International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 4 Issue 2, February 2017

ISSN: 2394-4404

Exploring The Relationship Among Metacognitive Awareness, Concept Representation And Achievement Of Senior Secondary School Students' In Physics

Akintoye Hakeem

Owolabi Tunde

Aregbede Solomon

Department of Science and Technology Education,
Faculty of Education, Lagos State University, Ojo, Lagos, Nigeria

***Abstract:** This study investigated the relationship among senior Metacognitive awareness, concept representation and achievement of senior secondary school students in physics. Correlational and descriptive research designs were adopted. Two hundred and twenty nine senior secondary school Physics students selected from four purposively sampled co-educational and urban schools in Education Districts V of Lagos State formed the sample. Metacognitive Awareness Inventory (MAI) and Physics Achievement Test (PAT) were used to collect data. The reliability coefficients of the Metacognitive Awareness Inventories using the Cronbach's alpha was determined to be 0.81while that of Physics Achievement Test using the split-half method was 0.97. Three research questions raised for investigation alongside one corresponding null hypothesis were tested. Quantitative data gathered were analysed using the Mean, Standard deviation, Bar graph and Analysis of covariance (ANCOVA) statistical tools. Findings of this study revealed that there was significant correlation between students' Metacognitive awareness and achievement; r = .422; p < .001; concept representation and achievement; r = .815; p < .001. Furthermore, the study revealed that there was a significant interaction impact of students' concept representation and Metacognitive awareness on senior secondary school physics achievement; F (61,116) = 1.614; p < 0.05. The study concluded that sporting activities enhanced the students' Metacognitive awareness and concept representation ability and achievement in Physics. The use of sporting activities should be explored by Physics teachers for meaningful teaching.*

***Keywords:** Metacognitive awareness, Concept representation, Physics achievement, Sporting activities, Intervention.*

I. BACKGROUND TO THE STUDY

Physics as one of the science subjects has contributed immensely to the technological development of countries the world over including Nigeria. However, the subject had been experiencing challenges in its teaching and learning at all levels of education in and beyond Nigeria. Many students believe that Physics is difficult because they have to contend with different representations such as experiments, formula and calculations, graphs and conceptual explanations at the same time (Angell, Guttersrud, Henriksen & Isnes, 2004). They also have to make transformations among the different modes of representations of Physics concepts. In order to eradicate or reduce students' difficulties in learning Physics, there is a need to take them through learning processes that will enable them construct mental models that allow for higher order performance as well as participate in the learning experience rather than sit as passive listeners (Churchill, 2003). Students learn meaningfully when they construct their knowledge actively by thinking and doing, through interactive experiences with the environment, rather than passive receiver (Acikgoz, 2004; Ozel, 2005). The idea of learning by doing is a self-regulation process through which students observe, evaluate and develop themselves. Mace and Kratochwill (1985) added that self-regulation is included in the concept of Metacognition which is important in learning and a strong predictor of academic success.

Metacognition in learning is of great importance because it is related to the learner's awareness of thinking and learning. It makes learners work independently and flexibly (Fazacur, Nasi, Muhammad, Muhammad & Saeed ul Hasan, 2011). Gardner (1991); Karmilofi-Smith (1992); Lee and Teo (2011); Mayer, 2009; Kuhn and Dean (2005); Magno (2010); Veenman, Kok and Blote (2005) found that metacognition is related to intellectual skills and problem solving ability. In order for students to learn about the process to solve problems, they need to take charge of their own learning through their ability to plan, monitor and evaluate their learning. Students without approaches are essentially learners without direction and ability to review their progress, accomplishments and future learning directions (Balcikauli, 2011). It is important to state that Metacognitive awareness is an important element in learning and crucial to the development of effective learning (Wenden, 1991, 1999; Wilkins-Canter, 1996). Metacognitive awareness was simply described by Flavell (1976) as being aware of one's own knowledge, processes, cognitive and affective states as well as of regulation of those states. Flavell further identified three parts of Metacognitive awareness: thinking of what one knows, thinking of what one is currently doing and thinking of what one's current cognition is. Good learners are found to be metacognitively adapted and poor ones metacognitively deficient in how they tackle learning tasks in most subjects (Baird, 1986, 1992, 1998; Shuell, 1998; Wang & Peverly, 1986). Conner (2006) reported that the degree of awareness of Metacognitive processing influences the extent to which individuals preferentially use learning strategies. Metacognitive awareness is also essential for generating effective mental representations and guiding processing for effective problem solving (Resnick, 1985). Baird (1998); Hacker (1998) revealed that learning can be enhanced if students use Metacognitive processes and are effectively engaged in teaching methods that are effective, activity-driven. This attest to the fact that students whose Metacognitive awareness processes is enhanced will possess higher order thinking which may stimulate their reasoning power and subsequently enhancing the development of their problem solving ability and capacity to represent concepts in Physics. Students' ability to represent physical processes in multiple ways is one of the difficulties they often experience, though, their ability to convert from one representation to another in any direction is also a challenge face by students (Meltzer, 2004).

