

## CONCEPT MAPPING TEACHING STRATEGY AND SECONDARY STUDENTS' ATTITUDE TO PHYSICS IN IBADAN, NIGERIA

**Kehinde ALEBIOSU**  
**Emmanuel MICHAEL**  
**Olabisi Onabanjo University**

### Abstract

*This study investigated the effectiveness of using concept maps in improving the attitude of senior secondary students to Physics. The study, a pre-test, post-test, control group quasi-experimental design involving 2x2x3 factorial matrix also investigated the moderating effects of gender and quantitative ability. Ninety Senior Secondary 2 students of intact classes participated in the study that was carried out in Ibadan, Nigeria using three validated instruments; Teacher Instructional Guide, Quantitative Ability Test, and Physics Attitude Test for data collection. Findings showed that concept mapping method had significant main effect on students' attitude ( $F(2,90) = 30.251, P < 0.05$ ) implying that using concept maps was more effective in improving students' attitude towards physics. There were no significant 2 way and 3 way interaction effects of variables on attitude. Physics teachers were implored to adopt the use of concept mapping instructional strategy in physics classes and to disallow discrimination among male and female low, moderate and high quantitative ability students.*

**Key Words:** Concept mapping, Conventional, Improve, Attitude.

### Introduction

Science, Technology and Science Education have immense contribution to the growth, development and survival of mankind. They constitute channels through which man gains the understanding of the world. Many advanced nations of the world have benefitted tremendously from the positive embrace of science and science education, thus explaining why experts in these biases continue to sensitize the public on the importance. More importantly, breakthrough in science and technology is deeply rooted in the strength of the science education.

The science subjects occupy such dominant positions to strongly determine the technological knowhow of a nation and it is in recognition of this that the conference of African Ministers of Education in 1962, recommended that sixty percent of admission into higher institutions of African countries should be for scientifically and technologically based courses. This was adopted by the Nigerian National Policy on Education (Federal Republic of Nigeria, 2004). Nonetheless, Yoloje (1994) doubted if any African nation had achieved this ratio.

Physics is a fulcrum subject among the sciences that requires special attention. Advancements in technologies in information and communication, medical, environmental, crime control and security are feats brought to fore through the knowledge of physics. It is in recognition of this that Egbugara (1986) advanced strongly that the specific priority of physics in the development of scientific and technological programmes of a nation is so important that backwardness and exploitation by other countries would be the only reward of a nation with poor records in physics. No nation therefore wishes to draw behind in the field of physics education.

The experience of low participation in physics among students at varying levels of learning seems to be global as reflected by Nashon (2003) in his study of physics teaching and learning in Kenyan classrooms, Mumba, Chabalengula and Wise (2007) who worked on the Zambian high school physics and Nigeria is not exempted (Egbugara, 1986; Gonzuk & Chagok, 2001; Adeoye & Okpala, 2005; Ariyo, 2006). This calls for investigation into factors that impede students' participation in the sciences, especially in physics.

Researchers have identified reasons for poor attitude, low enrolment and underachievement in the sciences to include ill-equipped laboratories, teacher and gender factors and insufficient funding (Meltzer, 2002; Delphonso, 2003; Danmole & Adeoye, 2004 and Alebiosu & Bamiro, 2007). The factor of high mathematical or quantitative demands (Onwu and Opeke, 1985; Egbugara, 1986 & Adepitan, 2004) has been identified specifically for physics. Iroegbu, (1998) asserted that poor numerical aptitude generates lack of confidence in handling numerical problems in physics. Similarly, Meltzer, (2002) explained that mathematical ability (figural ability) is positively correlated to achievement in physics.

The attitude formed by a child towards any subject will go a long way to decide and determine the child's choice and achievement in that subject as well as his or her career choice (Woolnough, Guo, Leite, deAlmeida, Ryu, Womg & Young, 1997). Simpson and Oliver, (1990) identified factors of teachers attitude, teaching methods and personality, attitude of parents and peers, nature and perception of the subject among components influencing attitude to school subject.

The above explains that teachers are very important determinants of enrolment, achievement and essentially attitude towards school subjects. Teachers constitute the pivot upon which schooling rotates (Alebiosu & Bamiro, 2007). The teacher is a consultant, guide, mentor, inspirator and moderator (Krejster, 2004). His / her use of innovative instructional strategy stands a higher chance of positively influencing the attitude of the learner to the subject.

