Effects of Constructivist Teaching Strategy on Secondary Schools Students' Achievement in Mole Concept in Chemistry in Meru South District, Kenya

Mark I. O. Okere, Antony Njue and Samuel W. Wachanga
Department of Curriculum, Instruction and Educational Management
Egerton University

Abstract

This study investigated the effects of using the Constructivist Teaching Strategy (CTS) on secondary school students' achievement in the mole concept in chemistry. Solomon Four non-equivalent control group design was used. Data were collected from four schools which were randomly sampled within Meru South District. The sample comprised 170 form 3 students. All the schools used were co-educational; this was to ensure homogeneity in characteristics. The experimental groups 1 and 3 were taught using CTS while the control groups 2 and 4 were taught through regular teaching methods. The students were pre-tested before implementation of the treatment. The treatment took five weeks after which the post-test was administered to all the four groups using Chemistry Achievement Test (CAT). Pre-test results were analysed using t-test while the post-test results were analysed using t-test and ANOVA. Least Significant Difference (LSD) was used to show differences between groups. The results show that CTS increased achievement in chemistry significantly, and that this was so with respect to both boys and girls. The researchers concluded that CTS is an effective teaching approach and should therefore be incorporated in all chemistry teacher education programmes in Kenya.

Introduction

While knowledge of chemistry is important for the technological development of any country, its teaching in Kenyan secondary schools has been found wanting. This is depicted by the low achievement of students in chemistry at Kenya Certificate of Secondary Education (KCSE) in Kenya (KNEC, 2006). One concrete example of this trend is the performance of students in Meru

South District. Students' performance in chemistry at KCSE for a period of five years in the district is given in Table 1.

Table 1: Performance in chemistry at KCSE in Meru South District

Year	Enrolment and performance in Chemistry		
	Enrolment	Mean Score	Mean Grade
2005	2500	3.96	D
2006	2611	4.45	D+
2007	2400	4.62	D+
2008	3498	4.46	D+
2009	3060	4.34	D+

Source: KNEC, 2010

Poor performance in chemistry has been attributed partly to the failure by teachers to use strategies that motivate learners during instruction. Okere (1996) points out that the quest for better teaching strategies has been going on for a long time without success. He also argues that the aims of the school curriculum will not be achieved unless appropriate teaching strategies are used. According to Kiboss (1997) most of the teaching strategies practised in Kenyan schools are expository and facts oriented, making students passive learners. Taking into account the poor performance in chemistry, there is a need to improve the teaching of the subject.

Campell (1995) established that generally boys receive encouragement and teacher initiated interactions while girls are criticised for the poor academic quality of their work. This differential treatment can lead to faulty perceptions that science is a male domain. Ausubel and Robinson (1969) ascertain that there is a complex assortment of social forces and procedures that influence gender inequalities related to chemistry. For example, parents of young children may express different expectations in chemistry classes for their sons and for their daughters.

The research findings in Kenya indicate that gender differences in chemistry achievement begin to appear in lower classes and increase at higher levels in colleges and universities (Maritim, 1994). This gender difference is attributed to a combination of factors within the school environment. Eshiwani (1975) argues that science and mathematics in secondary school classrooms have been depicted as masculine subjects and the link between science in the class-room and its relevance in everyday situations is lacking. Maritim (1994) observes that teachers act discriminately, encouraging and offering more

opportunities to high performing students. In turn high performing students become more responsive and dominate class discussions.

One of the possible factors that contribute to the poor performance in science subjects is the conventional approach used in the teaching of these subjects. An advancement in the study of chemistry has continued at a rapid rate. This study has been characterised by an increasing sophistication in the use of physical methods as well as concepts and insights. In spite of these developments teachers in Kenya have maintained the same basic approach with the objective of providing the students with background sufficient for comprehension of difficult topics in chemistry (Wachanga, 2002).