It is imperative for Physics students to be able to form a representation of a problem by interpreting and associating it with different pieces of knowledge. The knowledge used to represent a problem can be quite varied and may include knowledge of physical concept and principles, equations, procedures, associated images, and related problems. How a problem is represented ultimately determines how easily the problem is solved and what is learnt in the process (Beatty & Gerace, 2009). Nelson (2008) explained representation as a way in which a particular problem or concept can be expressed (examples include graphs, pictures, free body diagrams, formula, field line diagrams and so on). Skills in using different representations in coordinating multiple representations are highly valued in Physics as a tool for understanding concepts and attainment of good performance (Kozma, 2003). Emerging literature have been focusing on the impact of concept representations on learning the subjects such as Physics and Chemistry in primary, secondary and university schools (Yesildag & Gunel, 2009; Koc, Kingir & Gunel, 2012); analysing the transitions between different modes of representations (Celik & Saglam-Arslan, 2012); and identifying the modal representations (Demirbag & Gunel, 2014). Students' understanding of problems that involve multiple representations have proven effective in helping them to visualise Physics concepts hence resulting in higher level of conceptual understanding (Gilbert, 2007; Mayer, 2009). Kohl and Inkelstein (2005) identified representation skills as a factor alongside prior knowledge, metacognitive skills and the specific contextual features of the problem in performance difference of learners. In order to enhance students' Metacognitive and concept representation skills, there is need to engage them in activity-based teaching approaches engage students which will help to transform knowledge or information into their personal knowledge and then apply in different situations especially if the learning activities are real life experiences (Edwards, 2001). Khan, Muhammad & Ahmad (2013) added that activity-based approaches will help students construct mental models that allow for higher order performance such as applied problem solving and transfer of information and skills.

Therefore, this study investigated the relationship among senior secondary school students' Metacognitive awareness, concept representation and achievement in physics adopted a sporting activities strategy which is both activity-based and involves real life experiences as an Intervention in order to improve students' level of achievement, Metacognitive awareness and concept representation in Physics. This teaching approach was also out-of-classroom and exposed the students to real life learning. Students' out-of-class learning experiences such as field trips have been found to give students the opportunity to manage and direct their own learning (Anderson & Nashon, 2007) and actively engage students in learning.

II. STATEMENT OF THE PROBLEM

Physics has been taught majorly using teacher-centred teaching methods which has been found to be passive and failed to address students' poor performance in the subject (Williams, 2007). Teachers dominate classroom activities at the expense of students who are not encouraged to construct their own knowledge or take active part in learning. This has led to low students' achievement in Physics in the West African Senior Secondary School Certificate Examination (WASSSCE). In order to correct this anomaly, Owolabi (2006) opined that the need to teach Physics effectively through effective methods is indisputable. This is necessary because poor academic performance by majority of students in Physics is fundamentally linked to the application of ineffective methods adopted by teachers (Adunola, 2011). The search for appropriate methods and procedures for developing the skills required for quality teaching and learning of Physics engendered the birth of many procedures and methods that sought to promote students skills such as Metacognitive awareness and concept representation. However, little explanation has been provided in literature on the extent to which these strategies are implicated, both as individual and collectively in students learning achievement. This study was designed to investigate the impact of Metacognitive awareness and concept representation to Physics achievement using sporting activities as an intervention.

III. PURPOSE OF THE STUDY

The purpose of this study is to investigate the contributions of metacognitive awareness and concept representation to senior secondary school Physics achievement. Specifically, the study investigated:

- ✓ the level of contribution of Metacognitive awareness and concept representation on senior secondary school students' achievement in Physics
- ✓ the relationship between Metacognitive awareness on senior secondary school students achievement in Physics.
- ✓ the relationship between concept representation on senior secondary school students achievement in Physics
- ✓ the impact of Metacognitive awareness and concept representation on senior secondary school students' achievement in Physics.

