Science Education International
Vol. 25, Issue 4, 2015, 488-500

Effect of Programmed Instruction on Students' Attitude Towards Structure of the Atom and the Periodic Table among Kenyan Secondary Schools

M. J. WANGILA[*], W. MARTIN[†], M. RONALD[‡]

ABSTRACT: This study examined the effect of Programmed Instruction on students' attitude towards Structure of the Atom and the Periodic Table (SAPT) among mixed (co-educational) secondary schools of Butere district, Kakamega county, Kenya. The quasi-experimental research design was adopted, using the nonrandomized Solomon four-group as a model. The sample comprised of 300 form two (2nd grade in the Kenyan secondary school education cycle) students and 8 Chemistry teachers who were purposively sampled. Instructional software was developed, validated and used by subjects in the experimental groups while the control groups learned the conventional way. The Students' Attitude Determination Questionnaire (SADQ) was created, validated and used to collect raw data, which was analysed both descriptively (using mean, mean gain and standard deviation) and inferentially (using one-way ANOVA) at $\alpha=0.05$. It was concluded that Programmed Instruction is more effective in improving students' attitude towards SAPT than the popular conventional approaches because the results indicated that the attitude mean scores of the sampled students were statistically the same before intervention. However, the experimental groups obtained significantly higher attitude mean scores than the control groups after intervention. This significant change was attributed to the treatment that the experimental groups received.

KEY WORDS: programmed instruction, conventional approaches, attitude, SAPT, mixed school.

INTRODUCTION

The global aim of science education is to enable learners acquire knowledge, skills and attitudes that would be relevant to their future livelihoods (Taber, 2009). Chemistry education specifically aims at fostering students' positive attitude towards appreciating the usefulness and

[*] (Corresponding author) Msc, Chemistry and Mathematics Teacher, Shiraha Secondary School, P.O. Box 68 - 50101, Butere, Kenya. E-mail: jossemasinde@yahoo.com
[†] Phd, Lecturer, Masinde Muliro University of Science and Technology, Department of Science and Mathematics Education, P.O. Box 190 - 50100, Kakamega, Kenya. E-mail: msibweche@yahoo.com
[‡] M.ed, Lecturer, Masinde Muliro University of Science and Technology, P.O. Box 190 - 50100, KAKAMEGA, Kenya. E-mail: michiekamr@yahoo.com

relevance of science in the modern world (Jenkins and Whitefield, 1974). Chemistry is therefore an important subject in the secondary school curriculum since it provides knowledge that prepares learners for further study, vocations and to appreciate their environment. Furthermore, Chemistry integrates knowledge learnt from other subjects and therefore has many important applications in fields like; Agriculture, Medicine, Biotechnology, Engineering and Industrialization (Gilbert et al, 2000). Great emphasis is therefore placed on the application of Chemistry knowledge to solve environmental and other real life problems.

In China, USA, Japan, the UK and other developed countries, advances in technology have caused improved standards of living, health and infrastructure. These nations have invested heavily in science education via Science and Technology Innovations (S&TI) and have consequently gained competitive advantage on the global map. Sadly, African and most of the third world countries lag far behind in technological development, courtesy of their sorry state of science education (World Bank, 1989; Lewin et al., 1997; Godek, 2004; GoK, 2008). African countries continue to face several challenges in science education including scarce resources, inadequate funding, poorly trained teachers, poorly paid and ill-motivated teachers, lack of instructional materials, brain drain and flagging political will among other factors (World Bank, 1989; Godek, 2004).

In Kenya, one of the formidable problems currently facing Chemistry education is negative attitude towards abstract topics in the subject, which is believed to be one of the reasons why students perform poorly in the subject in form four national examinations (KNEC, 2010). Structure of the Atom and the Periodic Table (SAPT) has been reported as one of the abstract Chemistry topics in which students perform poorly, which has been attributed to teachers' use of teacher-centered instructional approaches (KNEC, 2010). Attitude as used in this study means students' feelings of approval or disapproval of the learning process. Research has revealed that use of effective student-centered instructional approaches has a significant impact on the aforementioned learning outcome, especially in abstract topics (Sola and Ojo, 2007). Chemistry teachers should therefore play their part in solving this problem by embracing such instructional strategies.

