Journal of Education and Practices
Vol 3 Issue No.3. January, 2023. PP 14-26. ISSN 2617-5444

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

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Abstract

Physics is a science that forms an important element in the Kenyan education system. It provides essential knowledge required for technological advancement, achievement of vision 2030 and realisation of sustainable development goals (SDGs). In spite of its importance, students' motivation to learn physics in Kenyan secondary schools remains low. Among the factors attributable to students' low motivation to learn physics include; use of teacher centred teaching methods and lack of teaching/learning resources. This study sought to find out the effects of Advance Organizer Concept Mapping Teaching Strategy (AOCMTS), on secondary school students' motivation to learn physics. Solomon's Four Non-Equivalent Control Group Design was used. Two experimental groups received the AOCMTS as treatment while two control groups were taught using regular teaching methods. The study was conducted in Rongai Sub-County. Four co-educational secondary schools were purposively selected and randomly assigned to experimental and control groups respectively. Data was collected from a sample of 192 form two students. It was gathered using Student Motivation Questionnaire (SMQ) and analysed with the aid of the Statistical package for Social Science. The t-test, one-way ANOVA and ANCOVA statistical techniques were used to analyse data. The hypotheses were tested at alpha level of 0.05. Findings of the study indicate statistically significant difference in motivation to learn physics between experimental and control groups in favour of experimental groups. Use of AOCMTS resulted in higher motivation to learn physics compared to the use of regular teaching methods. The study concluded that, Advance Organizer Concept Mapping Teaching Strategy may be effective in raising students' motivation to learn physics and hence physics teachers should be encouraged to use AOCMTS.

Key words: *Advance Organizer, Concept Mapping, Motivation, Physics Education, Teaching Strategy*

Introduction

Science is of great importance internationally for technological innovation and socio-economic development. Science also plays a major role in health improvement, industrialisation, communication and wealth creation (Egbogah, 2012). Even more, wireless technologies, for example the use of satellite dishes and computers have reduced the world into a global village. In addition, the use of mobile phone is an example of telephone innovation that has greatly improved life in Sub-Saharan Africa and the world at large. Most African countries are making use of science and technology as a driver for development among them, Rwanda's rapid ICT growth and Kenya's vision 2030 (Chakravorti & Shankar, 2019; Republic of Kenya, 2007).Physics is a branch of science concerned with properties of matter, energy and their interactions (Chu & Lin, 2002). It attempts to describe the physical universe around us (Minishi et al., 2012). Physics is an important subject in the educational system since it is widely used in everyday life and it also generates foundational knowledge essential for technological transformations.

Despite its importance, physics education continues to face myriad of challenges. Lack of motivation to lean physics is among the major challenges facing physics education not only in

Kenya, but also globally. In Brazil for example, most secondary students veer away from physics in secondary and tertiary levels (Dewitt& Archer, 2015).Similarly, in Malaysia, physics is considered as the most boring subject. In addition, physics is rated as the most unpopular science subject compared to biology and chemistry (Veloo &Khalid, 2015). Capturing and maintaining students' motivation to learn is an issue of concern in Kenyan Secondary schools. Few students show interest in physics at form three, and even fewer students choose to pursue physics or physics related courses at tertiary levels due to lack of motivation.

Strengthening of Mathematics and Science in Secondary Education (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. Among the major factors identified included: lack of teaching/learning resources, use of inappropriate teaching methods and lack of motivation among students (Waititu & Orado, 2009). According to Manasia (2015), motivation is the most important element in learning**.** Manasia (2015), notes that there exists an interrelation between motivation, mental cognition and conceptual change. Manasia (2015), also maintains that success in learning is determined by the level of motivation in learners.

Since motivation plays a key role in teaching and learning, physics teachers need to provide learning environments and learning experiences that are challenging enough to motivate learners. This may be achieved by use of Advance Organizer Concept Mapping Teaching Strategy (AOCMTS).Additionally, use of inappropriate teaching methods has been identified as one of the major causes of low motivation in physics students (Keraro et al, 2007).This study therefore sought to find out whether the use of Advance Organizer Concept Mapping Teaching Strategy, could help curb the problem of low motivation to lean physics in learners. An Advance Organizer is a teaching strategy used in introducing a lesson. It shows the relationship between what the students already know and the new information they are about to learn (Ausubel, 1963). It is usually presented during the beginning of the lesson and at a higher level of generality and inclusiveness than the content to be taught. Integration of new information into the existing mental structures is achieved when the new information interacts with Advance Organizers (Ausubel, 2000).