RESEARCH QUESTIONS

- ✓ What is the level of contributions of Metacognitive awareness and concept representation to senior secondary school students' achievement in Physics?
- ✓ Is there any relationship between Metacognitive awareness and senior secondary school students' achievement in Physics?
- ✓ Is there any relationship between concept representation and senior secondary school students' achievement in Physics?

HYPOTHESIS

- ✓ There is no significant impact of Metacognitive awareness and concept representation on senior secondary school students' achievement in Physics.

IV. STUDY DESIGN AND PARTICIPANTS

This study employed a descriptive survey research design. The sample consists of two hundred and twenty nine students who were was made up of one hundred and twenty-five male and one hundred and four female students selected from Four intact senior secondary school II classes. Four purposively sampled co-educational and urban schools from Lagos State Education Districts V were used. Purposive sampling was used so as to minimize experimental contamination (Fraenkel & Wallen, 2000) by using schools that are far from one another.

Two instruments were used to collect data in this study. These instruments include: Physics Student Concept Formation Metacognitive Awareness Inventory (PSCFMAI) and Physics Achievement Test (PAT) were used to collect data. The instrument was a modified version of Schraw and Sperling-Dension (1994). The Metacognitive Awareness Inventory was meant to assess students' level of Metacognitive awareness of their ability to understand, control and manipulate their cognitive processes. The Physics Achievement Test was developed by the researcher. Section A of PAT contained items on the demographic data of the students. Section B consisted nine essay type of Physics questions. The questions cut accross concepts such as Kinematics which include: concept of distance and displacement, concept of speed, velocity and constant velocity, concept of acceleration and deceleration/retardation, velocity-time graphs, concept of vector and scalar and vector quantities. These topics were chosen because students experienced difficulty (Okpala, 1988; Owolabi, 2006) and exhibited misconceptions regarding them (Cataloglu, 1996; Eryilmaz, 2002; Yilmaz, 2001). The topics which are first term work for senior secondary school II Physics students. All the questions covered the first term SSS II content area of Physics as stipulated in the National Curriculum for Senior Secondary School Physics and Lagos State Ministry of Education scheme of work.

Data on the two research questions raised were answered using descriptive bar graphs. Analysis of co-variance (ANCOVA) was used to test the hypothesis.

V. RESULT

RESEARCH QUESTION 1: What is the level of contributions of Metacognitive awareness and concept representation to senior secondary school students' achievement in Physics?

To answer this question, bar graphs of the mean and standard deviation of students' Metacognitive awareness and concept representation contributions to senior secondary achievement test scores in Physics were used. The result is presented in Figure 1.

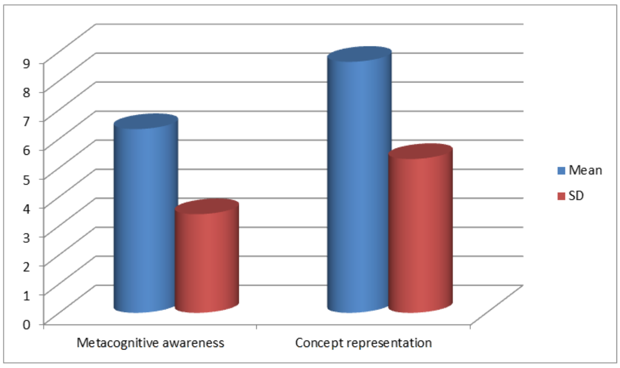

Figure 1: Graphical illustration of students' Metacognitive awareness and concept representations contributions to achievement in Physics

Figure 1 shows the graphical illustration of the contributions of Metacognitive awareness and concept representation to senior secondary school students' achievement in Physics. The figure shows that the students' concept representation (M = 8.15, SD = 4.87) had higher contribution to their achievement in Physics than their Metacognitive awareness (M = 5.86, SD = 2.93).

RESEARCH QUESTION 2: Is there any correlation between Metacognitive awareness and senior secondary school students' achievement in Physics?

To answer this question, Pearson's Correlation between Students' Metacognitive Awareness and achievement was used. The result is presented in Table 1.

Correlations

	Achievement	Metacognitive awareness
Achievement	1	.422**
Metacognitive awareness	.422**	1

*Note. * = p < 0.05; ** = p < 0.01; N = 229*

Table 1: Significant test of Pearson's Correlation between Students' Metacognitive awareness and Achievement in Physics

Table 1 shows the significant test of Pearson correlation between students' Metacognitive awareness and their achievement in Physics; r = .422; p < .001. This implies that the there is a significant correlation between students' Metacognitive awareness and achievement in Physics.