SAPT is a form two topic, ideally scheduled to be taught in 22 lessons of 40 minutes each. The specific objectives outlined in the syllabus state that by the end of the topic, the learner should be able to; (i) describe the structure of the atom and label it, (ii) perform simple calculations on atomic number, mass number and relative atomic mass, (iii) write the electron configuration of the first 20 elements, (iv) build a simple periodic table and explain the position of an element in the table, (v) define and derive valency and oxidation number of an element from its position in the periodic table, (vi) write the chemical formulae of simple compounds and radicals and (vii) write simple and well balanced chemical equations (KIE, 2009). KNEC annually evaluates the attainment of these curriculum objectives by way of an examination at the end of the four-year secondary school cycle - KCSE. Chemistry is examined in three papers, two of which are theory-based (Papers 233/1 and 233/2) and the third is a practical (233/3). Attainment of these objectives is however far from successful as shown in Table 1.

Table 1 **National mean scores of Chemistry compared to Biology from 2003 to 2010**

Year	2003	2004	2005	2006	2007	2008	2009	2010
Biology	41.10	49.07	41.59	54.89	53.90	60.64	54.29	56.00
Chemistry	37.40	39.62	38.05	49.82	50.78	45.48	39.52	38.52

Source: KNEC, (2010)

Table 1 reveals the sad story of Chemistry education in Kenya, where it is apparent that Chemistry has always been outperformed by Biology for the last eight consecutive years, yet it is a subject of similar difficulty level and students' enrolment (Masinde, 2014). This suggests that the students could be experiencing some difficulties in understanding some fundamental concepts like the SAPT as pointed out by annual examination reports. Being a core topic, its understanding or failure thereof has spill-over effects on other topics like the highly feared mole concept (Mulavu, 2011). It is therefore necessary to rethink the instructional strategies adopted in this topic, with a view to improving performance in the subject so as to ameliorate the predicament plaguing Chemistry education in the country. Butere district is one region in Kenya that has adversely been affected in this regard as shown in Table 2, which gives a comparison of the performance of the two science subjects for the last five years.

Table 2 **Chemistry and Biology mean scores for past Butere district KCSE exams**

Subject	2013	2012	2011	2010	2009
Chemistry	4.48	4.65	4.20	4.89	3.82
Biology	4.98	5.00	5.47	6.19	5.05

Source: DEO - Butere district

Table 2 clearly shows that something is amiss in Chemistry for there is no single year that the subject has competed favourably with Biology in the district for the last 5 years! A good student centred approach to the teaching and learning of all abstract topics in Chemistry should therefore be emphasized because they are much more difficult to internalize (Twoli, 2006).

Programmed instruction (PI) is one good example of a student-centred, self-teaching approach to learning, which was invented by the behaviourist B.F. Skinner to improve teaching. In this approach, content is sub-divided into small parts in sequential order, whereby the student must be successful in one part before he or she can proceed to the next (Skinner, 1958). Research reveals that PI materials represent a viable alternative for average and below average students who do not respond adequately to conventional approaches to instruction (Carbo & Davids, 1963).

Programmed Instruction is based on Skinner's theory of verbal behaviour as a means to accelerate and increase conventional teaching. It typically consists of self-teaching with aid of a specialized textbook or teaching machine that presents material structured in a logical and empirically developed sequence or sequences. PI may be presented by a teacher as well, and it has been argued that the principles of PI can improve classic lectures and textbooks (Goldfarb, 2006). PI allows students to progress through a unit of study at their own rate, checking their own answers and advancing only after answering correctly. In one simplified form of PI, after each step, learners are presented with a question to test their comprehension, then are immediately shown the correct answer or given additional information. However, the objective of programmed instruction is to present the material in very small increments (Emurian, 2007). The more sophisticated forms of PI may have the questions or tasks programmed well enough that the presentation and test model, which is an extrapolation from traditional and classical teaching, is not necessarily utilized. This idea was later adapted by Robert M. Gagne, who invented programmed learning for use in teaching in schools (Gagne, 1975). The terms programmed learning (PL) and programmed instruction (PI), are used synonymously by most people but some give the terms a more advanced meaning. For them, the difference between PI and PL is that PI is intended to modify behaviour, whereas PL is used for teaching facts and skills. To the behavioural psychologist, learning of facts and skills are definitely modifications of behaviour. The learner's behavioural repertoire has been expanded by the knowledge of facts and skills. Some use the term programmed instruction to imply the increase (or decrease if that is the desired outcome) in the probability of emitting the behaviour, such as when an autistic patient is taught and reinforced to make eye contact (Skinner, 1958). However, those who make no distinction between the terms would say, for example, that a programmed instructional unit to teach calculus to calculate a maximum or minimum of a parabola increases the probability that the technique will be used when confronting problems with parabolas. (Skinner, 1958)

