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European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.574666 Volume 3 | Issue 5 | 2017

EFFECTS OF SEQUENTIAL TEACHING METHODS ON RETENTION OF KNOWLEDGE IN BIOLOGY BY SECONDARY SCHOOL STUDENTS IN KENYA

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Abstract:
Despite the importance of knowledge in Biology, candidates' performance at the national examination, The Kenya Certificate of Secondary Education (KCSE) is poor. This could be attributed to the teaching methods. The purpose of this study was to compare differential effectiveness of Sequential Teaching Methods (STM) on the, retention of knowledge in Biology by secondary school students. The study was Quasi-experimental using the Non-equivalent control- group 16 study design. The target population comprised students in the 18 old category National Schools in Kenya that were in existence before 2012. Purposive sampling was used to obtain a sample of eight (8) schools and 402 Students. The students in the eight (8) sub-groups were taught the same Biology topic: "General Characteristics of Enzymes", using different sequences of three teaching methods namely: lecture, slide demonstration and laboratory (student experiment). Group I (ELD) began with experiments, followed by lecture method and was lastly shown, animated slides. The sequence of the three different methods used in the first group was altered in both the second and third groups as follows: The lecture method, slide demonstration and laboratory experiment (LDE) for Group II, and slide demonstration, experiment and lecture method (DEL) for group III. Students in group IV (control group) were taught using (oral-only) lecture method. The teachers gave

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lectures and performed slide demonstration while the students carried out laboratory experiments. The test was used as a pre-test and also as a retention test that was administered 40 days after the Post-test BAT. This test had 25 objective questions testing knowledge of facts, application of knowledge and problem solving ability. To measure Retention of Knowledge, the researcher used Biology Retention Test (BRT). The research hypothesis was tested using ANOVA at significant level of 0.05. The results and findings of the study show that STM, when efficiently used in instruction, enhance immediate retention of knowledge in Biology more effectively than the oratory lecture method predominantly used in Kenyan Secondary schools. Furthermore, DEL sequence was identified as the most effective in comparison to LDE and ELD. The findings of the study will help curriculum developers and teachers to choose the most appropriate sequence to use in Biology.

Keywords: sequential teaching, retention of knowledge, secondary school, Kenya

1. Background of the Study

Biology education has both intrinsic and extrinsic justifications (Brown, 1995). The former relates to advancement in Biology for its own sake as a discipline while the latter is concerned with the promotion of societal welfare. Inferably, the teaching and learning in Biology play both academic and social roles. Killermann (1998) explains that the academic role concerns the acquisition of scientific knowledge, skills and attitudes for application in the fields of medicine and agriculture among others. The social role pertains to the empowerment of individuals in economic and technology related areas. The overall goal of teaching Biology in Kenya is to make learners to fully understand themselves and the environment (Maundu, Sambili & Muthwii, 1998). The teaching of Biology therefore, aims at the production of a scientific community whose major role is to promote the welfare of humankind through application of knowledge in Biology. In addition, Biology fosters the advancement of science through research and publications (Lawson, 2001). .

In an attempt to achieve objectives of the Secondary School Biology syllabus, KIE (2006) suggested several methods of teaching. The methods include: practical work, class discussions, demonstrations, excursion/field trips and project work. However, the baseline survey done by the project, 'Strengthening of Mathematics and Science in Secondary Education' (SMASSE, 2007), shows that the predominantly used teaching methods for Biology include: lecture method, teacher demonstration and practical/laboratory work (student experiment). The Biology syllabus in Kenya is

organised in such a way that for most theory lessons, mainly taught through the lecture method, there is corresponding practical work. The recommendation by KIE (2006) is that practical or laboratory work should be done through either teacher demonstration or student experiments; allowance is made for practical lessons to be done before or after theory lessons. This in effect constitutes Sequential Teaching Methods Approach (STMA). However, in actual fact, Biology teachers in Kenya often use only lecture method (without demonstrations and experiments) in their lessons (Njuguna, 1998). Any attempt of STMA in teaching Biology in Kenya mainly follows the sequence: lecture method, teacher demonstration and student experiments (LDE). It is however, important that these methods be used in an appropriate sequence (pattern). In an effort to help the teachers implement the Biology syllabus effectively, emphasis is laid on the teachers' use of a combination of methods for a single topic (KIE, 2006). However, this may not be practically possible due to constraints such as lack of material resources and even space that curtail use of variety of teaching methods.