This study focused on how teachers and students can become a community of thinkers. A community in the sense that the classroom becomes a place where ideas are shared through an interactive learning environment in an atmosphere of coming to know through understanding and discussion. When guiding students, the teacher must have not only a model of the students' present conceptual structures but also an analytical adult conceptualisation towards which his guidance is to lead. This can be achieved by using the Constructivist Teaching Strategy (CTS) which is guided by the following five basic elements: activating prior knowledge, acquiring knowledge, understanding knowledge, using knowledge, and reflecting on knowledge (Tolman and Hardy, 1995). Activating prior knowledge is very important since what is learned is always learned in relation to what one already knows. When teachers are familiar with a student's prior knowledge they can provide learning experiences to build on the existing understandings (Steffe and D'Ambrosio, 1995). Prior knowledge can be activated in many ways, for example, by asking students what they know, by brainstorming, by doing semantic mapping, by predicting outcomes or by performing some skill or process.

Ngatia (2008) investigated the effect of CTS on students' conceptualisation of electrostatics in secondary school physics in Nakuru District, Kenya. Data were collected from form 1 students selected from four co-educational secondary schools (one class from each school). Two schools were experimented while two schools were control. Students in experimental schools were taught using CTS while the control groups were taught using the conventional approaches. When post-test was administered to the four groups, findings indicated that CTS enhances conceptualisation of electrostatics more than the conventional teaching methods.

The constructivist view of learning and teaching is very relevant to the teaching of most concepts in physics, which sometimes prove to be too difficult for students (Okere, 1996). According to Driver and Bell (1989) CTS could enhance the understanding of scientific concepts by learners since it involves construction of meanings based on learners' prior knowledge.

By incorporating CTS, chemistry teachers may overcome the shortcomings which hinder performance and improve students' achievement. In this strategy the learners are seen as constructing meaning from input by processing it through existing cognitive structures and then retaining it in long-term memory. This is done in ways that leave the input open to further processing and possible reconstruction (Okere, 1996).

What students come to know results from active construction of concepts in making sense of their experience. This construction process is important because unless students build their own representation of new learning, it will be retained as relatively meaningless and inert rote memory (Good and Brophy, 1995).

In this study the researchers aimed at determining the effects of using CTS on students' conceptualisation of the topic of the mole in the form 3 chemistry syllabus, in Meru South District. According to KNEC (2006) this is one of the poorly performed areas. The researchers were interested in determining whether the use of CTS could reverse this poor performance in the mole concept.

The mole concept is an abstract topic which is first mentioned in the form 3 chemistry syllabus. This topic is taught using practicals, and because it has no prerequisites, the learners rely on previous knowledge of the periodic table, chemical symbols and balancing stoichiometic equations, all of which are taught in form 1 when students have not conceptualised basic scientific ideas. This study used CTS in teaching the mole concept as follows:

During the introduction of the topic of the mole a constructivist teaching module which comprises five stages was used. These stages were: orientation, elicitation, restructuring, applying, and review. During the orientation stage, the teacher asked the learners probing questions which lead to the idea of relative atomic mass. A series of experiments were carried out which led to a discussion about the mole. For example, the teacher asked the learners to state how large quantities of coins with the same denominations could be counted.

This led to discussions in groups of learners who were expected to come up with ideas about the mole as a basic unit or simply a chemical counting unit.

The experimental classes were composed of eight groups of five learners each. The groups comprised both boys and girls. There was a group leader who took control of the group, kept order, and recorded the data collected. A sheet of paper containing instructions, procedures and tables to fill in the data was given to each group. The teacher played an observer and dispute settler role during practical sessions. There were class discussions after every practical session where each group presented their findings.

Statement of the Problem

Kenyan secondary school students' performance in chemistry, particularly in the section concerning the mole concept, has been poor. The mole concept is a very important component of the secondary school chemistry syllabus. About 40% of the questions in the three papers of chemistry lay emphasis on the mole concept. This section has consistently been performed poorly over the years by both boys and girls. One of the possible causes of the poor performance in the mole concept is poor teaching strategies used by teachers. CTS has been known to improve students' conceptualisation of certain topics like force in physics. However, it was not clear how this strategy would affect students' achievement in chemistry. This study applied CTS in teaching the mole concept to form 3 students and establishing its effects on students' performance.

The Purpose of the Study

This study was designed to determine the effectiveness of CTS on secondary school students' achievement in the mole concept in chemistry in Meru South District, Kenya.