RESEARCH QUESTION 2: Is there any correlation between concept representation and senior secondary school students' achievement in Physics?

To answer this question, Pearson's Correlation between Students' Concept Representation and senior secondary school students' was used. The result is presented in Figure 2.

Correlations

	Achievement	Concept representation
Achievement	1	.815**
Concept representation	.815**	1

*Note. * = p < 0.05; ** = p < 0.01; N = 229*

Table 2: Significant test of Pearson's Correlation between Students' Concept Representation and their Achievement in Physics

The result in Table 2 shows that there is correlation between concept representation and senior secondary school students' achievement in Physics and it is significant: r = .815; p < .001. This means that the students' concept representation had a significant impact on the senior secondary school students in Physics.

HYPOTHESIS 1: There is no significant interaction impact of Metacognitive awareness and concept representation on senior secondary school students' achievement in Physics.

To test this hypothesis, data obtained from the students' posttest achievement were organised and subjected to a Two-way Analysis of covariance (ANCOVA). The result is presented in Table 3

Dependent Variable: Posttest achievement

Source	*SS*	*Df*	*MS*	*F*	*p*	*η*
Concept representation	540.773	16	28.762	39.120	.000	.860
Metacognitive awareness	6015.324	34	164.240	260.321	.000	.927
Concept representation * Metacognitive awareness	64.821	61	1.109	1.614	.023	.441
Error	87.325	116	.753			
Total	116508.000	227				

a. R Squared = .990 (Adjusted R Squared = .985)

Table 3: Two-Way ANCOVA Table for Interaction Impact of Students' Concept Representation and Metacognitive Awareness on Senior Secondary School Physics Achievement

Table 3 revealed that there was a significant interaction impact of students' concept representation and Metacognitive awareness on senior secondary school physics achievement.; F (61,116) = 1.614; p < 0.05, partial η^2 = .441. Therefore, the hypothesis which states that there is no significant interaction impact of Metacognitive awareness and concept representation on senior secondary school students' achievement in Physics is hereby rejected

VI. DISCUSSION OF FINDINGS

This study sought to find out the relationship among Metacognitive awareness, concept representation and achievement on senior secondary school physics. From the findings, students' Metacognitive awareness and concept representation were positively correlated to achievement in Physics. The correlation between the students' Metacognitive awareness and achievement as well as concept representation and achievement was significant. This finding attests to the fact that the students involved in this study were aware of the Metacognitive process to employ when solving Physics problems. Also, the students' concept representation ability is reflected in its relationship with achievement. Khun and Dean (2005) revealed that Metacognition is very important in learning because it enables students solve new problems by retrieving and deploying strategy which they have learnt regarding similar context. Furthermore, McCarthy and Goldfinch (2010); Scharr & Redish (2005) reported that Physics students often have difficulties with representation of concepts in Physics especially, graphical and free body diagrams.

Active engagement of Metacognition is key to developing deeper conceptual understanding (Anderson & Nashon, 2007; Nashon & Anderson, 2004) and make them think about the errors that have occurred while they were performing tasks, and they are successful in connecting and adjusting learning strategies to the tasks at hand (Rahman et al., 2010). Likewise, Van Heuvelen and Zou (2001) reiterate that multiple representations are useful in physics education: they foster students' understanding of physics problems, build a bridge between verbal and mathematical representations and help students develop images that give mathematical symbols meaning.

This study further revealed that both concept representation and Metacognitive awareness contributed significantly to students' achievement in Physics. This will occur if students are actively engaged in learning activities that will help them transform knowledge or information into their personal knowledge and then apply in different situations especially if the learning activities are real life experiences (Edwards, 2001). Khan, Muhammad & Ahmad (2012) added that activity-based approach will help students construct mental models that allow for higher order performance such as applied problem solving and transfer of information and skills.

VII. CONCLUSION

From the findings of the study, there was significant correlation among Metacognitive awareness concept representation and achievement on senior secondary school physics. This is an indication that the students were better able to plan, process and evaluate their own learning process, which they needed to show for improved performance. This is supported by Paris and Winograd (1990) who stated that Metacognitive awareness is a way of enhancing problem solving skills through cognitive tools. Developing Physics students' skills on concept representation is highly valued in Physics, both as a tool for understanding basic concepts in Physics and as a means to solving Physics problems.

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