Biology teachers usually resort to use of lecture method owing to the aforementioned constraints. Consequently, learners miss the hands–on experiences, which enhance learning. The result is rote memorisation of information as opposed to meaningful learning. Mondoh (2005) observes that, in most lessons the whole difference lies in the fact that the student is asked to accept from outside an already organised intellectual discipline which he/she may or may not understand. Teaching method has been singled out as an important factor that determines learning outcomes (Trumper, 2006). It fosters or hinders learning. The teaching method used therefore affects achievement, retention and transfer of knowledge.

Research conducted by Wachanga & Mwangi, (2004) in Kenya to find out effects of various teaching methods on achievement in science subjects shows that cooperative class experiment as a teaching method enhances learners' achievement and motivation in Chemistry and Agriculture respectively. The findings of another study by Kibett and Kathuri (2005) involving secondary school students in Nakuru County showed that learners who were taught Agriculture using the project method performed better than their counterparts who were taught using the regular approach, mainly by lecture. In a related study, Orora, Wachanga and Keraro (2005) found that the cooperative Concept Mapping teaching method enhanced achievement and motivation in secondary school Biology in Gucha County, Kenya. Other studies (Johnson, 1991; Odubunmi & Balogun, 1991; Killermann, 1998; Esra, Ijlal and Ocak, 2009) have been carried out to determine the effectiveness of different methods of teaching Biology. The findings of these studies show that the methods of laboratory and slide demonstration are very effective in teaching Biology.

Research done by Esra, Ijilal and Ocak (2009), conducted in Turkey at Arturk University sought to determine the effect of Sequential Teaching Methods in Biology, on students' achievement and retention. The study aimed at determining the effects of Sequential Teaching Methods under three teaching modes; lecture, slide demonstration and laboratory (student experiment) on academic achievement, retention and transfer of knowledge in Biology by learners.

However, all the aforementioned studies involved a single teaching method except the study by Esra, Ijilal and Ocak (2009) who used a combination of methods. Their study is in line with KICD's suggestion on effective methods of teaching Biology; hence the interest of the researcher in this study.

The current study is a replication of the aforesaid study but with some adjustments. Esra's study was quasi- experiment that used only three non-equivalent groups. The present study used four groups. In addition, a control group that was taught using oral-only lecture method was also included. This study therefore, aimed at finding out the effects of Sequential Teaching Methods (STM) on secondary school students, retention of knowledge of Biology in Kenyan National schools.

According to the reports by the Kenya National Examination Council (KNEC 2007-2012) , the KCSE mean scores in Biology for the period 2007 to 2010 were as follows: 2007- 44% ; 2008- 30% ; 2009- 27%; 2010- 29%; 2011- 32% and 2012-26%). Accordingly, performance was influenced by many factors but the magnitude of each factor was not known. This research sought to put things in perspective instead of speculation.

2. Statement of the Problem

Despite the government's effort to review curriculum as well as change the examination format, students' performance in the KCSE Biology National examination continues to decline. Low achievement in Biology at KCSE examinations may imply that the information given is not sufficiently retained in future years of study and not consequently transferred for general use in life. Studies by (Wachanga & Mwangi, 2004; Kibet and Kathuri 2005; Orora, Wachanga and Keraro 2005: Esra, Ijlal and Ocak 2009) have been carried out in Kenya and elsewhere to compare effects of teaching methods on academic performance. These studies observed that teaching methodology is a crucial factor in determining academic performance of students. Mills (1991), observes that the teaching methodology is a crucial factor that affects academic achievement of students. Esra, Ijlal and Ocak (2009) suggested that the sequence of teaching methods affected performance. The Kenya 8-4-4 Biology syllabus recommends use of STM; this

has six possible combinations of sequences-LDE, LED, ELD, DLE and DEL. Information based on empirical studies on whether the STM was effective, and which sequence had greatest effect on academic performance in Biology in the Kenyan context was lacking. The determination of the best sequence was also important. However, a study on STM based on Kenyan conditions had not been conducted. The study therefore sought to address the problem of determining whether STM was an effective method of teaching Biology, and identifying the best sequence on retention of knowledge.

