it (Cepni, Aydin & Ayvci in Akyuz, 2004). The reason for such poor performance being the fact that physics has been branded by students as one the most difficult subjects in the school curriculum (Isola, 2010). This has been blamed on the way in which physics as a subject is being taught in secondary schools among other reasons. To improve this situation, researchers all over the world are trying various methods especially learner-friendly methods like metacognitive, activity-based and others in presenting physics concepts to the students. In line with this, the present study sought to investigate the effects of metaconceptual teaching intervention, a learner-centered approach on students' conceptual understanding in physics.

Metaconceptual teaching intervention was firstly suggested by Thorley (1990);though it was Yuruk (2005) who was the first to carry out a study using the approach. According to Yuruk (2005), metaconceptual teaching intervention involves practices designed to facilitate students' engagement in Metaconceptual Knowledge (MK), Metaconceptual Awareness (MA), Metaconceptual Monitoring (MM) and Metaconceptual Evaluation (ME).MK is one's stable and statable knowledge about concept learning and factors influencing concept formation and acquisition; MA 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; MM involves processes that generate information about one's cognitive state or thinking process and ME deals with making judgmental decisions about the validity of competing conceptions. Some practices such asposter drawings, journal writing, group debate, concept mapping, and class and group discussions as well as quantitative problem-solving (Yuruk, 2007) are designed to facilitate students' engagement in metaconceptual knowledge and processes. These practices are designed to help students to conceptually understand the scientific concepts taught. Processes also exist that have been found to facilitate metaconceptual learning. These include such processes as commenting on, comparing and contrasting, explaining, considering arguments to support or contradict one or another explanation and choosing one of these possible explanations. In Metaconceptual teaching intervention, conceptual change and metacognition models are merged in order to obtain a more robust model capable of enhancing students' conceptual understanding of science concepts.

Conceptual understanding, according to Johnson (2005), is a person's ability to see connectedness between concepts and procedures as well as being able to apply a given principle in a variety of contexts. It refers to an integrated and functional grasp of science ideas. Students with conceptual understanding know more than isolated facts and methods. They understand why an idea is important and the kinds of contexts in which it is useful. They have organized their knowledge into a coherent whole which enables them to learn new ideas by connecting those ideas to what they already know. Conceptual understanding cannot be acquired by rote but by thoughtful and reflective processes/practices. It is transferable between situations and involves seeing the connection between concepts and procedures as well as being able to apply a given principle in a variety of contexts. For instance, conceptual understanding in Physics develops when students see the connections among concepts and procedures and give arguments to explain why some facts are consequences of others (National Research Council, 2001). Sequel to this, facts are no longer isolated, but become organized in coherent structures based on relationships, generalizations and patterns notwithstanding the gender (Nworgu & Ugwuanyi, 2014).

Researchers are greatly worried concerning the influence of gender in students' conceptual understanding of sciences. It has been noted by researchers over the years that there is gender bias generally in science and mathematics but especially in physics (Nnaka & Ezekannagha, 2014;Nwankwo & Madu, 2014).The problem is even compounded by the fact that some science educators maintained that science, technology and mathematics are for males while arts and humanities are for females (Babajide, 2010; Longe and Adedeji, 2003).Anugwo and Dim (2014),for instance, reported that males performed better than females in geometry while Nwankwo & Madu (2014) reported that females did better than males in physics. Some other researchers (Nwankwo & Okoye, 2015; Orefor, 2016) opined that gender has no influence on students' achievement in the sciences. Lack of agreement among researchers on influence of gender on students' achievement in science subjects calls for an intensified study using such innovative and learner-friendly strategy as metaconceptual teaching intervention to see what effect it will have on the conceptual understanding of male and female students in the sciences especially Physics.

Research Questions

The study was guided by the following research questions.

1) What is the effect of metaconceptal teaching intervention (MTI) on conceptual understanding scores of students taught the concepts of heat and temperature in physics?
2) What is the influence of gender on the mean conceptual understanding scores of students when taught the concepts of heat and temperature in physics using MTI?

Hypotheses

The following null hypotheses were formulated and tested at 0.05alpha level.

