EFFECTS OF ADVANCE ORGANIZER CONCEPT MAPPING TEACHING STRATEGY ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN PHYSICS IN RONGAI SUB-COUNTY, KENYA

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ABSTRACT

This study investigated the effects of Advance Organizer Concept Mapping Teaching Strategy (AOCMTS), on secondary school students' achievement in physics. Solomon's Four Non-Equivalent Control Design was used. Four co-educational secondary schools were purposively selected from Rongai Sub-County and randomly assigned to experimental and control groups. Data was collected from a sample of 192 form two students using the Physics Achievement Test (PAT).One experimental (E_1) and one control group (C_1) were pre-tested using PAT, prior to implementation of AOCMTS. All the four groups were taught the same content for a period of four weeks. The two experimental groups were taught using (AOCMTS), while the two control groups were taught using Regular Teaching Methods. After treatment, all the four groups received a post-test using PAT. The t-test, one-way ANOVA and ANCOVA statistical techniques were used to analyse data. Findings of the study indicate that students taught using AOCMTS obtained significantly higher achievement in physics than those taught using regular teaching methods. The researcher conclude that AOCMTS is an effective teaching strategy which physics teachers should make use of.

1. Introduction

Physics plays a central role in science education as it is the most utilized subject in scientific discoveries and technological innovations. Moreover, apart from equipping students with skills in collecting analysing and interpreting data, physics offers fundamental knowledge in training of computer scientists, chemists and engineers. Therefore, the importance of quality teaching and learning of physics cannot be over emphasized because of its wide application and immense contribution towards economic and technological advancement (Zhaoyao, 2012).

Despite its importance, physics education in Kenya continues to face myriad of challenges. The challenges range from; lack of personnel, inadequate teaching/learning resources as well as poor performance (Okere, 2000; Changeiywo, 2002).Poor performance for instance is manifested in candidates' scores in physics in the Kenya Certificate of Secondary Education (KCSE) Examination. This has made the government to continuously look for ways of addressing the challenge of poor performance. One of the governments' initiative to mitigate poor performance in physics is through Strengthening of Mathematics and Science in Secondary School Education (SMASSE) Project (Oyaya & Njuguna, 2000; Oirere, 2008). SMASSE project was piloted in 1998 and launched in 2002.This followed a baseline study on factors contributing to poor performance in mathematics and science. The factors identified included: lack of motivation among students, instructional methods used, and lack of teaching and learning resources among others (Waititu & Orado, 2009). SMASSE was mandated to conduct continuous in-service training of mathematics and science teachers which according to Mutisya (2013), resulted in slight improvement in performance in KCSE physics. This implies that much more needs to be done to improve students' achievement in physics in Kenyan secondary schools.

The instructional method employed by a teacher to teach physics, plays a vital role in content delivery. In Kenya for example, research has shown that, physics teachers in secondary schools mainly use lecture method during instruction (Toplis & Allen 2012). However, lecture method is ineffective and only useful to a small number of students. These are the self-driven students who require minimum teachers' facilitation to perform well (Gekelman, Pribyl, Wise, Lee, Hwang, Eightebas, Shin and Baker, 2011). Wasonga (2015), indicates that use of innovative teaching strategies may enhance content delivery in physics. This study therefore anticipates that success in teaching and learning of physics can be attained through the use of appropriate teaching strategies. It is from this perspective that the study investigated the effects of Advance Organizer Concept Mapping Teaching Strategy on students' achievement in physics.

According to Mayer (2003), advance organizers are information presented to the learner before learning, which can be used to organise learning and interpret new material. Novak and Canas (2008), define an Advance Organizer as a cognitive bridge which helps a learner to link new information to existing knowledge. It enables the learner to make use of relevant previous knowledge thus simplifying intricate tasks. Advance organizers can be in form of metaphors, graphics or models (Ausubel, 1968).

A concept map is a graphical tool which displays relationships between concepts and ideas. Concepts are written in shapes such as circles, triangles and boxes and joined by use of arrows which split out in a descending hierarchical structure. Linking words, which are indicated in arrows, defines how concepts and ideas are related (Novak & Gowin, 1984). Complex ideas are placed at the highest level while successively simpler concepts placed at lower parts of the hierarchy. They also contend that concept mapping allows the learner to build on existing knowledge, by connecting new information to it, thus enhancing meaningful learning. Its effectiveness is attributed to the fact that encoding new information into existing knowledge framework requires retrieval of stored information, which reinforces knowledge retention, critical thinking and higher order thinking skills.