2.1 Purpose, Objective and Hypothesis of the Study

The purpose of the study was to determine which sequence (pattern) of the three Sequential Teaching Methods (lecture, demonstration and experiment) must take precedence in order to increase learners' retention of knowledge (remembrance). As such, the study sought to evaluate differential effectiveness of three versions of Sequential Teaching Methods namely; ELD, DEL and LDE. The objective therefore was, to: compare the retention of Knowledge of learners taught Biology using different sequences of Sequential Teaching Method. The null hypothesis (Ho2) tested was: There is no difference in retention of knowledge in Biology when learners are exposed to different sequences of teaching methods.

2.2 Theoretical Framework

The study was guided by two theories: [1] the General Systems Theory proposed by Bertalanfty (1968). Noting that a system is an interrelationship of various elements which work in unison to achieve a designated goal, each element or variable in the system has its own specific roles to perform. Based on the General Systems Theory, the teaching in Biology involves elements that include the teacher, learners, teaching-learning process, teaching-learning resources and physical facilities such as the classroom. The current study involves independent, dependent and extraneous variables. All these variables must interact with each other in order to move the system from an input condition of original or entry behaviour to an output condition of modified behaviour. The expected modified behaviour, for instance higher, retention of knowledge serves as the goal of the system whereas actual retention serves as feedback of the teaching process. The General Systems Theory guided the conceptual framework. [2] The Cognitive Load Theory of learning proposed by Sweller (1994). According to this theory, the working memory is finite and has limited capacity. The information received through the auditory channel gets direct access to the working memory thus clogging it. This affects information processing.

The treatment given to the learners in the study was based on this theory; the human working memory has a threshold of 4 to 10 elements making some material difficult to learn. Sweller (1994), provided evidence that the cognitive load of some learning material can be greatly reduced if the information is presented pictorially or otherwise as in the case of lecture and slide demonstration.

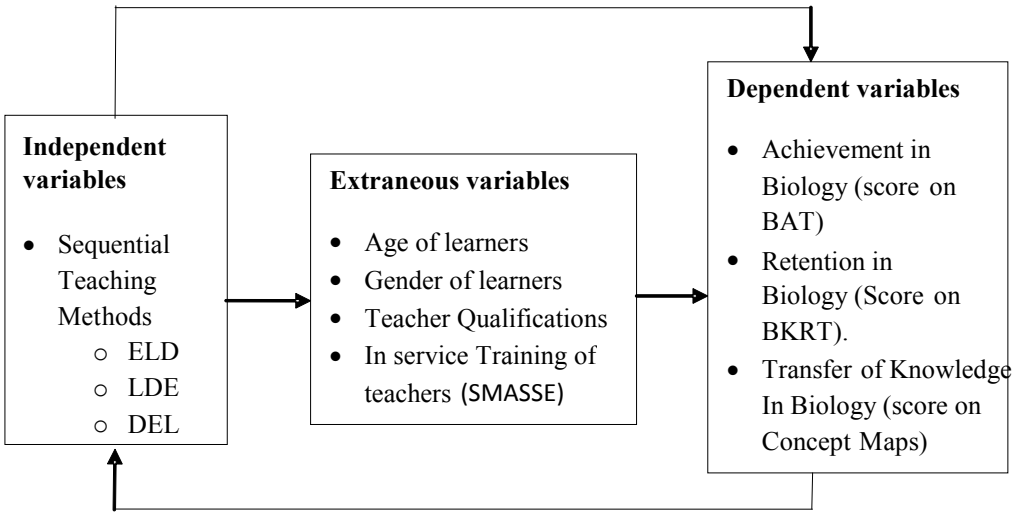
2.3 Conceptual Framework

Several factors or variables interact and affect learning. The variables could be categorised as extraneous, independent and dependent. These variables and their interactions constitute the conceptual model of this study. The conceptual framework that guided this study is based on the General Systems Theory. Accordingly, the teaching and learning process has inputs and outputs. Therefore, in order to achieve good academic results, the input should have appropriate instructional methods. Damico and Roth (1994) noted that quality education is defined in terms of output such as the number of students passing an important national examination. Thus, a school of students with low achievement scores is said to be of low quality or non-performing. However, Fowler (1995) observed that *"a diagnosis of school quality problem that focuses on outputs such as student performance fails to inform about the antecedent causes such as teaching methods."*

Arguably, learning outcomes are influenced by several factors. In the study, these included both learner and teacher characteristics which, and constituted extraneous variables that had to be controlled. As explication, the learners' age determines what they are to be taught. Teacher's qualifications and training on the other hand determine the instructional approach that a teacher would prefer to use more often and how effective the teacher would use the approach. Gender of learners was an extraneous variable which could not be controlled but whose effect could also not be ignored.