Negative attitude towards a certain subject makes learning or future – learning difficult (Guzel, 2004), hence when students are positively inclined towards a subject they tend to do well in that subject. Developing students' attitude towards science is the most important purpose of science education and apart from students, teacher's attitude towards science and science teaching is also crucial (Guzel, 2004). Adepitan (2004) remarked that the problem of understanding concepts in physics is not only common among students, it is also peculiar to teachers.

Consequently, Grober and Jodl (2010) suggested the use of self study, problem oriented learning and remote lab/web experiments while Adeoye and Okpala (2005) advanced the systematic assessment procedure. Invariably, instructional strategy and teaching method are important determinants of attitude to science (Orji, 1998; Meltzer, 2002 and Alebiosu, 2006). One of such is the concept mapping instructional strategy.

Concept mapping relates with the meaningful learning theory whose advantage lies on the fact that learning new knowledge is dependent on what is already known. It upholds that new knowledge gains meaning when it can be largely related to a framework of existing knowledge rather than being processed and stored in isolation. By using concept maps, the learning process becomes active rather than passive.

Johnson (n.d) alluded that concept maps have a number of very practical applications

for students. According to the researcher, they allow for handy ways to take notes during lectures and are excellent aids to group brainstorming. They assist in planning students studies and also provide useful graphics for presentations and written assignments. That they help the student to refine creative and critical thinking was emphasized. Some researchers like DeSimone, Schmid and McEwen (2001), Danmole and Adeoye (2004) and Chang (2008) used concept maps in innovative forms.

The foregoing revealed that it is expedient to explore ways of improving attitude of students towards studying physics at the secondary school level. Hence the problem of the study is to examine the effectiveness of the use of concept mapping instructional strategy in improving secondary students' attitude to physics.

### **Research hypotheses**

The following hypotheses were generated and tested in the study:

1. There is no significant main effect of;  
(a) Concept mapping and conventional teaching methods (b) gender and (c) quantitative ability, on students' attitude to physics.
2. There is no significant interaction effect of;  
(a) teaching methods and gender (b) teaching methods and quantitative ability and (c) gender and quantitative ability, on students' attitude to physics.
3. There is no significant interaction effect of teaching methods, gender and quantitative ability, on students' attitude to physics.

### **Methodology**

This study made use of the pre-test, post-test, control group. It is a quasi-experimental study involving a 2 x 2 x 3, factorial matrix investigating the moderating effects of gender and quantitative ability. Independent variable was the instructional strategies of concept mapping and conventional teaching while the moderator variables were gender at two levels (male and female) and quantitative ability at three levels (high, moderate and low). The dependent variable was attitude to physics. With a sample of Ninety Senior Secondary II students of intact classes selected from four purposively chosen Secondary schools in Ibadan, Nigeria. The students comprised of 46 and 44 in the concept mapping and conventional method groups respectively when the four classes were pooled together. Physics teachers in the schools were used as participating teachers and research assistants.

Three validated instruments; Teacher Instructional Guides (TIG), Quantitative Ability Test (QAT) of 30 items adapted from the Otis-Lenon standardized Mental Ability Test and with a reliability co-efficient of 0.74, and Physics Attitude Questionnaire (PAQ) which consisted of two sections, A and B. Section A required the basic demographic data such as age, sex, class and school while Section B contained 35 items placed along side 4 point Likert type response of strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD). Students were expected to select options that best described the extent of their agreement or disagreement with each stated item. It had reliability co-efficient of 0.76.

The teacher's instructional guides were used as specific working guides given to participating teachers to ensure that they adhered to the principles guiding the experiment especially the teaching methods while they taught the wave topic and its related concepts. It

was to eliminate the possibility of introducing their biases. For the conventional method, the outline for using the method which although was the prevailing instructional practice was presented to the teachers of the control group. While for the concept mapping strategy, the outline was presented in a simple form with emphasis on the attributes of concept map, that is, as tools for organizing and representing knowledge in hierarchical order, as techniques for representing knowledge in graphical or diagrammatic forms with concepts and related ideas enclosed in boxes or circles and linked with lines and phrases, and as leading questions allowing students to reason out every stage critically.

Data was collected in phases after training the co-operating teachers on the purpose of the experiment and how to use the instructional guides for one week. First was the pre-test phase during which the physics attitude questionnaire (PAQ) was administered on the participating students as pretest. But before this administration, the quantitative ability test (QAT) was administered for the purpose of splitting the students into three quantitative ability groups of low, moderate and high, and the data was processed separately. Then there was the treatment phase involving the actual teaching that lasted six weeks in which groups were taught using the concept mapping and the conventional teaching methods. Finally, there was the last phase in which the PAQ was administered as post-test. Before the post-test exercise was carried out, the PAQ items were re-numbered so that the students would not suspect that the same instrument used as pre-test was repeated as post-test Data was analysed by means of inferential statistics of the analysis of covariance (ANCOVA).