One of the recommendation made by Eggen, Kauchak and Harder (2004), was the integration of concept mapping with other instructional strategies to make it more effective, rather than using it in isolation. This work therefore sought to combine Advance Organizer with Concept Mapping thus making it a more effective tool for physics instruction. Advance Organizers were used during the introduction of the lesson while Concept Mapping was used during lesson development. Concept mapping activities for the learners involved; completion of partially completed maps and generation of maps from provided terminologies.

1.1 Statement of the Problem

Persistent poor performance in physics in KCSE in Kenya is disturbing and also an issue of national concern. This is because if the trend of poor performance goes on unchecked, it will hamper Kenya's plan of achieving vision 2030. Among the factors identified as contributing to continued poor performance in physics include the use of inappropriate teaching methods. The use of Advance Organizers Concept Mapping teaching strategy could help curb this problem. However, there is insufficient documented information on studies conducted in Kenya especially in Rongai Sub-County on AOCMTS. This study therefore attempts to fill this gap by investigating the effect Advance Organizer Concept Mapping Teaching Strategy in teaching 'Waves 1' in form two physics within Rongai Sub-County.

Objective

To investigate the effects of Advance Organizer Concept Mapping Teaching Strategy on secondary school students' achievement in physics.

Hypothesis

There is no statistically significant difference in students' achievement in physics between students taught using Advance Organizer Concept Mapping Teaching Strategy and those taught using Regular Teaching Methods.

2. Methodology

The study used Quasi-Experimental Research using Solomon four non-equivalent control group design (Fraenkel & Wallen, 2000; Gall & Borg, 2006). The design was appropriate for this study because secondary school classes exist as intact groups and school authorities do not allow the classes to be reconstituted for research purposes (Shodish, Cook & Campell, 2002). The study was conducted in Rongai Sub-County, Nakuru County, Kenya. The target population was all secondary school physics students in co-educational schools of Rongai Sub-county, Nakuru County, Kenya while the accessible population was form two students in public co-educational secondary schools of Rongai Sub-County. Form two students were chosen because the topic 'Waves I' is taught at this level in all Kenyan Secondary schools (Republic of Kenya, 2002).The sample was drawn from twenty public Sub-County co-educational secondary schools in Rongai Sub-County. Sub-County co-educational secondary schools were used because they have been performing poorly in Physics in the last five years. Purposive Sampling technique was used to obtain a sample of four schools. Selected schools were randomly assigned to experimental and control groups. In schools with more than one form two streams, all the streams were exposed to AOCMTS. Simple random sampling was used to pick one stream for data collection. The number of students per group was more than 30 which was suitable because experimental studies require at least 30 students per group (Mugenda & Mugenda, 2003). The actual sample size that participated in the study was 192 form two students.

2.1 Intervention

The Physics Achievement Test (PAT) was used to collect data. PAT was pilot-tested in two secondary schools in Rongai Sub-County, which were not part of the study but had similar characteristics to the sampled schools. The PAT had 18 structured questions having subsections, on the topic of ‘Waves I’ with a total score of 50. Each item was allocated one mark. PAT items were constructed using a table of specification. This ensured that the items were proportionally distributed across all levels of learning.

Group I and Group III were given a pre-test (PAT) prior to implementation of AOCMTS. Treatment took four weeks during which the experimental group was taught using AOCMTS, while the control group was taught using regular teaching methods. At the end of the four weeks treatment period a post-test (PAT) was administered to all the four groups (I, II, III and IV).Data was analysed by use of t-test, one-way ANOVA, analysis of covariance ANCOVA. T-test was used to determine if there was a significant difference between the means of boys and girls who were taught using AOCMTS. ANOVA was used to determine if there was a significant difference in the means of the four groups' post-test scores. Analysis of covariance ANCOVA was used to cater for initial differences among the groups. All significant tests of statistics were computed at $\alpha = 0.05$ level of significance.

3. Result and Discussion

The study employed quasi-experimental research using Solomon's four non-equivalent control design. The design enabled the researcher to subject two groups; experimental group (E_1) and control group (C_1) to a pre-test. This was done to check the entry behaviour and establish whether the groups were similar before commencement of the study. Results are presented in Table 1.