Objectives of the Study

The study was guided by the following objectives:

(i) To determine if CTS affects secondary school students' achievement in the mole concept.

(ii) To establish if the effect of CTS on secondary school students' achievement in the mole concept is gender dependent.

Hypotheses

To achieve the above objectives, the following hypotheses were tested at 0.05 level of significance.

HO_1 There is no statistically significant difference in secondary students' achievement in the mole concept between those who are exposed to CTS and those not exposed to it.

HO_2 There is no statistically significant difference in the achievement of secondary school students who are exposed to CTS in the mole concept in terms of their gender.

Conceptual Framework

Learning outcomes depend on the teaching strategies the teacher uses. In this study the conventional teaching method and CTS were the independent variables on which the learning outcomes depended. The learning outcome was the students' conceptualisation of the mole concept and which formed the dependent variable.

Learning outcomes are also influenced by other factors forming the extraneous variables. Students' gender influences the attitude to learn science where girls feel that science subjects are hard and therefore a male domain. Age will also determine the prior experience learners have about the mole. The teachers' training and experience determine their effectiveness in teaching the science concepts. Environment and facilities will also determine the practical skills and experiences acquired by learners.

Figure 2 gives the conceptual representation of the relationships of the variables of the study. The teacher variables were controlled by involving male teachers whose training and experience are equivalent. This was ascertained by involving teachers who are trained and have at least three years teaching experience. The researchers also trained the teachers in the use of CTS. The age of students was controlled by involving form 3 students only who are approximately of the same age.

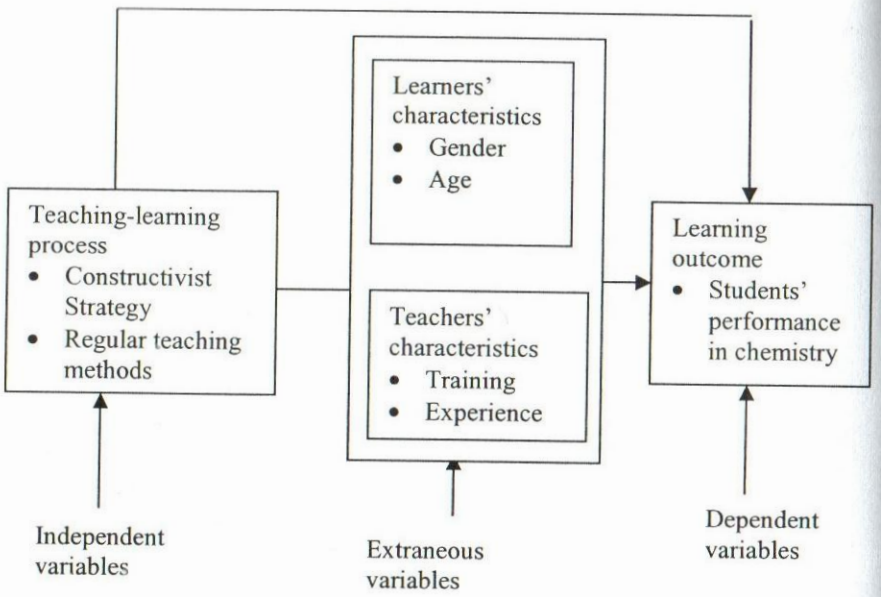

Figure 1: Conceptual Framework showing the relationship between variables

Methodology

The study involved quasi-experimental research design (Coolican, 1994). This is because secondary school classes once constituted exist as intact groups and school authorities do not allow such classes to be broken up and constructed for purposes of research (Borg and Gall, 1989). The design is shown in figure 2.

Group 1	O_1	X	O_2
Group 2	O_3	-	O_4
Group 3	-	X	O_5
Group 4	-	-	O_6

Figure 2: Solomon's Four non-equivalent control group design

In this design, subjects were assigned randomly to four groups. Groups 1 and 3 received the experimental treatment (X) whereby CTS was used in teaching. Group 1 received pre-test (O_1) whereas groups 2 and 4 were taught using the conventional method. Group 2 received pre-test O_3 and finally all the groups received post-test. Post-test results for the four groups are O_2, O_4, O_5 and O_6 respectively. In this research design, post-test only group 4 and the pre-test-post test (group 2) control extraneous variables of testing, namely, history and maturation, respectively.