The conceptual framework shows the relationship of variables for determining the effects of using sequential teaching methods on secondary school students' achievement, retention and transfer in Biology knowledge. The framework is represented diagrammatically in Figure 1.

Figure 1: The Conceptual Framework



3. Research Methodology

This study was quasi-experimental, using the Non-equivalent Control-Group Sixteen study design. It was found suitable for controlling all the threats to internal validity. All the four groups took a pre-test, post-test, knowledge retention test and transfer test hence a total of 16 observations were made. All the sixteen observations made were used to generate estimations of the effect of the experimental treatment, interactive testing variables and that of the control variables. The general model of the study design is represented in Figure 2.

Group I	O_1	X	O_2,	O_3,	O_4
Group II	O_5	X	O_6,	O_7,	O_8
Group III	O_9	X	O_{10},	O_{11},	O_{12}
Group IV	O_{13}	C	O_{14},	O_{15},	O_{16}

Figure 2: General Model of the Non-equivalent Control- Group 16 Study Design

Source: Adapted from Tables 8.3 and 8.4 in John W. Creswel, "Research Design, 3rd edition, Sage Publications New Delhi, 2011. pp 160

Where: O_1, O_5, O_9 and O_{13} are pre-tests;
O_2, O_6, O_{10} and O_{14} are post-tests;
O_3, O_7, O_{11} and O_{15} are retention – tests;
O_4, O8, O_{12} and O_{16} are Transfer-tests.

X is the treatment where students were taught using sequential teaching methods (STM) C- means no treatment. It refers to the control group:

Group I was the experimental group that received the pre-test, the treatment (X=ELD), the post-test, the retention test and the transfer test.

Group II was the experimental group that received the pre-test, the treatment (X=LDE), the post test, the retention test and the transfer test.

Group III was the experimental group that received the pre-test, the treatment (X=DEL), the post test, the retention test and the transfer test

Group IV was the control group that received the pre-test, followed by the control condition (C=OOL), the post test, the retention test, and lastly the transfer test. Quasi experimental design was used because the classes were naturally formed in the school and remain intact during the study. The classes were randomly assigned to teaching methods (LDE, ELD and DEL) with oral-only lecture method as a control variable. The aim was to evaluate differential effectiveness of STM based on testing of the hypotheses.

Note: The study had several objectives but only one is singled out for purposes of this paper.

The design was suitable for testing and establishing the cause-and-effect relationship between Sequential Teaching Methods and Retention of Knowledge. According to Sekeran and Bougie (2011), the design allows for manipulation of the independent variable so that the extent of its causal effects could be established. This design is the most comprehensive and also guarantees maximum internal and external validity, ruling out many other rival hypotheses. The study was analytical and predictive in nature. The research process was thus manipulative not enumerative. It was a snapshot or cross-sectional study where sufficient data was collected at one point in time. Form One classes were used as the unit of analysis.

3.1 Sampling Techniques and Sample Size

The unit of sampling in this study was the secondary school rather than individual students. This means therefore that each school was considered as one sub-group. The school sample was drawn through multi-stage sampling, from 18 Old Category National schools.

First, the schools were divided into four clusters according to the regions where they are located. The 18 National secondary schools were visited to ascertain their suitability for the study. The criteria for suitability included qualifications, training and performance index (mean score) of subject in Biology for the teachers in the schools. Participating schools from the four clusters were then selected by purposive sampling

after identifying schools categorised as boy's only schools or girls only school. Purposive sampling was used to select the schools that finally constituted the sample of the study.

3.2 Sample Size

The actual schools sample consisted of eight Old Category National schools (four boys and four for girls). A participant sample of 402 learners was purposefully identified from the school sample. The reason was to cater for both gender and regional representation. Summary is given in Table 1:

Table 1: Sample Size

Group	Gender		Total
	Male	Female	
1	51	51	102
2	46	51	97
3	53	51	104
4	58	41	99
Total	**208**	**194**	**402**

The sample size was determined by the enrollment in the schools selected. The selection was done on the basis of location, syllabus coverage, willingness to cooperate and gender balance. Since gender was an aspect to be investigated, four of these schools were boys only schools while the other four were girls only schools. Fraenkel and Wallen (2000) recommend at least 30 subjects per group. The sample size as shown in Table 1 was thus adequate for the study.

3.3 Instrumentation

In this study three tools were used for data collection.