1) Students taught heat and temperature using MTI and those of a control group taught using conventional teaching method (CTM) do not differ significantly in their conceptual understanding scores.
2) There is no significant difference in conceptual understanding scores of male and female students taught heat and temperature using MTI
3) There is no significant interaction between teaching approach and gender on students' conceptual understanding scores in physics

2. Method

A quasi-experimental research design, specifically non-equivalent control groups design was used for the study. Sixty-eight SS 2 physics students (30 males &38 females) drawn through multi-stage sampling approach from four co-educational secondary schools in Onitsha Education Zone of Anambra State were used for the study. In stage one, simple random sampling technique with replacement was used to select one out of the three local government areas in the zone. Onitsha-South Local Government Area was thus selected. In the next stage, purposive selection of only the four co-educational schools in the local government area was made. The technique was used so as to provide classes where boys and girls work together under the same classroom environment. This was followed by the use of purposive sampling technique for the selection of two out of the four co-educational schools 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. Intact classes were used in the sampled schools so as not to disrupt the normal school activities.

Six weeks were used for the experiment. Each week had three periods (one single and one double) of 40 minutes. The control group was taught using conventional method in which the single period was used for normal teaching while the double period was used for only such content-rich activities like demonstrations, experiments and quantitative problem-solving without engaging the students in metaconceptual processes.

For the experimental class, the same set of activities as for the control group were carried out for both single and double periods; but in addition to discussing and writing down their observations, students were engaged in such metaconceptual activities as:

a) Poster production which helped students to engage in metaconceptual awareness and monitoring.
b) 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.
c) Group discussions where students were arranged in groups of 3-4 members to discuss their ideas about a given situation; like why food cook faster in pressure cooker, with prompts from the facilitator (the research assistant).
d) Class discussions: Class discussions were constantly held especially after each group-based activities

The instrument used for data collection was the Thermal Concept Evaluation (TCE) which was adapted from Zadnik and Yeo (2001) to assess students' conceptual understanding after being exposed to heat and temperature concepts in physics. The original version of TCE comprised 26 multiple-choice items with four or five options. The adopted version has only 20 items. The scoring guide for the instrument was obtained using the average score of three physics experts. The new instrument was then re-validated and tested for reliability using Kendall's ω Test which yielded a coefficient of concordance of .94.The instrument was firstly administered as 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 post-test.

Both tests were scored by the researcher to avoid bias. The results were used for analysis.

3. Results

Research Question 1: What is the effect of metaconceptal teaching intervention (MTI) on conceptual understanding scores of students taught the concepts of heat and temperature in physics?

Answer to research question 1 is presented in Table 1.

Table 1: Mean conceptual understanding and standard deviation scores in physics, of students taught heat and temperature using MTI and CTM

Teaching Approach	Pre-test			Post-test			Meangain Score
	N	Mean	SD	N	Mean	SD	
Metaconceptual	38	8.66	2.91	38	29.26	6.49	20.60
Conventional	30	8.77	3.36	30	16.90	6.93	8.13

As shown in Table 1, the pre- and post-tests mean conceptual understanding scores of students taught heat and temperature using MTI were 8.66 and 29.26 while the gain in mean score was 20.60. Their counterpart taught using CTM, on the other hand, had 8.77, 16.90 and 8.13 as pre-test, post-test and gain in mean scores respectively. This shows a 12.47 difference in gain in mean scores between the two groups in favour of students taught with MTI. The result also shows a remarkable difference in mean gain scores between students taught heat and temperature in physics using MTI. These students had higher post-test mean conceptual understanding score and greater gain in meanscore in conceptual understanding than students taught using CTM.

Research Question 2: What is the influence of gender on the conceptual understanding scores of students when taught the concepts of heat and temperature in physics using MTI? Answer to research question 2 is provided in Table 2.