The population consisted of all co-educational secondary schools in Meru South District. Simple random sampling technique was used to draw four schools out of accessible 46 schools for this study. According to Mugenda and Mugenda (1999), at least 30 cases per group are required for experimental research. Four schools were sampled and one stream from each school was included in the study sample.

The actual sample size that participated was 170 students. However, during the coding of data, it was found that three students had either incomplete data and/or missed some test, hence reduced the sample size for data analysis to 167 students. These subjects were used in their intact classes in the four schools that were randomly assigned to experimental groups 1 and 3 with 43 and 32 students respectively, and control groups 2 and 4 with 47 and 48 students respectively.

The instruments used in assessing students' chemistry achievements were CAT1 and CAT2 which were developed and validated prior to the main study. The tests were given to five university lecturers who gave their comments after studying the items. Language and other noticeable problems were corrected. The two tests were then validated by three secondary school chemistry teachers who were also chemistry examiners with KNEC.

The test items in CATs 1 and 2 were pilot tested using a co-educational day school that was not part of the study, but having similar characteristics as the sample schools. This school was drawn from Embu District. This ascertained the tests' suitability, content validity, and reliability.

The reliability coefficient was estimated using Cronbach's coefficient Alpha, as the items on the instrument were not scored dichotomously (Gall and Borg, 1986). This was appropriate as the instruments contained items that were

scored through a range of scores. CAT1 and CAT2 had reliability coefficients of 0.72 and 0.83 respectively.

Pre-test CAT1 was first administered to students in experimental group 1 and control group 2 for purpose of ascertaining their entry level of heterogeneity. Experimental groups 1 and 3 were exposed to a series of lessons in teaching the mole concept using CTS. Groups 2 and 4 were taught the same topic using the conventional teaching approach, which was mainly teacher centred. After the students in the four groups had been taught the mole concept, CAT2 was administered at the same time to all the groups. Table 2 shows the t-test analysis of the pre-test scores.

Results

Result of the Pre-Test

As shown in Table 2, the pre-test mean scores of both groups 1 and 2 were similar. A further analysis was necessary to establish whether the mean scores were statistically different at $\alpha = 0.05$ significance level. The t-test value was $t(73) = 0.265$, $p>0.05$. The t-test analysis reveals that the pre-test mean scores for groups 1 and 2 on CAT1, were not statistically significant at $\alpha = 0.05$ significance level.

Table 2: The t-test of the pre-test scores on CAT1:

Variable	Group	Mean	SD	t-value	p-value
CAT1	1	24.38	14.64	0.265	0.79(ns)
	2	23.47	12.82		

Group 1, N = 43 Group 2, N = 32

Table 3 gives a summary of the pre-test scores on CAT1 based on students' gender.

Table 3: Independent sample t-test of the pre-test scores on CAT1 based on students' gender

Variable	N	Gender	Mean	SD	t-value	p-value
CAT1	54	M	24.68	14.52	0.54	0.59
	36	F	22.75	12.45		

The results in Table 3 indicate that the male students had a mean score of 24.68 while that of female students was 22.75.

Thus, it is clear that CAT1 pre-test mean scores of the male and female students were similar. A further analysis of these results was necessary in order to establish whether the mean scores were statistically different at $\alpha = 0.05$ significance level. The t-test results reveal that CAT1 pre-test mean scores of the male and female students were not statistically different ($t(.88) = 0.541$, $p>0.05$). This indicates that the groups used in the study were comparable and had similar entry behaviour, hence were homogenous. This made them suitable for study.

Effects of CTS on Students' Achievement

In order to determine the effect of CTS on students' achievement in chemistry, an analysis of the students' post-test CAT scores was carried out.

Null hypothesis 1 (HO_1) of the study sought to find out whether there was a statistically significant difference between achievements of students who were exposed to CTS and those who were not exposed to it.

Table 4 shows CAT2 post-test mean scores obtained by the students in the four groups.