According to Novak (1998), a concept map is a conceptual diagram used to represent knowledge in two dimensions. Information is usually organised using circles and boxes connected by linking lines. The linking lines have wordings which specifies the relationship between concepts. Links between concepts and ideas can be linear, bilateral or directionless.

Similarly, Makoba (2012), maintains that Concept Mapping Teaching Strategy is among the Strategies advocated by Centre for Mathematics Science and Technology Education in Africa (CEMASTEA), as one of the student-centred teaching strategy. Its advantage is based on the fact that meaningful learning occurs when learners integrate new information into the existing mental structures. Similarly, Novak and Gowin (1984), strongly advocates for the use of Advance Organizers in teaching. According to them, Advance Organizers promote mastery and meaningful learning (Novak and Gowin 1984).

With regard to the immense contribution of Advance Organizers and Concept Mapping in learning, it is an area worth more research especially on the combination of two strategies. This study therefore sought to combine Advance Organizer with Concept Mapping as one teaching strategy and find its effects on motivation to learn physics. Advance Organizers were used during the introduction of the lesson while Concept Mapping was used during lesson development. Combining the two strategies provided learners with a wide range of learning experiences that provided activities for cognitive stimulation and learner interaction. Concept mapping activities for the learners involved; completion of partially completed maps and generation of concept maps using provided terminologies. The strategy is therefore likely to improve students' motivation to learn physics.

Research Objective

To investigate effects of Advance Organizer Concept Mapping Teaching strategy on secondary school students' motivation to learn physics. This was achieved by comparing motivational gains between students taught using Advance Organizer Concept Mapping Teaching Strategy and those taught using regular teaching methods.

Hypothesis of the Study

There is no statistically significant difference in students' motivation to learn physics between taught using Advance Organizer Concept Mapping Teaching Strategy and those taught using regular teaching methods.

Methodology

The study used Quasi-Experimental Research using Solomon four non-equivalent control group design because it is the most rigorous design for experimental and quasi experimental research (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 et al., 2002). Using the design, subjects were randomly assigned into four groups. Two of the groups were assigned experimental groups and received the treatment while the other two groups were assigned control groups which did not receive the treatment. Treatment was done using Advance Organizer Concept Mapping Teaching Strategy (AOCMTS).Learning experiences used in AOCMTS were:

i. Production of water and sound waves using water and vibrating springs.
ii. Generation of concept maps individually, in pairs and in groups of three.
iii. Summarisation of a subtopic using developed concept maps.
iv. Completion of partially completed maps.
v. Identification of key concepts in the concept maps.
vi. Establishing the interconnections between concepts.

One experimental and one control group received a pre-test. The post-test was administered to all the four groups. The pre-test was administrated to assess the plausibility of pre-test (sensitisation) effects, that is whether the pre-test itself had an influence on the post-test scores (Gall & Borg, 2006).The design adequately controls threats to external and internal validity, and allows the researcher to exert total control over the variables. The threats to internal validity are selection bias, history, instrumentation, maturation and regression to the mean. The research design was as shown in Figure 1.

Figure 1

Solomon Four Non-equivalent Control Group Design.

Group				
I	O_1	X	O_2	Experimental group
II	-	X	O_3	Experimental group
III	O_4	-	O_5	Control group
IV	-	-	O_6	Control group

Source: Gall and Borg (2006)

Key;

Pre-test: O_1 and O_4

Post-test: O_2, O_3, O_5 and O_6

Treatment: X

_ _ _ _ _ _ _Dashed lines show that the experimental and the control groups have not been equated by randomisation hence non-equivalent groups.

Group I was the experimental group which received a pre-test, treatment and post-test.

Group II was not given a pre-test but received the treatment followed by post- test.

Group III was the control group which received a pre-test and post-test.

Group IV was the control group which received a post-test only.

The target population was all physics students in all co-educational secondary schools of Rongai Sub-county, Nakuru County, Kenya. The accessible population was form two physics students in co-educational schools within the sub-county. The population of form two students was chosen because the topic 'Waves I' is taught at this level in all Kenyan Secondary schools (Republic of Kenya, 2002).