While not so popular today, PI continues to be used. Recently, the application of PI principles was reapplied to training in computer programmes, after some popularity in a series of books on functional programming, and combined with Benjamin Bloom's taxonomy to teach college students (Bloom, 1956). Some have argued that there is a resurgence of research on PI due to use of computers and internet, which is perfectly true if this study is anything to go by.

The specific objective of this study was to find out effect of programmed instruction on students' attitude towards structure of the atom and the periodic table, among Kenyan secondary schools. One null hypothesis was formulated from this objective and statistically tested at the 0.05 alpha level of statistical significance. It was, "There is no significant difference in attitude towards SAPT between students taught using programmed instruction and those taught using the conventional approaches."

This study based on the Dual Coding Theory of information processing. The theory, which has roots in constructivism, postulates that learning is best achieved when information is processed both in form of images and in form of words (Paivio, 2006). The theory further postulates that the human cognition consists of two subsystems that process knowledge simultaneously. One subsystem processes verbal information and the other deals with visual objects. The two subsystems have different functions; the verbal subsystem processes and stores linguistic information whereas the visual subsystem processes and stores images and pictorial information. While the two subsystems can be activated independently, their interrelations and connections allow dual coding of information. Conventional approaches, which were used by the study's control groups and programmed instruction, which was used alongside the conventional approaches by the experimental groups of this study provided the linguistic and imagery forms of SAPT concepts respectively, hence dual coding.

LITERATURE REVIEW

In Noble and Gray's (1968) longitudinal study on the impact of programmed instruction on students' attitude, a questionnaire designed to measure students' attitude towards programmed instruction, with proven reliability and validity was given at weekly intervals to three forms in a mixed modern secondary school. Attitudes were found to decline significantly as the term progressed. Girls' attitudes were often significantly more favourable and did not decline as rapidly as boys' attitudes. Attitudes were also found to be related to both performance and personality measures.

Teacher intervention had the effect of reversing attitude change by stopping unfavourable attitudes from developing.

Abimbade (1983) reported that students exposed to programmed instruction recorded higher and more favourable attitude towards Mathematics than those who did not. His study agrees with Aiyelaagbe's (1988) study, which also reported more positive attitude of students after exposing them to self-learning strategies in Nigeria.

Roblyer's (1989) meta-analytic review indicated that programmed learning environments lead to significant improvements on students' attitudes towards the school and the subject matter. On the other hand, Kullik et al (1983) noted that programmed instruction appears to have an important positive effect on students' attitudes towards computers and also appears to have similar positive effect on students' attitudes towards school. Kullik and Bangert (1990) on an extensive review of the effectiveness of computer tutoring reported that computer tutoring generally has positive effects on students' attitudes towards instruction and computers, while also reducing the amount of time spent in teaching.

A study by Hasselberg (1984), which compared the attitudes and achievement of students in programmed instruction treatments as opposed to CMI, found that those in programmed instruction treatments demonstrated equal or better learning in less time. A similar study by Hownsell and Hill (1989) on the attitudes of secondary school students in a Biology class revealed that the students who were exposed to programmed instruction achieved significant high scores on both attitude and achievement tests than those in CMI treatments.

Several studies on the efficiency of computer based learning in the late 20th century have continued to show positive effects on learners' achievement gain, attitudes towards computers and the subject matter and perceptions of classroom environments (Garcia, 1992; Voogt, 1993). There is a significant factor in all these studies that seem to indicate that there is a relationship between attitudes, achievement gain and type of classroom environment.