Table 2: Students' Mean Scores and Standard Deviation in Physics Conceptual Understanding by Teaching Approach and Gender

Teaching Approach	Gender	Pre-test			Post-test			Mean Gain Score
		N	Mean	SD	N	Mean	SD	
Metaconceptual	Male	21	7.29	3.38	21	27.86	6.87	20.57
	Female	17	7.29	2.97	17	31.00	5.72	23.71

The data in Table 2 showthe pre- and post-tests mean conceptual understanding scores of male students (7.29 and 27.86) and their female counterpart (7.29 and 31.00) taught heat and temperature in physics using MTI. The gain in mean score for male students was 20.57 while that of the female students was 23.71. This indicates a mean difference of 3.14.

Hypotheses

1) Students taught heat and temperature using MTI and those of a control group taught using CTM do not differ significantly in their conceptual understanding scores.
2) There is no significant difference in the conceptual understanding scores of male and female students taught heat and temperature using MTI.
3) There is no significant interaction between teaching approach and gender on students' conceptual understanding scores in physics.

Table 3: Summary of Analysis of Covariance of Students' Conceptual Change Scores in Physics by Treatment and Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3915.231	4	978.808	38.510	.000
Intercept	883.327	1	883.327	34.753	.000
Conceptual understand' n. Pretest	1222.781	1	1222.781	48.108	.000
Approach	2527.338	1	2527.338	99.434	.000
Gender	43.555	1	43.555	1.714	.195
Approach * Gender	17.997	1	17.997	.708	.403
Error	1601.284	63	25.417		
Total	44063.000	68			
Corrected Total	5516.515	67			

Hypothesis 1: Students taught heat and temperature using MTI and those of a control group taught using CTA do not differ significantly in their conceptual understanding scores. The test of this hypothesis is presented in Table 3.

Table 3 shows that there is a statistically significant difference in the conceptual understanding scores of students taught heat and temperature using MTI and those of a control group taught using CTM, $F(1,63) = 99.432$, $P(.000)<0.05$. Therefore, the hypothesis was rejected implying that a significant difference exists in favour of the experimental group.

Hypothesis 2: There is no significant difference in conceptual understanding scores of male and female students taught heat and temperature using MTI. The test of hypothesis 2 is presented in Table 3 which shows that there is no statistically significant difference in conceptual understanding scores of male and female students taught heat and temperature in physics using MTA, $F(1,63) = 1.714$, $P(.195) >0.05$. This led to acceptance of the null hypothesis of no significant difference in conceptual understanding scores with respect to gender.Hence both male and female students do not statistically differ in their conceptual understanding scores.

Hypothesis 3: There is no significant interaction between teaching approach and gender on students' conceptual understanding scores in physics. The test of hypothesis 3 is presented in Table 3. The Table 3shows that there is no statistically significant interaction between teaching approach and gender on students' conceptual understanding scores in physics. $F(1,63) = 708$, $P(.403)>0.05$. The hypothesis was therefore accepted. This shows that no statistically significant interaction existed between gender and teaching approach.

4. Findings

The findings of this study are summarized as stated:

1) Experimental group taught heat and temperature in physics using Metaconceptual Teaching Intervention (MTI) had higher post-test conceptual understanding scores and greater gain in mean scores in conceptual understanding than students taught using conventional teaching method (CTM).There is, therefore, a significant difference in the conceptual understanding scores of students taught heat and temperature in physics using MTI and those taught using CTM.
2) Male and female students taught heat and temperature in physics using MTI were not much different in their mean post-test conceptual understanding scores and gain in mean scores.Hence, gender has no significant influence in the conceptual understanding scores of students taught using MTI.
3) No significant interaction was observed between teaching approach and gender on students' conceptual understanding scores in physics.

5. Discussions

The result of this study as shown in Tables 1 revealed that students taught heat and temperature in physics using MTI and those of the control group taught with conventional method were similar in terms of their metaconceptual understanding. This is evident from their mean pre-test scores (8.66 & 8.77 respectively). However, after the experiment, the experimental group performed better in conceptual understanding test than those taught using CTM (29.26 & 16.90). From Table 3, significant difference existed between the conceptual understanding scores of the experimental and control groups in favour of the experimental group. This result is consistent with the findings of Yuruk (2005). In that study, Yuruk observed that MTI had a significant positive effect in promoting students' conceptual understanding when compared with the effect of conventional method of instruction.