Table 4: CAT2 post-test scores obtained by the students in four groups

Group	N	Mean score	SD
1	43	72.05	10.88
2	47	40.56	8.54
3	32	59.81	11.95
4	48	25.39	9.80
Total	**170**	**53.61**	**10.29**

Results in Table 4 show that the CAT2 post-test mean scores for the experimental groups 1 and 3 (72.05 and 59.81) and those of control groups 2 and 4 (40.56 and 25.39) respectively, were similar. However the CAT2 post-test mean scores for the experimental groups 1 and 3 were much higher compared to those of control groups 2 and 4. This suggests that the experimental groups performed better than control groups in the CAT2. In order to determine whether the differences in the CAT2 post-test mean scores

were statistically significant, a one-way ANOVA was performed. The results of the one-way ANOVA based on these mean scores are shown in Table 5.

Table 5: ANOVA of the post-test scores on CAT2

Source of variation	Sum of squares (SS)	DF	Mean squares	F-ratio	p-value
Between groups	5103.71	3	1701.23		
Within groups	15677.66	169	92.76	18.34*	0.05
Total	**20781.37**	**172**			

* denotes significant mean differences at $p<0.05$
(F tabulated 3,167 = 2.63
(F computed =18.34)
DF = Degree of Freedom

The results in Table 5 reveal that the differences between CAT2 post-test mean scores of the four groups were statistically significant ($F(3,169) = 18.34$, $p<0.05$). Having established that there was a significant difference between the means, it was necessary to carry out further tests to find out where the difference occurred. Table 6 shows the results of the Least Significant Difference (LSD) post-hoc comparison.

Table 6: Post-hoc comparisons of post-test of CAT2 mean scores for the four groups

	(I) Group	(J) Group	Mean difference (I - J)	P-Value
LSD	1	2	20.15*	0.00
		3	1.74	0.64
		4	21.24*	0.00
	2	1	-20.15*	0.00
		3	-18.41*	0.00
		4	1.09	0.77
	3	1	-1.74	0.64
		2	18.41*	0.00
		4	19.50*	0.00
	4	1	-21.24*	0.00
		2	-1.09	0.77
		3	-19.50*	0.00

* = The mean difference is significant at $P<0.05$

The results on Table 6 show that the pairs of CAT2 mean scores of group 1 and 2, 1 and 4, 2 and 3 and 3 and 4 were significantly different at $\alpha = 0.05$ level of significance. However, the mean scores of experimental groups 1 and 3 and the control groups 2 and 4 were not statistically different. With reference to these findings, the null hypothesis 1 (HO_1) which suggested that there was no statistically significant difference between achievements of students who were exposed to CTS and those who were not exposed to it is rejected.

The control groups were taught through the conventional teaching method. This is in support of the idea that CTS results in higher achievement in chemistry than conventional teaching approach.

Effects of CTS on Boys and Girls

Groups 1 and 3, which were taught through CTS, comprised 39 boys and 36 girls respectively. An independent sample t-test was carried out in order to test null hypothesis 2 (HO_2) that was meant to establish whether there was any statistically significant difference in achievement scores between girls and boys taught through CTS. The post-test CAT2 scores obtained by boys and girls in groups 1 and 3 are presented in Table 7.

Table 7: Independent sample t-test of the post-test CAT2 scores for boys and girls exposed to CTS

Gender	N	Mean	SD	T	Df	P-Value
Boys	39	53.83	19.20	0.23	73	0.81
Girls	36	52.77	16.71			

ns = Not significant at $p<0.05$ level

Table 7 shows that the results of post-test CAT2 mean scores for boys and girls (53.83 and 52.77) respectively were close. From the table it is clear that boys attained a slightly higher mean score than girls.

Further analysis was necessary to establish whether the difference between the mean scores was significant at $\alpha = 0.05$ level of significance. The t-test results indicate that the difference in CAT2 post-test mean scores of boys and girls were not statistically significant ($t(73) = 0.23$, $p>0.05$). With reference to this the null hypothesis 2 (HO_2) which indicates that there was no statistically significant difference in achievement in the mole concept of boys and girls

who are exposed to CTS is accepted. This implies that boys and girls who are exposed to CTS perform equally well.