The sampling unit was co-educational secondary schools in Rongai Sub-County. The sample was drawn from forty public Sub-County co-educational secondary schools in Rongai Sub-County. Purposive Sampling technique was used to obtain a sample of four schools. Form two physics classes from the four sampled schools had the following number of students; 45, 49, 50, 48 forming a sample size of 192 students. 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 for the experimental schools. Simple random sampling was then used to pick one stream for data collection. The number of students per group was more than 30 which is suitable because experimental studies require at least 30 students per group (Mugenda & Mugenda, 2003). The sample size that participated in the study was as indicated in Table 1.

Table 1

Sample size of the Study

Group	Number students in each group
E_1	45
E_2	49
C_1	50
C_2	48
Total	192

The Student Motivation Questionnaire (SMQ) was used for data collection. The Student Motivation Questionnaire (SMQ) was used to assess students' level of motivation to learn 'Waves 1'.The researcher adopted and modified the questionnaire developed by Glynn (2011). SMQ items were constructed on a five-point Likert scale. To obtain data from the Student Motivation Questionnaire, the responses to the items on the SMQ were coded as follows; strongly disagree (1), disagree (2), undecided (3), agree (4), strongly agree (5).Responses to negative items on the SMQ were reverse coded. The scores were as follows; strongly disagree (5), disagree (4), undecided (3), agree (2), strongly agree (1).The data obtained was used in assessing the learners' level of motivation when taught using Advance Organizer Concept Mapping Teaching Strategy and when taught using Regular Teaching Method.

Content and face validity of the items in the Student Motivation Questionnaire was determined by research experts from the Department of Curriculum Instruction and Educational Management, Egerton University. Comments from the experts were used to improve the instruments. To establish reliability of the instruments, a pilot study was conducted in two schools from Rongai Sub-County, which were not part of the study but had similar characteristics to the sampled schools. The results from pilot testing were used to estimate the reliability of SMQ which was calculated using Cronbachs' alpha formula. The method was appropriate since the instrument was 5-Likert type items and was administered once (Mugenda & Mugenda, 2003).The Student Motivation questionnaire was adopted after the instrument yielded a reliability coefficient 0.73, which was above the required threshold of 0.70 (Mugenda & Mugenda, 2003).

Data was analysed by use of t-test, one-way ANOVA and Analysis of Covariance (ANCOVA).The t-test was used to determine if there was a significant difference between the means of students taught using AOCMTS and those taught using RTM. 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 that may have existed among the groups. All significant tests of statistics were computed at $\alpha = 0.05$ level of significance. Data was analysed with the aid of Statistical Package for Social Sciences (SPSS).

Results and Discussion

Pre-test Analysis

The study employed quasi-experimental research using Solomon's four non-equivalent control group 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 2.

Table 2

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

Test	Group	N	Mean Score	Std deviation	T-value	P-value
SMQ	E_1	45	69.71	12.86	0.64	0.34
	C_1	50	68.48	12.46		0.34

The results in Table 2 indicate that students' SMQ mean scores and standard deviation for E_1 and C_1 were (M=69.71, SD=12.86) and (M=68.48, SD=12.46) respectively. Independent sample t-test was done to establish whether the differences in mean scores were statistically significant at the level of $\alpha = 0.05$.Results in Table 2 also indicate that there was no statistically significant difference between the SMQ means of experimental group (E_1) and control group (C_1); (95) = 0.64 $P>0.05$. The data therefore shows that students in experimental and control groups had comparable abilities hence suitable for the study.

Effects of AOCMTS on Students Motivation to Learn Physics

The hypothesis sought to establish whether there was any significant difference in students' motivation to learn physics between students taught using AOCMTS and those taught using Regular Teaching Method. An analysis of SMQ post-test was carried out to determine the effect of AOCMTS on students' motivation to learn physics. The analysis compared motivational scores between students taught using Advance Organizer Concept Mapping Teaching Strategy and those taught using Regular Teaching Methods. The statements in the SMQ were quantified using a 5-point Likert scale. The values on the Likert scale were attached as follows. Strongly Agree (SA)=5,Agree(A)=4,Undecided(U)=3,Disagree(D)=2,Strongly Disagree(SD)=1.The negative statements were score in a reverse order. Table 13 shows a comparison of mean scores for SMQ post-test scores obtained by students in the four groups.