The foregoing reviews clearly reveal that the use of programmed instruction provides a viable way of addressing the issue of improving student performance in examinations and of helping them develop positive attitudes and interest towards instruction and subject matter. This being the 21st century, the present study will contribute positively to the realization of the need to adopt instructional approaches that can enhance positive students' attitudes towards Chemistry in the modern day student.

METHODOLOGY

This study adopted the quasi-experimental research design using the non-randomized Solomon four-group as a model. The design was chosen because the units of sampling i.e. form two classes were already constituted and therefore it was unethical to re-constitute others randomly. The design however involved random assignment of intact classes to four groups labelled E1, E2, C1 and C2. Groups E2 and C1 received both pre- and post-test while groups E1 and C2 only received post-test. E1 and E2 were the experimental groups, hence were taught using PI while C1 and C2 were the control groups, and hence were taught the conventional way. This design controlled for all major threats to internal validity, except those associated with interactions of selection-history, selection-maturation and selection-instrumentation (Shadish, Cook & Campbell, 1979). To control for interaction between selection and maturation, the intact streams were assigned randomly to the control and experimental groups. No major event was experienced in any of the sampled schools that would have resulted in interaction between history and selection. The conditions under which the instrument was administered were kept as similar as possible in all the schools to control for interaction between selection and instrumentation (Gall, Borg & Gall, 1996).

Purposive sampling was used to select four mixed secondary schools in Butere district, Kakamega county in Kenya, which offer computer studies as an examinable subject. This was because the instructional software developed for this study required many computers, whose sufficient number could only be found in such schools. Only mixed schools were used so as to control for gender as an intervening variable. Butere was the preferred district because for the last 5 years, it has been performing poorly in Chemistry in the Kenya Certificate of Secondary Educations (K.C.S.E) as compared to Biology, a subject of similar student enrolment. Only form two students from each of the four sampled schools were included in the study sample because the topic under investigation - SAPT is taught at this level the Kenyan secondary school Chemistry curriculum. A total of 300 students and 23 Chemistry teachers participated in the study. This sample size was arrived at using the formula of Krejcie and Morgan, (1970).

Raw data was collected using the Students' Attitude Determination Questionnaire (SADQ). This was a close-ended questionnaire, whose items were placed on a five point Likert-type scale and administered as pre-test to all the 146 form two students in groups E2 and C1. It was again administered as post-test but to all the 300 students in the four groups (E1, E2, C1 and C2) that had participated in the study. The SADQ consisted of 8 favourable and 8 unfavourable statements, which sought information about the students' perceptions of the instructional method(s) used, the Chemistry lessons, Chemistry assignments done and Chemistry as a subject, before and after intervention. Favourable statements in the SADQ were scored in descending order i.e. Strongly Agree=5, Agree=4, Undecided=3, Disagree=2 and Strongly Disagree=1 while unfavourable statements were scored in ascending order i.e. Strongly Agree=1, Agree=2, Undecided=3, Disagree=4 and Strongly Disagree=5. A pilot study was carried out one month prior to the actual study in one mixed secondary school in Butere district to establish the suitability of the research instruments for actual study.

The criteria of Kahn and Best (1998) was used to determine the validity of the SADQ. The researcher requested three experts from the department of Science and Mathematics Education of Masinde Muliro University of Science and Technology to scrutinize, critique and assess the content, face, construct and criterion validity of the questionnaire, guided by a rating scale of zero to ten. The scores awarded to the various validity types in the instrument were as shown in Table 3.

Table 3 The validity scores awarded to the SADQ by research experts

Expert	Type of Validity				Average
	Content	Face	Construct	Criterion	
1	8.5	9.5	7	7	8
2	9	9	8	8.5	8.6
3	9	7	6	7	7.3

As the Table indicates, the SADQ had a strong ability to measure what it purportedly measured, to acceptable scholastic levels, because all the average validity scores were above the standard and recommended minimum of 6 out of 10 (or 0.6 in decimal form) for educational researches (Kahn and Best, 1998). Comments from the three experts were used by the researcher to modify the instruments, so as to make them more suitable for data collection in the actual study.