In the present study, MTI was used to highlight the intelligibility and the usefulness of the selected physics concepts and so promoted conceptual understanding in students by getting them actively involved in constructing their own knowledge through active involvement in metaconceptual processes. The result also agreed with the findings of Zubeyde and Omer (2011) who in a case study found that Metaconceptual Teaching Intervention increased students' self-efficacy and hence, enhanced their performance in chemistry. Similarly, this result was supported by the findings of Yuruk, Selvi and Yakisan (2011) who reported that Metaconceptual Teaching Activities was capable of bringing about positive changes in most of the alternative conceptions held by students prior to instruction and replaced them with sound scientific conceptions, thus promoting conceptual understanding. Furthermore, Mesut and Katty Cabe (2016) in their study on the Contribution of Metaconceptual Awareness in Pre-Service Early Childhood Teachers' Learning of Science Concepts noted that the experiment yielded a positive result by bringing about conceptual understanding in these students. Since all these researchers reported similar results with the findings of the present study, the efficacy of the use of Metaconceptual Teaching Approach in the enhancement of students' conceptual understanding in physics is then obvious. This is why Nworgu and Ugwuanyi (2014) commenting on the importance of the use of student-centered, activity-oriented instructional procedures (as is the case with metaconceptual teaching intervention) in their study on the Assessment of Senior Secondary School Physics Students' Conceptual Understanding of Force and Motion remarked that if students' current conceptual understanding is not improved, most students will continue to provide wrong answers to questions in force and motion (and generally in many concepts in physics). More so, the metaconceptual 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. Resolving these dissatisfactions result in conceptual understanding as well. 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, CTM 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 CTA does not engage students in metaconceptual processes like poster drawings and others and so, did not have enough quality to eliminate students' alternative conceptions and bring about conceptual understanding in students.

The data presented inTables2 and 3showed that gender has no influence on students' performance on TCE when taught heat and temperature in physics using MTI. This is because, no significant difference existed between the conceptual understanding scores of male and female students in the experimental and control groups. The result agrees with Piraksa, Srisawasdi and Koul (2013) who noted that gender does not significantly impact on students' scientific reasoning ability. Still in line with the findings of this research, Nnorom (2015) in a study on the effect of cooperative learning instructional strategy on senior secondary school students' achievement in biology inAnambra State reported no gender influence on students when taught using the approach. Taking it further, Orefor (2016) while examining the Effect of Metacognition Teaching Strategy on Students' Achievement in Chemistry noted no gender disparity on the students when taught with the matacognition teaching strategy.However, contradictory findings were reported by some scholars. For instance, Jacobson (2010) and Amir, Satter & Kourosh, (2011)in their independent studies reported that male students did better academically than females when exposed to the same instructional strategy. Supporting this assertion, Abdul-Raheem (2012) opined that male students performed better than their female counterparts in basic science. From another angle, Nworgu, Ugwuanyi and Nworgu (2013) noted a gender difference in students' conceptual understanding of force and motion in favour of female students when exposed to an instructional strategy designed to assess senior secondary school physics students' conceptual understanding of force and motion. Similarly, Nwankwo and Madu (2014) observed that female students achieved better than their male counterparts when taught the concept of refraction in physics using analogy teaching approach.

From the on-going discussions, it is clear that gender influence on students' conceptual understanding scores in science still remain a controversial issue. This is because no consensus has been reached among researchers regarding the influence of gender on students' academic achievement in the sciences. The diversified results obtained by different researchers could have emanated from other factors like attitude, interest, efficacy of the research method used and different settings in which the researches were conducted as well as students' general belief that science especially physics is difficult rather than on biological factors as claimed by some researchers. However, from the findings of the present and other related studies cited, it is observed that both male and female students were excited about this innovative teaching approach and this excitement led to their high performance. The metaconceptual teaching approach is therefore gender friendly.

From the Data displayed in Table 3 no significant interaction between instructional approach and gender on students' conceptual understanding 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. In the same vein, Akpoghol, Ezeudu, Adzape and Otor (2016) observed that gender and instructional strategy did not have any significant interaction on retention in electrochemistry.