## Results

Summary table of the analysis of covariance is presented in Table 1. This is to explain the hypothesis involving main and interaction effects of teaching methods, gender and quantitative ability on students' attitude to physics.

**Table 1: Summary of Analysis of Covariance on Students' Attitude Scores According to Methods, Gender and Quantitative Ability**

Source of variation	Sum of squares	Df	Mean square	F	P Sig.of F
Intercept	910.647	1	910.647	57.606	.000
Pretest	2887.774	1	2887.774	182.676	.000
<b>Main Effects</b>					
Methods	478.214	1	478.214	30.251	.000*
Gender	2.110	1	2.110	0.134	.716
Quantitative ability	52.243	2	26.121	1.652	.198
<b>2 Way Interaction</b>					
Methods X Gender	59.929	1	59.929	3.791	.055
Methods X Quantitative ability	46.227	2	23.113	1.462	.024
Gender X Quantitative ability	16.238	2	8.119	0.514	.600
<b>3 Way Interaction</b>					
Methods X Gender & Quantitative Ability	21.302	2	10.651	0.674	.513
Error	1217.232	77	15.808		
Total	827613.000	90			
Corrected total	4879.389	89			

\* R Squared = .751 (Adjusted R Squared = .712); \* Denote significant F at P < 0.05

The summary of ANCOVA results in Table 1 reveals that there is significant main effect of the concept mapping and conventional methods on students' attitude ( $F = 30.251, P < 0.05$ ). This implies that the post-test attitude mean scores of students exposed to the concept mapping strategy is significantly different from those of the conventional method. The Null hypothesis which states that there is no significant main effect of treatment on students' attitude to physics is therefore rejected.

In other to examine the magnitude of the difference in attitude, the pairwise comparison was done and is presented in Table 2.

**Table 2: Pairwise Comparison of Post Attitude Scores on Concept Mapping and Conventional Methods**

(I) Group	(J) Group	Mean Diff (I – J)	Std error	Sig <sup>a</sup>
Concept mapping	Conventional method	5.921*	1.077	.000
Conventional method	Concept mapping	-5.921*	1.077	.000

Table 2 shows that concept mapping strategy is significantly better than the conventional method in raising students' attitude to physics. The mean difference of +5.921 was obtained.

The summary of ANCOVA results of main effect of gender in Table 1 revealed no significant main effect of gender on students' attitude ( $F = 0.134, P > 0.05$ ) hence the Null hypothesis cannot be rejected. This is an indication that post attitude scores of male and female students in the groups do not differ significantly thus implying that gender only does not have any significant main effect on students' attitude to physics. The pairwise comparison of the mean scores is shown on table 3.

**Table 3: Pairwise Comparison of Post Attitude Scores of Male and Female Students**

(I) Gender	(J) Gender	Mean Diff (I – J)	Std error	Sig <sup>a</sup>
Male	Female	-.348	.951	.716
Female	Male	.348	.951	.716

The summary of ANCOVA results in table 1 revealed no significant main effect of quantitative ability on students' attitude to physics ( $F = 1.652, P > 0.05$ ), hence the Null hypothesis cannot be rejected. This indicates that post attitude mean scores of low, moderate and high quantitative ability students do not significantly differ thus implying that students' attitude is not sensitive to quantitative ability. The pairwise comparison of the mean scores is presented in Table 4.

**Table 4: Pairwise Comparison of Post Attitude Scores of Low, Moderate and High Quantitative Ability (Q.A) Students**

(I) Q.A	(J) Q.A	Mean Diff (I – J)	Std error	Sig <sup>a</sup>
Low	Moderate	-.041	1.121	.971
	High	1.915	1.190	.112
Moderate	Low	.041	1.121	.971
	High	1.955	1.216	.112
High	Low	-1.915	1.190	.112
	Moderate	-1.955	1.216	.112

The summary of ANCOVA results of the 2-way interaction effect in table 1 revealed no significant interaction effect of methods and gender on the students' post attitude scores, ( $F = 3.791$ ,  $P > 0.05$ ), hence the Null hypothesis is not rejected. Therefore treatment and gender did not interact to have significant effect on students' attitude to physics. This implies that students' attitude did not differ irrespective of their gender when they are exposed to either the concept mapping or conventional method. This means that none of the treatment conditions was particularly superior over the other for any of the gender groups.