Table 1

SMQ Post-test Mean Scores for the Four Groups

Group	N	Mean Score	SD
E_1	45	106.84	14.87
E_2	49	103.61	11.87
C_1	50	72.30	8.78
C_2	48	76.19	8.01

Results in Table 3 indicate that the mean scores for SMQ in experimental groups in E_1 (106.84) and E_2 (103.61) were higher than those of control groups C_1 (72.30) and C_2 (76.19). Experimental groups E1 and E2 taught using AOCMTS obtained significantly higher scores in the SMQ than control groups C1 and C2, taught using RTM. The results indicate that the use of Advance Organizer Concept Mapping Teaching Strategy had a significant effect on students' motivation to learn physics compared to the use of regular teaching methods.

ANOVA test was carried out on SMQ mean scores to establish whether the differences were statically significant. ANOVA results on SMQ scores are presented in Table 4.

Table 2

Analysis of Variance (ANOVA) on SMQ Post-test Scores

	Sum of Squares	df	Mean Score	F	Sig
Between groups	46590.85	3	15530.28	125.38	.000
Within groups	23287.36	188	123.87		
Total	69878.20	191			

Results in Table 4 indicate that the differences in mean scores among the groups are statistically significant at F (3,191) =125.38 $P<0.05$. There was need to conduct a post hoc analysis using the least significant difference (LSD) to establish where the differences occurred. Results of the LSD post hoc analysis of SMQ post-test scores are presented in Table 5.

Table 3

Post -hoc ANOVA of SMQ Post-test Means for the Four Groups

I group	J Group	Mean differences(I-J)	p-value
E_1	E_2	3.23	0.16
	C_1	34.54*	0.00
	C_2	30.66*	0.00
E_2	E_1	-3.23	0.16
	C_1	31.31*	0.00
	C_2	27.42*	0.00
C_1	E_1	-34.54*	0.00
	E_2	-31.31*	0.00
	C_2	-3.89	0.86
C_2	E_1	-30.66*	0.00
	E_2	-27.42*	0.00
	C_1	3.89	0.86

Results in Table 5 indicate that the differences in SMQ 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 $P < 0.05$. However, the mean differences for E_1 and E_2 were not statistically significant and neither were those for C_1 and C_2. Since the study involved the use of non-equivalent control group design, there was need to perform analysis of covariance (ANCOVA) to confirm the results. Kenya Certificate of Primary Education (KCPE) Science scores were used as covariates. Results on ANCOVA are presented in Table 6.

Table 4

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

	Sum of squares	df	Mean Score	F	P-value
KCPE	4.46	1	4.46	0.04	0.85
Group	46268.99	3	15422.10	123.87	0.00
Error	23282.90	187	124.51		

$F=123.87$ DF=3, $P<0.05$ Covariate KCPE marks=222.72

Analysis of covariance (ANCOVA) results indicate that the differences in SMQ mean scores between the groups is statistically significant at $F(3, 187) = 123.87$ $P<0.05$. Post hoc pairwise comparison was conducted to establish where the least significant differences occurred. Results of post-hoc pairwise comparison are presented in Table 7.

Table 5

Post-hoc Pairwise Comparison on SMQ Post-test Scores Based on ANCOVA

I group	J Group	Mean differences(I-J)	p-value
E_1	E_2	3.10	0.20
	C_1	34.49*	0.00
	C_2	30.66*	0.00
E_2	E_1	-3.10	0.20
	C_1	31.39*	0.00
	C_2	27.56*	0.00
C_1	E_1	-34.49*	0.00
	E_2	-31.39*	0.00
	C_2	-3.83	0.94
C_2	E_1	-30.66*	0.00
	E_2	-27.56*	0.00
	C_1	3.83	0.94

Post-hoc pairwise comparison based on ANCOVA in Table 7 indicate that there was a statistically significant difference in the following groups.

i. Group E_1 and C_1
ii. Group E_1 and C_2
iii. Group E_2 and C_1
iv. Group E_2 and C_2

However, there was no statistically significant difference between groups E_1 and E_2 and groups C_1 and C_2 ANOVA and ANCOVA results revealed the following

i. There was no interaction between the SMQ pre-test and the treatment, if there were any interaction, results from the pre-tested groups would have been significantly different from the non-pretested groups.
ii. The study involved two experimental groups E1 and E2 and two control groups C1 and C2.Experimental group E1 and control group C1 were given the SMQ pre-test. The difference in students' motivational scores between the experimental groups E1 and E2 was not statistically significant. Similarly, the difference in students' motivational scores between control groups C1 and C2 was not statistically significant. This implies that the pre-test did not affect students' motivation to learn physics.