Contrary to this result, Baser and Durmus (2010) noted a significant interaction between gender and instructional treatment on students' achievement in current electricity. Sequel to the findings of these researchers, it is obvious that there is no agreement in the research community concerning the interaction effect that 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 in more studies in order to shed further light on this issue.

6. Conclusion

Using Metaconceptual teaching intervention in science instruction is effective in increasing physics students' academic achievement, an evidence ofconceptual understanding in physics students. This is because, the students performed significantly better in TCE, a conceptual understanding test when taught heat and temperature in physics using MTI than when taught same concepts using CTM. The study however, showed no significant gender difference in students' conceptual understanding scores. Both male and female students benefited equally from the MTI. Any differences observed may have occurred as a result of other factors not related to gender.

On the issue of interaction, none was observed from the study between gender and teaching approach on students' conceptual understanding scores. The study also expended the larger body of researches on the effect of MTI in increasing students' conceptual understanding in physics.

7. Recommendations

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

1) Federal Ministry of Education should incorporate metaconceptual teaching intervention based on the information collected here as a basis for taking decision on the best instructional approaches to be adopted in Nigerian secondary school physics curriculum as opposed to using CTM. This is so, as activity-based approaches are aimed at making science (especially physics) learning interesting and exciting.
2) Teacher-training programme designers should include in its curriculum a course on metaconceptual teaching processes, while practicing teachers should be re-trained in the approach through seminars, workshops, conferences, in-service trainings, annual teacher vacation courses and refresher courses.
3) Curriculum should be reviewed by curriculum planners to reflect the approachwhile textbook authors should be encouraged to incorporate the approach in the textbooks.

References

[1] Abdul-Raheem, B. O. (2012). The influence of gender on secondary school students' academic performance in south west, Nigeria. *Journal of social sciences, 31(1),* 93-98.

[2] Akyuz, V. (2004). The effects of textbook style and reading strategy on students' achievement and attitude towards heat and temperature. *An unpublished Thesis submitted to the Graduate School of Natural and Applied Science of Middle East Technical University*.

[3] Amir, A., Sattar, K, & Kourosh, M. N. (2011). Effect of metacognitive strategies on economic progress of llam Medicine University students. *Psychology research, 1 (4)*, 244-250.

[4] Anugwo, M. & Dim, C. (2014). Effect of Survay, Question, Read, Recite and Review (SQ3R) on students'achievement in geometry. *Journal of science teachers association of Nigeria, 49*(1), 206-217.

[5] Babajide, V. T. F. (2010). A generative and predict-observe-explain instructional strategies as determinants of senior secondary school students' achievement and practical skills in physics. *Unpublished PhD dissertation, University of Ibadan, Nigeria*.

[6] Baser, M & Durmus, S. (2010). The effectiveness of computer supported versus real laboratory inquiry learning environments on the understanding of direct current electricity among pre-service elementary school teachers. *Eurasia journal of mathematics, science and technology education, 6(1),* 47-61.

[7] Ceylan, E.&Geban, O. (2010). Promoting conceptual change in chemical reactions and energy concepts through conceptual change-oriented instruction. *Education and science, 35(157),* 46-34.

[8] Isola, O. M. (2010). Effects of standardized and improvised instructional materials in students' academic achievements in secondary school physics. M. Ed. Thesis, University of Ibadan, Ibadan.

[9] Jacobson, B. N. (2010). Effect of instruction on metacognitive self-assessment strategy on chemistry students' self-efficacy and achievement. *Academia Arena, 2(11),* 1-10.Retrieved from: *http:www.sciencepub.net*.

[10] Johnson, S.K. (2005). Conceptual and procedural knowledge in mathematics: an introductory analysis. Conceptual and procedural knowledge: the case of mathematics (Pp1-27). Hillsdale, NJ: Erlbaum. Retrieved from*Http://Wik.Ed.Uiuc.Ed/Index.Php/Conceptual Knowledge.*

[11] Longe, R. S. & Adedeji, S.O. (2003). Increasing girls' access to technical and vocational education in Nigeria. O.Ayodele-Bamisaiye, I. A. Nwazuoke & O. Okediran (Eds.). *Education this Millennium-Innovation in theory and practice, Ibadan*: *Macmillan Publishers*, Nigeria.