Table 1

Comparison of Pre-test Means and SD on PAT

Test	Group	N	Mean Score	Std Deviation
PAT	E_1	45	2.38	2.36
	C_1	50	2.62	2.16

PAT maximum score = 50

The results in Table 6 indicate that the student mean score in PAT in E_1, (M=2.38, SD =2.36) was found to be lower than the mean score in C_1 (M=2.62, SD=2.16). Standard deviation in PAT for E_1 and C_1 were different. Independent sample t-test was done to establish whether the differences in mean scores were statistically significant at the level of $\alpha = 0.05$. Table 2 shows t-test results for mean scores in PAT pre-test for E_1 and C_1.

Table 2

Independent Sample t-test on the Pre-test Score on PAT

Test	Group	N	Mean Score	Std deviation	T-value	P-value
CAT	E_1	45	2.38	2.36	0.60	0.66
	C_1	50	2.62	2.16		0.66

Results in Table 2 indicate that there was no statistically significant difference between the PAT means of experimental group (E_1) and control group (C_1) at t (95) = 0.60 P>0.05. Similarly, the differences were not statistically significant.

The hypothesis sought to establish whether there was any significant difference in physics achievement between students taught using AOCMTS and those taught using RTM. An analysis of PAT post-test scores was carried out to determine the effect of AOCMTS on students' achievement in physics. Table 3 shows a comparison of mean scores for PAT post-test scores obtained by students in the four groups.

Table 3

Post-test scores on PAT for the four groups

Group	N	Mean Score	Std deviation
E_1	45	21.42	5.92
E_2	49	22.57	4.74
C_1	50	17.66	5.87
C_2	48	15.33	4.18

Results in Table 3 indicate that group E_2 obtained the highest mean score of 22.57 in the PAT post-test followed by group E_1 with a mean score of 21.42. Groups C_1 and C_2, which were control groups, obtained a lower mean score of 17.66 and 15.33 respectively.

One way ANOVA was carried out to test hypothesis (H_O1) which sought to establish whether there was any significant difference in physics achievement between students taught using AOCMTS and those taught using RTM. Results of PAT post-test mean scores are shown in Table 4.

Table 4

ANOVA results for PAT Post-test Scores

	Sum of Squares	**df**	**Mean Score**	**F**	**Sig**
Between Groups	1410.34	3	470.11	17.21	.000
Within groups	5135.86	188	27.32		
Total	6546.20	191			

Table 4 reveal that there exists a statistically significant mean difference across the four groups, F (3,191) =17.21 P<0.05. Thus, the null hypothesis was rejected. It was necessary to carry out a post hoc analysis using least significance difference (LSD), to find out where the differences occurred within the groups. LSD was used because it is suitable for experimental research involving four groups and it also calculates the smallest significant differences between the groups (Arkkelin, 2014). Results of the LSD post hoc analysis of PAT post-test scores are presented in Table 5

Table 5

Post -hoc Analysis of PAT Post-test Means for the Four Groups

I group	J Group	Mean differences(I-J)	p-Value
E_1	E_2	-1.15	0.28
	C_1	3.76*	0.00
	C_2	5.51*	0.00
E_2	E_1	1.15	0.28
	C_1	4.91*	0.00
	C_2	6.65*	0.00
C_1	E_1	-3.76*	0.00
	E_2	-4.91*	0.00
	C_2	1.74	0.10
C_2	E_1	-5.51*	0.00
	E_2	-6.65*	0.00
	C_1	-1.74	0.10

The results in Table 5 indicate that the differences in PAT mean scores for groups E_1 and C_1, E_1 and C_2, E_2 and C_1, and E_2 and C_2 are statistically significant at $P < 0.05$.The means for E_1 and E_2 were not statistically significant and neither were those for C_1 and C_2. On that account H_O1 was rejected, at $\alpha = 0.05$ level of significance. Findings of this study have shown that the use of AOCMTS resulted in a better achievement in physics than the use of regular teaching methods.

Further, analysis of covariance (ANCOVA) was carried out since the study was a quasi-experimental. KCPE results were used as covariates. Results on ANCOVA are presented in Table6.

Table 6

Analysis of Covariance (ANCOVA) on PAT Post-test Scores with KCPE as Covariate

	Sum of squares	df	Mean Score	F	P-value
KCPE	762.13	1	762.13	32.59	0.00
Group	1068.66	3	356.22	15.23	0.00
Error	4373.74	187	23.39		

F=15.23 DF=3, P<0.05 Covariate KCPE marks=222.72

Analysis of covariance results indicate that, there is a statistically significant difference in mean score between the control groups and the experimental group $F (3,187) = 15.23$ $P<0.05$.