A. Pre-test BAT

This tool was an adoption of the test developed by Esra, Ijlal and Ocak in 2009. The test items exhaustively covered the topic 'enzyme activity'. The test duration was one hour, and taken individually. It contained 25 multiple choice items, each with five distractors.

B. Post-test BAT

The Post-test BAT was similar to the pre-test BAT except for the order of questions. The test was also taken by individual learner and scored using a marking scheme and Scores were expressed as a percentage.

C. The Biology Knowledge Retention Test (BKRT)

The BKRT was designed by changing the order of the test items in the post Test BAT. It was administered 40 days after the post-test BAT. BKRT was also taken by individual learners over duration of one hour. It was scored using marking scheme. The scores were expressed as a percentage.

3.4 Data Collection Procedure

Data for this study was collected between May and July 2013. The researcher trained the teachers in Biology on how to administer the treatment. Each trained teacher was provided with a teaching manual with content of the topic and other teaching and learning resources. In addition, the pre-test BAT was administered by teachers to the four groups of learners in order to determine homogeneity in their knowledge of the topic "Enzymes," as well as similarity in learning ability. Treatment was given over a period of two weeks and was administered by the teachers. Biology Knowledge Retention Test (BKRT) was administered by teachers 40 days after administration of the BAT post – test). BKRT was also a one hour sit–in individual test. This was to gather numerical and quantitative data from the learners to compare knowledge retention of different sequences of STM. BKRT had the same items and response format as BAT, the only change being order or sequence of questions. Similarly, BKRT was used to obtain raw test scores as a measure of retention. According to Sisson, Swartz and Wolf (1992), knowledge retention rate is highest (>85%) immediately after learning but generally falls to 75% of its original level 3 months after original learning. Therefore 1½ months is assumed optimum period for assessing short – term retention of knowledge and expecting more than 85% level of retention.

3.5 Data Analysis

The score sheets for the pre-test, BAT, BKRT were all checked and edited for accuracy and consistency. They were categorised according to groups. Data coding was done to conceal identity of study groups. *The analysis involved one-way and two- way Analysis of Variance (ANOVA), using the univariate general linear model. This type of ANOVA was suitable for estimating the effect of multiple independent variables such as teaching methods on one dependent variable such as retention. The method was used to assess the mean differences*

between the four groups. Nassiuma and Mwangi (2004) affirm that ANOVA is a useful technique in research where multiple sample cases are involved. The Null Hypotheses were tested at the 0.05 significance level Data consisted of scores on BKRT. The Means and standard error calculated from the raw scores of the BKRT constituted the descriptive statistics. A Two-way ANOVA was used in data analysis Tukey's post-hoc comparisons were carried out to show mean separation in order to determine where the significance in difference between the means had occurred.

4. Results, Interpretation and Discussion

It was necessary to find out the effect of teaching methods and gender as well as their interaction on the retention of knowledge. The measure of retention is the score obtained on BKRT. The results of a two-way (ANOVA) of effect of interaction between STM, and gender, based on mean scores of the BKRT for the four groups are presented in Table 2.

Table 2: Two-Way ANOVA of Effect of Teaching Methods and Gender on Retention

Independent Variable	Ss	Df (N-I)	Ms	F	Sig
Teaching Method	23829.82	3	7943.27	85.26	0.000
Gender	7062.98	1	7062.98	75.81	0.000
Gender interacting with Teaching Method	521.43	3	173.81	1.87	0.135
Error					
Total	36708.61	394	93.17		
	974080	402			

A significant effect was found among the sequences of STM ($F(3,394)=85.26, p<.05$). The interaction between teaching methods and gender had no significant effect on retention of knowledge ($F= (3,394) =1.87, p<.05$). The null hypothesis which stated that 'there is no statistically significant difference in retention in Biology when learners are taught using different sequences of lecture, demonstration and experiment methods' was thus rejected.

The results of ANOVA suggest that the treatment had significant overall effect. The results also indicate significant difference between treatment groups. It was thus necessary to perform Tukey's post hoc comparisons to determine where the differences exactly occurred. The results of mean separation are presented in Table 3.