[12] Mankillik & Agal (2014). Effects of oriented conceptual change instruction on secondary school students' achievement in physics in Northern Zone, Plateau State. *International journal of research in science, technology and mathematics education, 2* (2), 1-16.

[13] Mesut, S., &Katty Cabe, T. (2016). Change or durability? The contribution of metaconceptual awareness in pre-service early childhood teachers' learning of science concepts*Research in science education.*Retrieved from *Http://Citeweb.Info/20160462862">Change Or Durability*? 1-17.

[14] National Research Council. (2001*). A framework for k-12 science education: practices, crosscutting concepts and core ideas*. Washington, DC: national academies press.

[15] Nnaka, C. V. & Ezekannagha, G. N, (2014). Society's current attitude towards women inscience and technology based artisan jobs as a factor in mainstreaming girls into STM education. *Journal of science teachers association of Nigeria, 49*(1), 19-30.

[16] Nnorom, N. R. (2015), Effect of cooperative learning instructional strategy on senior secondary school students' achievement in biology in Anambra State. *International journal for cross-disciplinary subjects in education (IJDSE), special edition 5(1)*,2424-2427

[17] Nwankwo M. C. &Madu B. C. (2014). Effect of analogy teaching approach on students' conceptual change in physics. *Greener journal of educational research. 4(4),* 119-12 *http://dx.doi.org/10.15580/gjer.2014.4.032414160*

[18] Nwankwo, M. C. & Okoye, K. R. E. (2015). Influence of college clubs in increasing students' interest and achievement in Nigerian post-primary schools as perceived by science students.*Journal of education and practice, 6(18),* 184-193. *www.iiste.org*

[19] Nworgu, B. G. &Ugwuanyi, C. S. (2014). Assessment of senior secondary school physics students' conceptual understanding of force and motion. *Journal of science teachers association of Nigeria,49(1)*,170-186.

[20] Nworgu, B. G, Ugwuanyi, C. S. & Nworgu, L. N.(2013). School location and gender as factors in senior secondary school students' conceptual understanding of force and motion. *International journal of educational research and technology, 4 (4),* 71-76

[21] Orefor, J. A. (2016). Effect of metacognitive instructional strategy on secondary school students' academic achievement in chemistry. *An unpublished M. Sc. Thesis, Dept.* of Science Education,Nnamdi Azikiwe University, Awka.

[22] Piraksa, C., Srisawasdi, N. & Koul, R (2013). Effect of gender on students' scientific reasoning ability: a case study in Thailand. *Procedia social and behavioral sciences, 116 (2014),* 486-491.

[23] Thorley, N.R. (1990). The role of conceptual change model in the interpretation of classroom interactions. *Thesis (Ph. D.),* University of Wisconsin-Madison. dissertation abstract international, 51-69, Section: A, P 3033.

[24] Yuruk, N. (2005). Analysis of the nature of students' metaconceptual processes and the effectiveness of metaconceptual teaching practices on students' conceptual understanding of force and motion. *Doctoral dissertation,*Dept. of Science Education, Ohio State University, Columbus.

[25] Yuruk, N. (2007). A case study of one student's metaconceptual processes and the changes in her alternative conceptions of force and motion. *Eurasia journal of mathematics, science and technology education*, 3(4), 305-325

[26] Yuruk, N., Selvi, M. & Yakisan, M. (2011). The effect of metaconceptual teaching activities on pre-service biology teachers' conceptual understanding about seed plants. *Educational sciences: theory and practice.*

[27] Zadik, M.&Yeo, S. (2001). Introductory thermal concept evaluation: assessing students' understanding. *The physics teacher, 39*, 496-304.

[28] Zubeyde, D. K, & Omer. G. (2011). The nature of the metaconceptual processes of students during the implementation of metaconceptual teaching activities. *New perspectives in science education.*