Reliability of the SADQ was also verified in the pilot study. This was done using the Guttmann's split-half method, where the pilot data consisting of students' attitude scores was arranged in descending order then subjected to reliability analysis using the Statistical Package for Social Sciences (SPSS) version 20. A Cronbach's alpha coefficient of 0.898 was obtained, which implied that this instrument, if used again would produce similar results because the reliability co-efficient value obtained was above the minimum recommended value of 0.7 for educational researches (Cronbach, 1970).

Programmed Learning Software (PLS) was used by students in the experimental groups for teaching and learning of SAPT. The researcher, with the help of a software engineer, created it on a compact disk which he labelled "the PLCD". This was the main 'teacher' of students in the experimental groups. Once inserted into the DVD/CD drive of a computer, the users were required to double-click on "my computer", then on

“DVD/CD drive” to open the software. The software was designed such that it is menu-driven. Each subtopic was preceded by statement of the objective(s). The main menu could readily be accessed from any point in the program. The PLCD comprised of 9 frames, each with content on one of the 9 sub-topics of the topic SAPT. On each frame were 6 icons namely: - Lesson Objective, Content, Example, Quiz, Answer and Help. The “Lesson Objective” icon once double-clicked would reveal a brief sentence stating the short term objective of that lesson. The “Content” icon once double-clicked would reveal a sub-topic of the SAPT. Left clicking on the subtopic would reveal explanations to the various concepts therein. The “Example” icon once double-clicked would reveal a solved question on what had just been presented on the previous frame and also some tricks or clues to getting the correct answer. The “Quiz” icon once double-clicked would reveal a question on the previously explained content. The “Answer” icon once double-clicked would bring forth a blinking cursor on the screen, which required the learner to type in their response to the question on the previous frame using the keyboard or to select one answer from the available multiple-choices using the mouse. The “Help” icon once double-clicked would roll down a menu of several options that a student who may have been unable to answer the previous question correctly was to follow e.g. a reminder of the instructions (for using the software), going back to the previous frame, going to another frame with easier examples and questions or quitting the program altogether. The primary input device was therefore the mouse, but the keyboard was used when need arose e.g. if a mouse was not installed or when typing in a response. The PLCD was used for instruction, practice and revision of the whole topic of the SAPT by the experimental groups. The teacher’s role was only to facilitate learning i.e. he or she was required to organize and supervise the students learning process during the PI lessons and to introduce/summarize the topic. The subjects in the experimental group therefore received about 90% of all their instructions via the PLCD. The instruction and lesson tasks were conducted in the computer laboratories during normal Chemistry lessons.

Data collection was done with the help of eight research assistants, who administered the SADQ in the respective schools. Groups E2 and C1 were first given the pre-test, followed by intervention (done at the same time as the other two groups E1 and C2) that lasted for four weeks. The same questionnaire was then administered as post-test to all the four groups some two days after the completion of the topic. The researcher then analysed all copies to the completed SADQ using SPSS and generated quantitative data. The data was analysed using one-way ANOVA to determine if the attitude mean scores of the four groups differed significantly among themselves. ANOVA was used because it is robust when many groups have been used and is also effective in minimizing type 1 error (Shuttleworth, 2009).

FINDINGS

Results of descriptive analysis of the sampled students' attitude before and after intervention were as presented in Table 4.

Table 4 Descriptive analysis of students' attitude

Group	Pre-test		Post-test		Mean Gain
	Mean	Std. Dev.	Mean	Std. Dev.	
E1 (N=76)	-	-	74.2566	21.0305	-
E2 (N=74)	56.1081	21.2645	73.1419	19.1872	17.0338
C1 (N=72)	53.3333	19.8459	56.8194	20.7550	3.4861
C2 (N=78)	-	-	58.6859	19.8002	-
Whole sample	54.7207	20.5552	65.7260	20.1932	11.0053

An examination of Table 4 reveals a small margin of 2.7748 marks in the pre-test attitude mean scores between experimental group E2 and control group C1. However, in the post-test, the Table reveals that the margin between the mean scores of E2 and C1 increased six fold to 16.3225 marks, with E2 outperforming C1. In the same post-test, the mean scores of E1 and C2, both of which were not pretested had a margin of 15.5707, which is comparable to the margin between the mean scores of the pretested groups E2 and C1. This implies that pretesting had no effect on the intervention. The post-test means scores of the experimental groups E1 and E2 (74.2566 and 73.1419 respectively) were apparently superior to those of the control groups C1 and C2 (56.8194 and 58.6859 respectively). The Table further reveals that while the mean gain of the entire sample was 11.0053, the mean gains of the pretested groups E2 and C1 were 17.0338 and 3.4861 respectively, which shows that the experimental group had a greater attitude change than the control group.