The summary of ANCOVA results of the 2-way interaction effect in table 1 revealed no significant interaction effect of methods and quantitative ability on the students' post attitude scores in physics, ( $F = 1.462$ ,  $P > 0.05$ ), hence the Null hypothesis is not rejected. This implies that methods did not interact with quantitative ability to influence students' attitude to physics. In other words, methods were not differentially effective for any of the quantitative ability groups. This means that with respect to student's quantitative ability, the concept mapping and conventional methods did not have significantly different impacts on attitude of students to physics.

The summary of ANCOVA results of the 2-way interaction effect in table 1 revealed no significant interaction effect of gender and quantitative ability on students' post attitude scores in physics, ( $F = 0.514$ ,  $P > 0.05$ ), hence the Null hypothesis is not rejected. This explains that there was no significant difference in the students' attitude to physics based on the methods among all possible combinations of gender and quantitative ability i.e male-high Q.A, male-moderate Q.A, male-low Q.A, female-high Q.A, female-moderate Q.A and female-low Q.A. In other words, quantitative ability does not work with gender to influence students' attitude to physics.

The summary of ANCOVA results of the 3-way interaction effect in table 1 revealed no significant interaction effect of methods, gender and quantitative ability on students' post attitude scores in Physics, ( $F = 0.674$ ,  $P > 0.05$ ), hence the Null hypothesis is not rejected. This by implication explains that methods, gender and quantitative ability do not interact to significantly influence students' attitude to physics. To expatiate further, it implies that none of the possible 12 combinations of treatment, gender and quantitative ability work together to influence achievement.

## **Discussion**

The results revealed significant differences in post-test mean attitude scores of students. This explains that there is significant main effect of teaching methods on the attitude of students to physics. The implication is that the concept mapping instructional strategy is more effective in improving students' attitude towards physics. The findings provide empirical support to DeSimone, Schmid and McEwen (2001), Danmole and Adeoye (2004) and Chang (2008) in recommending this innovative strategy. Chang (2008) revealed that the use of On-line concept mapping was able to instill students to adopt deep learning approaches and develop affective cognitive information processing ability. The beauty of this research lies on its tendency to have a positive impact on the achievement of students in physics. Moreover, positive correlation between attitude and achievement has been argued before (Simpson and Oliver, 1990).

The main effect of gender on students' attitude to physics was not significant as in the findings of Oyedele (1999) and Alebiosu (2006) but at variance with Mubarak (2006).

Similarly, the main effect of quantitative ability on students' attitude was not significant in this study conforming with the studies of Adeoye, (2000) and West (1992) as cited by Raimi and Adeoye (2006), but at variance with the findings of Pang and Good (2000) cited by Guzel (2004). The implication is that concept-mapping is not sensitive to gender and quantitative ability. Therefore no special training or counseling is needed in making use of the method for male and female students of different levels of quantitative ability.

### Conclusion and Recommendation

One very important factor of effective learning is the strength of what the learner already knows. Propelled by this discovery, science educators and researchers have geared their efforts towards understanding the characteristics, strengths and weaknesses of the individual learner so as to design appropriate instructional programmes that will meet his / her needs. Consequent upon the claim in literature that concept mapping leads to meaningful learning and the findings of the study that the strategy significantly improves learning, it is recommended that Physics teachers should embrace concept mapping strategy and other participatory strategies during instruction. By so doing, learners would be guided to learn step wisely and meaningfully and would be assisted to develop positive attitude towards physics. Also, teachers should allow equal encouragement among the male and female students with varying levels of quantitative ability.

Capacity building opportunities and exposure of teachers to challenging tasks for updating their teaching skills and techniques are tools for improving productivity and these are strongly recommended.

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Kehinde ALEBIOSU

Professor of Science Education, Department of Curriculum Studies & Instructional Technology

Olabisi Onabanjo University

Ago – Iwoye. Nigeria.

[alebiosukk@yahoo.com](mailto:alebiosukk@yahoo.com)

Emmanuel MICHAEL

Doctoral Student of Science Education, Department of Curriculum Studies & Instructional Technology

Olabisi Onabanjo University

Ago – Iwoye. Nigeria.

[emmanuelmichael@yahoo.com](mailto:emmanuelmichael@yahoo.com)