Discussion

In this study the researchers found that students who were taught through CTS achieved relatively higher scores in CAT2 as compared to those not taught through it. This implies that the use of CTS is more effective than the conventional teaching approach. In CTS the teacher plays the role of helping the student to conceptualise ideas and processes. He facilitates the learning process. Constructivism fosters interaction between students themselves and between the teacher and the students which enables the students to make consensus (Okere, 1996).

The findings of this research further support findings of Wachanga (2002) that achievement in chemistry and science in general depend on the effective use of modem teaching methods that emphasise heuristic approach (in this case CTS).

A constructivist teacher offers his or her students options and choices in their work. He/she rejects the common practice of telling students what to do. Students may participate in the construction of the curriculum by negotiating the themes that will be the focus of their work along with the selection of literature from a predetermined range of literature. Students may also participate in the design of their assignments, although the parameters for these may be established by their teacher. Finally, students may discuss with their teacher how their assignments are evaluated.

In this study students worked in groups of five, who later presented the results of their discussions to the whole class. Results of this study show that there is no statistically significant difference between the achievement of boys and girls who were taught through CTS. They also show that boys and girls who were taught through CTS performed better than those who were taught through the conventional teaching approach. In essence, CTS appears to be more effective in enhancing students' achievements in chemistry regardless of gender.

In a study aimed at improving the participation and performance of girls in science and mathematics in secondary schools in Kenya, it was found that girls' achievement in chemistry was lower than that of boys partly due to the

former's negative attitude towards science (Wachanga, 2002). This study further reported that the teacher in a normal competitive class consciously or unconsciously discourages girls' participation in learning. For example, some teachers assume that girls would be unable to answer certain types of questions or perform certain science concepts (ibid.). Under CTS, learning is a social process where students interact with each other and with the teacher, therefore all the students have equal opportunities to participate.

Some teachers also make remarks which make girls feel lesser students and lazy. Campell (1995) established that boys receive more praise and teacher initiated contacts while girls are criticised more frequently for the academic quality of their work. This differential treatment causes a faulty perception that chemistry and mathematics are male domains. Sandkers and Pihney (1979) observed that male and female teachers are biased by giving more attention to boys than to girls. This practice has made the girl child to believe that she is less capable, a factor which in turn affects her self-esteem and confidence leading to poor performance.

Contrary to earlier studies which indicate that some students interact more with their teacher than others (Maritim, 1994; Campell, 1995), the findings of this study placed all the students on the same level. This implies that in a constructivist classroom, irrespective of gender, learners have equal opportunities to interact and fully participate in lessons. Indeed, studies have shown that the collaborative socialisation during the teaching and learning process is critically important in students' achievement (Eshiwani, 1983; Kiboss, 1997; Wachanga, 2002).

In a constructivist classroom the chemistry teacher is able to balance the class interaction patterns between boys and girls. By using CTS, similar attention is given to boys and girls and in both, a reasonably high achievement is realised. In this regard, it is evident that disparity between girls' and boys' achievements in KCSE chemistry examination can be addressed through CTS.

Conclusion

Bases on the results of this study the following conclusions have been reached:

1. CTS facilitates students' learning in chemistry better than regular teaching methods.

2. Both girls and boys who are taught chemistry through CTS will learn and achieve significantly better results than those who are taught through regular teaching methods.

Implications

The following implications can be deduced from the findings of this study:

CTS enabled students to interact freely in the construction of knowledge. This helped the creation of a conducive atmosphere for effective learning. It is important therefore for science and mathematics teachers to make use of CTS in their teaching and also put in consideration the learners' prior knowledge so as to build on it in the subsequent learning activity.

Driver (1984) suggests that learners' prior knowledge is an important factor in their understanding of school science. In this regard CTS is an effective teaching approach in the learning of the mole concept in chemistry. Teachers should therefore take into consideration the learners' prior ideas on the given topic before introducing complex aspects of the topic in chemistry instruction.

CTS as embraced in this study revealed that the coverage of the constructivist lessons took longer than what would have been the case with a conventional lesson. This means adequate time is needed for the preparation of a constructivist class so as to develop challenging activities which will enhance the effective acquisition of knowledge by learners.