Using the descriptive measures displayed in Table 4 (mean and standard deviation), F-ratio was computed using the Daniel Soper online one-way ANOVA calculator obtainable at www.danielsoper.com/statc. The results were as reported in Table 5, which indicates that in the pre-test, there was a statistically non-significant difference in the attitude mean scores of the two groups [$F(1, 144) = 0.664$, $p = 0.417$ at $\alpha = 0.05$]. The results further indicate that in the post-test, there was a statistically significant difference in attitude mean scores between the four groups [$F(3, 296) = 15.661$, $p < 0.001$ at $\alpha = 0.05$].

Table 5 One-way ANOVA on students' attitude scores

Source	Test	D.F	Ss	Ms	F	P
Between Groups	Pre-test	1	280.980	280.980	0.664	0.417
	Post-test	3	19,177.625	6,392.542	15.661*	0.001
Within Groups	Pre-test	144	60,973.106	418.407	-	-
	Post-test	296	120,818.357	408.170	-	-
Total	Pre-test	145	61,254.086	-	-	-
	Post-test	299	139,995.983	-	-	-

*Significant at $\alpha = 0.05$

These results imply that while the difference in attitude mean scores between the two pre tested groups was not statistically significant, the difference in attitude mean scores of all the four groups in the post test was statistically significant. This is especially so because the p-value obtained in the pretest was greater than the stipulated alpha while the one obtained in the posttest was less than the stipulated alpha.

The null hypothesis (Ho) of the study was, “There is no significant difference in attitude towards the SAPT between students taught using PI and those taught using the conventional approaches”. The study however found a statistically significant f-ratio on the four posttest attitude mean scores, which implies the contrary. The null hypothesis was therefore rejected as the empirical evidence resulting from both descriptive and inferential statistics of this study with respect to the study’s main objective suggests that while the attitude of students in both the experimental and control groups was statistically the same before intervention, those who were taught the SAPT using PI had a significantly better (positive) attitude towards the topic than those taught using the conventional approaches after intervention. It can now alternately be asserted that incorporating PI with the conventional approaches is more effective in promoting students’ attitude towards the SAPT than using the conventional approaches alone.

DISCUSSION AND CONCLUSION

It was established that incorporating programmed instruction with the conventional methods of instruction in the SAPT improves the attitude of form two students towards the topic. This is so because in the pretest, the attitude of students in both groups E2 and C1 (who had all hitherto been taught Chemistry lessons using conventional approaches only) was statistically found to be similar but different in the posttest. The sharp contrast in attitude between students in the experimental groups and those in the control groups is attributed by the researcher to the treatment (using PI) that the experimental groups received because all the possible threats to internal validity were taken care of.

The findings of this study concur with Kullik and Bangert's (1990) study, which revealed, "programmed instruction generally has positive effects on students' attitude towards learning and computers while also reducing the amount of time spent in teaching". The findings are also in perfect agreement with Mahajan and Singh, (2003), whose study found out that learning is more effective when more than one teaching method is used as was done in the experimental groups of this study by integrating PI with conventional approaches.

On the basis of data collected in this study and the empirical evidence provided by the study's findings, it has been concluded that using programmed instruction alongside the conventional approaches in the SAPT significantly improves students' attitude towards the topic and Chemistry as a subject due to its student-centeredness than the conventional approaches. Teachers of Chemistry should therefore embrace it especially in all abstract topics they teach so as to solve the attitude crisis currently plaguing Chemistry education in Kenya.

REFERENCES

Bloom, B. (1956). *Taxonomy of Educational Objectives, Handbook 1: The Cognitive Domain.* New York: David McKay Co. Inc.

Carbo, J. & Davids, F. (1963). *Teaching Students to Read Through Their Individual Styl*e. Ohio: Ohio Press.