Table 3: Tukey's Post Hoc comparison of the retention test scores on the BKRT

Group(i)	Group (j)	n(i)	Mean score (i)	Mean diff (i-j)	P value
1	1	102	45.65± 1.321	-	-
1	2	-	-	-3.92	0.010
1	3	-	-	-12.43	.000
1	4	-	-	9.69	.000
2	2	97	49.57± 1.311	-	-
2	3	-	-	8.51	.000
2	4	-	-	13.61	.000
3	3	104	58.08± 1.145	-	-
3	4	-	-	22.12	.000
4	4	99	35.96± 1.211	-	-

The results show that there was significant difference between group means. That is, the retention mean score of groups 1, 2, 3 and 4 were all different at 0.05 level. Group 3 (DEL) had the highest retention score at 58.08 compared to group 2 (LDE) and group 1 (ELD) whose means scores were 49.57 and 45.65 respectively. Group 4 (Control) had the lowest mean at 35.96. Since the interaction of teaching methods and gender was not significant, there was no need to perform a one-way ANOVA for each gender separately.

The results in Table 3 point to the following findings:

i. The use of STM led to improved retention of knowledge compared to use of oral-only lecture method.
ii. DEL sequence mean scores were highest on BKRT
iii. Gender had significant effect on retention with female learners scoring higher than their male counterparts.
iv. Interaction of teaching method (STM) and gender showed no significant effect on retention of knowledge.

4.1 Effects of STM on Students' Retention of Knowledge in Biology

Aziz (1990) perceives retention as storage, the process of holding encoded information in memory. The results presented in Table 3 show that students who were taught through the STM had significantly higher scores in the Biology Knowledge Retention Test (BKRT) than those taught using the oral-only lecture method. This therefore, implied that the STM was more effective in enhancing students' retention of knowledge than the oral-only lecture method. STM ensures maximum utilisation of most parts of the memory. The study also sought to determine the best sequence of the STM that would lead to highest retention levels. To address this, students' retention of content material relative to the three sequences was analysed. The analysis of results indicated

that the students who were taught through the DEL sequence obtained significantly higher scores in the BKRT than those who were taught through the LDE and ELD sequences. Perhaps DEL provides the best pattern for elaborative rehearsal of information. DEL seems to enhance attention to information while in the working or short term memory. Sisson et al (1992) provide literature on clinical information with regard to knowledge retention of material taught and examined in Biology. However, the history of research on retention is fairly recent. It is rather unfortunate that in education a great deal of time and effort is devoted to the acquisition of knowledge but very little is known about how long this knowledge is retained. Addressing this issue has practical relevance to educational policy and practice. It also has implications for theoretical models of memory and knowledge representation.

The first attempt to address the issues about the retention of formally acquired knowledge was reported by Bahrick (1984). He found a strong relationship between retention and the initial depth of learning. Nevertheless, his study laid a strong foundation upon which subsequent researches were conducted in various specific disciplines, Biology Education included. Results of a study done by Esra et al. (2009), focusing on effects of STM on retention in Biology, showed higher retention level in lessons beginning with experiment or slide demonstration as opposed to lecture method. Their findings agreed with results of previous researches that laboratory work offer students hands-on-experience thus enhancing their remembrance to 90%. Similarly, the present research findings agree with Esra's slide demonstration but differ on the aspect of experiment. Esra et al. (2009) reported that student comprehension is enhanced with lesson started with experiment, because laboratory activities increase students' interest in the topic. They seem not to have taken into account the impact of the nature of knowledge as well as its representation. Maslow's Theory of learning highlighted the differences between experimental knowledge, procedural knowledge, theoretical and spectator knowledge. Similarly, the difference in learner's retention may not only be in the method but also in the dimension or domain of knowledge. For example, dimensions or domains of knowledge in Biology include Anatomy, Physiology, Morphology and Histology. The most effective method is one that can represent the specific domain of knowledge in a transparent manner for learners to see.

In the present study, animated slide demonstration is a more effective instructional compliment for teaching processes or mechanisms in Biology. This view is strongly supported by O'Day (2009), who observed that on retention, animated slide demonstration rival and at times surpasses the pedagogical value of lab work. This is true especially when dealing with knowledge that involves a physiological process or mechanism.

The aspect that needs to be addressed is: How students could learn about the mechanism of enzyme action through laboratory work and what the students were supposed to observe. It was not enzyme activity itself but rather mere effect of enzyme activity. Pedagogically, learning about enzyme action can only be inferred through experiment. Animated slide demonstration therefore, provided for direct observation of the mechanism, hence better understanding and higher retention.

Inquiry-based laboratory approaches are more effective than verification approaches (Opara 2011). In this study, start of lesson with experiment was probably less effective because it focused on verification as opposed to discovery of concepts and observation of actual mechanism of enzyme activity.