Although the findings of this study show a very significant improvement in the learners' achievement in the mole concept, for sound and valid generalisations, more studies on the effect of CTS on learners' achievement in other topics in chemistry is necessary. Of particular concern are its effects on students' achievements in organic chemistry, electrolysis and radioactivity.

This study raises some possibilities for improving educational practice in chemistry and some questions about the way professional development has traditionally been delivered and new curricula implemented. New curricula emphasise an holistic and constructivist rationale, and the implementation of these new curricula necessitates that teachers make significant changes in the way they teach in addition to understanding the constructivist philosophy upon which CTS is based. Teachers, administrators and others involved in implementing these new curricula need to understand the kinds of changes

teachers need to undertake as they make the transition from more regular forms of instruction to constructivist strategies as well as how they can make these changes.

References

Ausubel, D. & R. Robinson (1969) *School Learning: An Introduction to Education Psychology*. New York: Holt, Rinehart & Winston.

Borg, W. & M. Gall (1989) *Educational Research: An Introduction* (5th edition). New York: Longman.

Campell, B. P. (1995) "Redefining the Girl Problem in Mathematics." In: B. P. Campell, *New Direction for Equity in Mathematics Education*. New York: Cambridge University Press, pp. 259-275.

Coolican, H. (1994) *Research Methods and Statistics in Psychology* (2nd edition). London: University Press.

Driver, R. (1984) "A Review of Research into Children's Thinking and Learning in Science." Paper presented at a conference on "Learning Doing and Understanding Science," London.

Driver, R. & B. Bell (1989) "Students Thinking and Learning of Science a Constructivist View." – *The School Science Review*, Vol. 67, No. 240, pp. 443-457.

Eshiwani, G. S. (1975) "Sex Differences in Learning Mathematics among Kenya High School Students." Paper for Staff Seminar at Bureau of Education Research, University of Nairobi, May 21.

Eshiwani, G. S. (1983) *Research into Methods of Teaching Mathematics*. Nairobi: Kenyatta University.

Gall, M. D. & W. R. Borg (1986) *Education Research: An Introduction* (6th edition). White Plains, New York: Longman.

Good, T. C. & J. Brophy (1995) *Contemporary Educational Psychology*. White Plains, NY: Longman.

Kiboss, J. K. (1997) "Relative Effect of Computer Based Instruction in Physics on Students' Attitudes, Motivation and Understanding about Measurements and Perception of Classroom Environment." Unpublished Ph.D. Thesis, University of Western Cape, Dellville.

KNEC (2006) *KCSE Report 2005*. Nairobi: KNEC.

_____ (2010) *KCSE Report 2009*. Nairobi: KNEC.

Maritim, E. K. (1994) "Observed Classroom Interaction and Academic Performance of Primary School Pupils." – *Kenya Journal of Education*, Vol. 1, No. 1, pp. 1-21.

Mugenda, O. M. & A. G. Mugenda (1999) *Research Methods: Quantitative and Qualitative Strategies*. Nairobi: Act Press.

Ngatia, B. G. (2008) "Effects of Constructivist Teaching Strategy on Students' Conceptualisation of Electrostatics in Secondary School Physics." Unpublished M.Ed. Thesis, Egerton University.

Okere, M. I. (1996) *Physics Education: A Textbook of Methods for Physics Teachers*. Egerton University EMC/ Nairobi: Lectern Publications Ltd.

Sandkers, W. B. & T. K. Pihney (1979) *The Conduct of Social Research*. Chicago, CA: Holt, Rinehart and Winston.

Steffe, L. P & B. S. D'Ambrosio (1995) "Toward a Working Model of Constructivist Teaching a Reaction to Simon." – *Journal of Research in Mathematics Education*, Vol. 26, No. 2, pp. 146-159.

Tolman, M. N. & G. R. Hardy (1995) *Discovering Elementary Science Method, Content and Problem Solving Activities*. Needham Heights, MA: Allyn & Bacon.

Wachanga, S. W. (2002) "Effects of Co-operative Class Experiment Teaching Method on Secondary School Students' Motivation and Achievement in Chemistry." Unpublished Ph.D. Thesis, Egerton University.