It was necessary to carry out a post hoc pairwise comparisons to establish where differences occurred. Results on post hoc pairwise comparisons are presented in Table 7.

Table 7

Post-hoc Pairwise Comparison on PAT Post-test Scores

I group	J Group	Mean differences(I-J)	p-value
E_1	E_2	0.61	0.56
	C_1	4.52*	0.00
	C_2	5.50*	0.00
E_2	E_1	-0.61	0.56
	C_1	3.91*	0.00
	C_2	4.89*	0.00
C_1	E_1	-4.52*	0.00
	E_2	-3.91*	0.00
	C_2	0.99	0.32
C_2	E_1	-5.50*	0.00
	E_2	-4.89*	0.00
	C_1	-0.99	0.32

Post-hoc pairwise comparison results in Table 7 indicate that the differences in PAT mean scores for groups E_1 and C_1, E_1 and C_2, E_2 and C_1 and E_2 andC_2 are statistically significant at $P < 0.05$. However, the differences between E_1 and E_2 and C_1 and C_2 are not statistically significant. From ANOVA and ANCOVA analysis, the experimental groups (E_1 and E_2) performed better than the control groups (C_1 and C_2).

3.1 Discussion

Results of the study have shown that students taught using AOCMTS performed better in PAT than those taught using RTM. ANOVA and ANCOVA results indicated a significant difference in achievement between control and experimental groups with experimental groups outperforming the control groups. The null hypothesis which stated that there is no statistically significant difference in students' achievement in physics between students taught using AOCMTS and those taught using RTM was rejected at $\alpha = 0.05$ level of significance. This implies that AOCMTS was more beneficial teaching physics as compared to RTM. This could be attributed to visual representation of concepts which helped learners to identify misconceptions and grasp concepts with ease. Ausubel (2000), pointed out that when learners relate and integrate new concepts into existing knowledge it prompted retention of information and storage in the long-term memory. This implies that, frequent mental activity of assimilating new ideas into existing knowledge could have led to a better understanding of concepts Similarly, Novak (1998), indicated that the process of constructing and identifying interrelationships among concepts facilitates logical organisation of thoughts thus enhancing high order thinking. Additionally, this could have promoted better performance in the experimental group.

Better performance portrayed by the experimental groups could also be credited to meaningful learning which enable learners relate and organise incoming information within their cognitive frameworks. Finally, the better performance in favour of experimental groups could have increased level of independent and innovative thinking prompted by concept mapping. This was supported by (Barchok, Too & Ngeno, 2013).Therefore, AOCMTS should be blended in physics teaching in secondary schools to reduce the problem of poor performance.

Findings of this study are in agreement with that of Wasonga (2015), on the Effects of Concept Mapping Based Instruction on Students' Achievement in Physics. The findings of the study showed that students taught using concept mapping performed better than those taught using regular teaching methods. Observations of this study concur with findings of Kipkemoi (2019).Their study was based on effect of collaborative concept mapping teaching strategy on students' attitudes towards mathematics in secondary schools in Bomet County, Kenya. In his study, the concept mapping involved group discussions. This facilitated exchange of ideas and experiences thus promoting a better understanding of concepts. This was comparable to the current study since learners worked in pairs while generating and completing concept maps which facilitated sharing of information hence promoting meaningful learning.

Further, findings of this study are consistent with findings of the study conducted by Omondi, Keraro and Anditi (2018), on effects of advance organizers on students' achievement in biology in secondary schools in Kilifi County, Kenya. In this kind of framework advance organizers presented prior to learning assisted learners in organizing and interpreting incoming information thus fostering retention of knowledge. The same applied in the present study since advance organizers presented at the beginning of the lesson helped students to connect new information to existing knowledge. Frequent retrieval of pre-existing knowledge and connecting it to new knowledge fostered recall and storage of information into long-term memory.

4. Conclusion and Recommendations

Advance Organizer Concept Mapping Teaching Strategy is an effective teaching strategy in teaching physics since it results in high achievement in physics and also increases students' motivation to learn physics. Therefore, it is recommended that: Teacher training colleges should incorporate learner centred teaching methods such AOCMTS. This will equip teachers with effective teaching strategies capable of improving students' performance in physics. The ministry of education should in-service teachers on effective teaching methods for example the use of AOCMTS. This will enhance content delivery and consequently improve students' performance in physics.

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