Applying Cognitive Load Theory to teaching, learning will be maximised by ensuring that as much of a learner's working memory as possible is free to attend only to encoding to-be-learned information. Accordingly, lecture method imposes a relatively high level of cognitive load (Sweller, 1994). On the other hand, the major weakness of laboratory experiments in teaching a psychological process such as enzyme action is that learners may successfully carry out the practical, yet effectively learn nothing. Slide demonstration impose very low levels of cognitive loads thus facilitate learning (Mousavi, Low & Sweller, 1995). While use of DEL sequence provided an effective alternative to both LDE and ELD sequences, it can be argued that perhaps DEL fosters original learning, which in turn is determinant of retention. This effect could be attributed to reduced cognitive load when visual presentations (animations) are used in the beginning. In conclusion, DEL sequence has been demonstrated to be highly effective at improving retention of psychologically based content such as enzyme activity in Biology. The association between concepts and the motion in the graphic is clearly indicated in slides. This is necessary for construction of meaning.

The laboratory work and class experiments have a redundancy effect since they only show the presence of catalase enzyme in cells, effects of pH and temperature on enzyme activity, but do not show the typical or real mechanism of enzyme action on substrate to yield products. Use of DEL is thus encouraged since it also has a positive effect on transfer of knowledge in Biology (see the subsequent section for a detailed explanation of this subject).

4.2 Gender-based Effect on Retention of Knowledge in Biology

The results of this study indicate that there is a significant difference in retention of knowledge between male and female learners at .05 level. This could be attributed to the difference in original learning as reflected in achievement scores. A comparison between mean scores of male and female learners on BKRT reveals that female learners

scored significantly higher than their male counterparts. The effect of original learning was therefore positively carried forward to the retention of knowledge. Although a few studies have been undertaken to investigate gender-based effect on retention of knowledge, so far scanty literature is available. The present study therefore attempted to bridge the knowledge gap on gender differences in retention of knowledge of Biology.

4.3 Effect of STM Interacting with Gender on Retention of Knowledge

The results showed that although both STM and gender separately had significant effect on retention but the interaction between the two indicated that there was no significant effect. The findings also revealed that different versions of STM differ with respect to their effect on retention of knowledge in Biology. Furthermore, the female gender appeared to retain more of the knowledge learned. The insignificant interaction effect of STM and gender could be attributed to other factors beyond the scope of the present study. It could perhaps be due to the nature in Biology subject, which includes many abstract concepts events, sub-topics and facts that students have to learn. These, according to Trumper (2006), pose learning difficulties at individual learner's level.

5. Summary, Conclusions and Recommendations

The use of STM led to improved retention of knowledge compared to the use of oral-only lecture. There was also a significant difference in students' retention of knowledge in Biology between students taught using different sequences of STM. DEL sequence results were highest (58.08%) on Biology knowledge retention test.

The teaching philosophy emerging from the findings of this study is that, each teaching method used yielded some amount of learning. The use of a combination of teaching methods sequentially enhances mastery and meaningful learning. This is characterised by high achievement, retention and transfer of knowledge. A combination of teaching methods is more effective due to complementarity and the supplementary role that each plays. Each method of teaching has its own strengths and weaknesses.

The effects vary depending on the position of a particular method in the specific sequence of teaching. Thus, the first method in the sequence determines the amount of original learning that occurs.

6. Recommendations at the pedagogical level

(1) The KICD should formulate new policy guidelines laying emphasis on use of Sequential Teaching Methods as a means to improve learners conceptual understanding of knowledge in Biology especially that concerned with physiological processes or mechanisms such as 'enzyme action'.
(2) Universities, colleges and CEMASTEA should improve on the existing policy on implementation in Biology syllabus by training and retraining teachers on use of STM. This could be done through workshops, seminars, conferences and training programs. Animated Slide Demonstration Experiment-Lecture (DEL) sequence is highly recommended.
(3) Universities and colleges should focus on training for innovative teaching rather than knowledge.

7. Recommendations for Further Research

The question that remains unanswered by the study is how the same sequence (DEL) affects knowledge relating to Anatomy, Histology and Morphology.

The recommendation in this regard, is that research be carried out to explore the effects of STM (DEL, LDE and ELD) on retention in relation to different kinds of knowledge in Biology such as Physiology, Anatomy, Morphology and Histology.

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