Results from ANOVA and ANCOVA confirms that there was a statistically significant difference between SMQ means of experimental and control groups. ANOVA and ANCOVA results indicated a remarkable difference in motivational scores between control and experimental groups in favour of experimental groups. Thus, the null hypothesis which stated that there is no statistically significant difference in students' motivation to learn physics between students taught using Advance Organizer Concept Mapping Teaching Strategy (AOCMTS) and those taught using Regular Teaching Methods (RTM) was rejected at $\alpha = 0.05$ level of significance. This indicates that use of AOCMTS increased students' level of motivation to learn concepts in Waves 1 in physics. This could be attributed to the use of varying teaching strategies. Concept mapping allowed learners to use various activities which included completion of partially completed maps, generation of new concept maps and summarisation of a subtopic using developed concept maps.

According to D'souza and Masheswari (2010), the level of motivation in learners increases when the teacher is responsive and attentive to learners. The use AOCMTS provided teachers' activities that ensured increased teachers' attention and provision of immediate feedback to the students. This might have resulted in increased student motivation in the experimental group. These teachers' activities were;

i. Assisting learners in developing the concept maps, guiding them and providing feedback during the concept mapping process.
ii. Moving around the class from one group to another monitoring, supervising and marking learners' work and correcting any misconceptions.
iii. Providing opportunities for group discussion.

Results of this study concur with findings of Keraro et al. (2007). Their study investigated the effect of cooperative concept mapping teaching approach on secondary school students' motivation in biology. In their study, students were required to arrange concepts hierarchically beginning with general concepts while splitting them downwards into more specific concepts.

Identification of key concepts and establishing the interconnections amounted to active engagement which facilitated meaningful learning and increased students' motivation. The same applied in this study owing to the fact that concept mapping enabled students to make frequent meaningful connections between concepts which led to active mental engagement and consequently led to improved students' motivation in learning concepts in Waves. The engagement aspect of concept mapping helped students to persist in learning despite challenges and obstacles experienced. They also portrayed willingness to participate in the authentic learning activities thus promoting higher levels of achievement in the physics achievement test.

The results of this study are also consistent with findings by Wachanga et al. (2015). In their study on the effects of collaborative concept mapping teaching approach on secondary school students' motivation to learn biology, in Nakuru County, students taught using collaborative concept mapping teaching approach portrayed a higher level of motivation than those taught using regular teaching methods. Increased motivation in the experimental group was due to the interactive aspect of concept mapping. In the present study, AOCMTS provided an opportunity for students' to interact. This promoted motivation as it provided an environment for exchanging ideas and sharing of feedback amongst students.

Results of the present study also agrees with findings by Shihusa and Keraro (2009). In their study they assessed the effect of advance organizers on students' motivation to learn biology. Results of their study revealed that students taught using advance organizers attained a higher level of motivation than those taught using regular teaching methods. The increased level of motivation in the experimental group was due active cognitive engagement provided by advance organizers. In the present study, advance organizers facilitated active cognitive engagement through scaffolding of mental processes which enabled incorporation of more elaborate information. According to Ryan and Deci (2009), learners get motivated to learn when they engage in activities that are related to their real life experiences. Use of Advance Organizers raised learner's motivation to learn physics as it enabled them to engage in activities they could relate with their day to day experiences. These activities included production of water and sound waves using water and vibrating springs respectively.

Additionally the repeated activity of connecting concepts and establishing their relationships promoted better understanding of content in Waves 1 (physics). This is because concept mapping advanced students' thought process and stimulated reflective thinking which consequently led to increased motivation. Further, the visual aspect of concept mapping stimulated thinking and aroused interest in learning. This could have led to improved motivation in the experimental groups.

Similar work by Namasaka (2009), investigated the effect of concept and vee mapping on students' achievement and motivation to learn Biology. The study employed two different teaching strategies which were used separately during lessons. The same also applied to the present study. Two different strategies were employed during instruction i.e. advance organizers and concept mapping. However, contrary to the study mentioned above, advance organizers and concept mapping were used jointly in all lessons in the present study.

Conclusion and Recommendation

Based on the findings of the study, it can be concluded that students taught using Advance Organizer Concept Mapping Teaching Strategy developed higher motivation to learn physics than those taught using regular teaching methods. Therefore, this study recommends that teacher training colleges incorporate learner centred teaching methods such as AOCMTS. This may equip teachers with effective teaching strategies capable of improving students' motivation to learn physics.

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