Cronbach, L.J. (1970). *Essentials of Psychological Testing*. Third Edition. New York: Harper and Row Emurian, H.H. (2007). Programmed Instruction for Teaching Java: Consideration of Learn Unit Frequency and Rule Test Performance. *The Behavior Analysis Today.*

Gagne, R.M. (1975). *The Conditions of Learning*. New York: Holt, Rinehart and Winston.

Gall, M.D., Borg, W.R. & Gall, J.P. (1996). *Education Research: An Introduction* (6th edition.). White Plains, NY: Longman

Gilbert, J.K., Boulter, C.J. & Elmer, R. (2000). *Positioning Models in Science Education and in Design and Technology Education.* Dordrecht: Kluwer Academic Publishers

Godek, Y. (2004). The Development of Science Education in Developing Countries. G.U. *Journal of Education*, 5 (1), 1-9.

Goldfarb, R. (2006). *Operant Conditioning and Programmed Instruction in Aphasia Rehabilitation*. Sip: Aba

Government of Kenya, (2008). *First Medium Term Plan (2008-2012): Kenya Vision 2030 - A Globally Competitive and Prosperous Kenya*. Nairobi: Government Printer.

Jenkins, E. & Whitefield, R. (Eds). (1974). *Readings in Science Education: A Resource Book.* London: McGraw Hill.
Kahn, J.V. and Best, J.W. (1998). *Research in Education.* 8th Edition. Boston: Allyn and Bacon Publishers.
KIE, (2009). *The Revised Secondary School Chemistry Syllabus*. Nairobi: Kenya Literature Bureau.
KNEC, (2010). *The Kenya Certificate of Secondary Education Annual Examination Report*. Nairobi: Kenya Institute of Education.
Krejcie, R.V. and Morgan, D.W. (1970). Determining Sample Sizes for Research Activities. *Educational and Psychological Measurement. 607-610*
Kullik, J.E. and Bangert, R.L. (1990). Computer Based Teaching on Secondary School Students. *Journal of Educational Psychology,* 175, 19-26.
Lewin, K., Göttelmann-Duret, G, and Françoise, C. (1997). *Science Education and Planning and Policy Issues at Secondary Level*. Paris: UNESCO/IIEP.
Mahajan, D.S. & Singh, G.S. (2003). Instructional Strategies in Organic Chemistry: Teachings and Perceptions of Science and Agriculture in Undergraduate Students in Botswana. *Education*. 123 (4), 714.
Masinde, J.W. (2014). *Incorporating Programmed Instruction in the Learning of the Atomic Structure and the Periodic Table Among Mixed Secondary School Students in Butere Distict.* Unpublished Master's Thesis. Masinde Muliro University of Science and Technology.
Mulavu, W.G. (2011). *Effect of Using Molecular Models on Students' Understanding of Structure and Bonding in Kenyan Public Secondary Schools.* Unpublished Master's Thesis. Masinde Muliro University of Science and Technology.
Paivio, A. (2006). *Mind and Its Evolution: A Dual-Coding Theoretical Interpretation*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
Shadish, W.R., Cook, T.D., & Campbell, D.T. (1979). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston: Houghton Mifflin Company
Shuttleworth, M. (2009). *Solomon Four Group Design.* Retrieved October 25, 2013 from http://www.explorable.com/solomonfour-group-design.
Skiner, B.F. (1958). *Behavioral Approach to Language Learning*. New York: Appleton Century.
Sola, A.O. & Ojo, O.E. (2007). Effects of Project, Inquiry and Lecture: Demonstration Teaching Methods on Senior Secondary Students' Achievement in Separation of Mixtures Practical Test. *Educational Research and Review 2 (6), 124-132.*
Taber, K. (2009). *Progressing Science Education: Constructing the Scientific Research Programme into the Contingent Nature of Learning Science*. Dordrecht: Springer.
Twoli, N. (2006). *Teaching Secondary School Chemistry: A Text Book for Chemistry Teachers in Developing Countries*. Nairobi: Nehema Publishers.
World Bank, (1989). *Sub-Sahara Africa: From Crisis to Sustainable Growth: A long Term Perspective Study.* Washington, D.C.