Effect of Online Based Concept Maps on Secondary School Students' Academic Performance in Biology in Endebess Sub-County, Kenya

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Abstract

Performance in sciences especially in Biology has continuously been a concern to the Government of Kenya, Biology teachers and various stakeholders in Education. For a considerable the past five years, Biology subject has performed below the expectation and for this reason researchers in this field are out to unlock the anomaly. This study investigated the effect of online based concept maps on secondary school students' performance in Biology in Endebess sub-county, Trans-nzoia County, Kenya. The objective was to find out the effect of online based concept maps on secondary school students' performance in biology in Endebess sub-county. The study employed quantitative research method. The study used Quasi experimental design; non-equivalent pre-test post-test groups design. The target population included all form one students in Endebess Sub-County with a population of 2845 students drawn from 18 schools. Using Krejcie and Morgan table for calculating sample sizes for research, a sample size of 451 students and 18 teachers was obtained. The study employed tests as data collection instruments. Tests were derived from qualified sources and were validated by specialists. A Cronbach's alpha of 0.79 was obtained and the instruments were considered appropriate and reliable. The data was analyzed by SPSS (version 21) and Microsoft Excel statistical packages. The results of the study showed that online based concept maps were a superior tool to conventional methods of delivery of content. It is hoped that the results will form basis for advising biology instructors in organizing concepts by the used of Biology concept maps, which promote meaningful learning for learners, supporting the overall learning style and enhancing the understanding of concepts to the learners.

Keywords: Online Based Concept Maps, Performance, Biology

INTRODUCTION

For the development of majority of the African countries, each society depends on a well-built education system that tends to impart scientific knowledge through various ways. However, in many cases, the teaching-learning process does not have a good quality and is indicated by several factors such as academic failure, lack of academic motivation, test anxiety and education regardless of context (Chen, 2019). Academic achievement means the growth of learning curriculum that is measured by standardized or teacher-made tests (Feld man & Kubota, 2015). Academic achievement is not only affected by knowledge structures and information processing methods, but also by motivational factors such as beliefs, attitudes and teaching methods of teachers

(Safarzadeh Saharroomarashian, 2015). Hence, nowadays, Education is not passive and aimless, but it is a purposeful activity to promote learning (Bolin, 2017). Concept maps originated in the constructivist learning movement and they draw their importance in the way we think and see relationships between knowledge. It has a wide usage by instructional designers, engineers, technical writers, educational settings and others to organize and structure knowledge. Typically concept maps represent information and ideas in boxes/circles connected by arrows in a downwards branching hierarchical structure (Stoica, Moraru & Miron, 2022). Constructivist teachers who use concept maps in their classes are interested in students understanding the relationships between facts presented.

A concept map is also known as a conceptual diagram as well as a knowledge graph. Concept maps are usually visual representations of information in the format of charts, graphic organizers, flowcharts, tables, Venn diagrams, timelines or T-charts which show suggested relationships between concepts. Concept maps are usually produced in a hierarchical manner, that is, more general and comprehensive content is placed at the top level and near the bottom, the concepts and content are more detailed (Martin, 1994).

Concept maps were developed by a team lead by Joseph Novak (1973) during their research on the psychology of children's learning based on Ausubel's theory of learning. The major notions of Ausubel's theory to distinguish rote learning and meaningful learning. Rote learning means the memorization of facts which one thinks of that they are true. Meaningful learning only happens when various new ideologies and conceptual facts are linked to those that students already know, i.e., when new information is integrated with current students' knowledge. Information acquired through meaningful learning is remembered for a longer time, and, even more importantly, there is a higher chance that students will use it successfully than rote learning.

An excellent example of how big an effect concept maps can have been given by Novak (2010). A high school in Costa Rica decided to start using concept maps in all subjects for both instruction and assessment. As a result, in four years, the success rate in National High School Graduation Exam increased from 65 % to 100 %. The main benefit of concept mapping is achieving meaningful learning instead of rote learning.

Although the students might feel that creating and editing concept maps is hard work, modern software tools like Context Minds allow creating new maps quickly and easily. For example, Context Minds automatically suggests new concepts suitable for adding to the map, according to the context set by the concepts already present in the map. That means that students can draft the map almost without typing and focus on thinking about the relationships.

Concept Maps and Performance

There are a number of studies that have been carried out by teachers across the world that had varied findings. Shun-Ho Wang (2019) explored the use of concept mapping teaching method. Their study found out that concept mapping helped learners build knowledge scaffolding, in that learners were able to organize scattered knowledge and construct meaning. In addition, it helped learners to present abstract concepts in a concrete way, and to clarify the relationship between concepts and facts, and to connect new information and prior knowledge in order to make meaningful learning. Wang regarded concept maps as a powerful teaching tool as it not only contributed to the construction and memory of knowledge, the communication and negotiation of

meaning, the evaluation and improvement of learning results, but also contributed to the organization of information and the innovation of ideas. Choudhary and Bano (2022) investigated the effectiveness of concept maps in formative assessment for the teaching and learning of biological concepts in a Pakistan secondary school. They found out that concept maps were useful tools for the development of a clear understanding of concepts in Biology. This element points clearly that concept maps can be utilized as an effective formative assessment tool in Biology as well as other subjects at secondary schools to improve on the performance.

Concept mapping teaching strategy has been used widely up to and including higher institutions of learning. For instance, Luchembe, Chinyama and Jumbe (2014) conducted a study in Mukuba university in Zambia among undergraduate students taking introductory Physics Course. Their findings showed that the experimental group's posttest mean score was higher than that of the control group. They concluded that concept mapping was more effective compared to tutorial sheet strategy used in the study. Interestingly the findings showed that students had a positive attitude towards the use of concept mapping strategy. In another study, Romero, Cazorla, & Buzon (2017) carried out a study on teaching-learning of the concept map technique applied to the Natural Sciences course in the second year of Compulsory Secondary Education in Spain. By the end of the two-year study 65% of the learners were able to learn how to, meaningfully construct concept maps, leaving 35% who didn't manage. This indicates that learners were interested in acquiring the skill of constructing concept maps.

Online based Concept Maps as a Teaching Strategy

Online concept maps are a powerful tool for identifying relationships among ideas you learn in class as argued by Javonillo and Martin-Dunlop, (2019). Understanding these relationships and depicting them visually can help you learn course material at a much deeper level and retain it better too. The main point is to always end up with a diagram with all the important ideas and main agenda of a particular topic and add the linking terms to bring out the effectiveness of an online concept map. Online concept maps are a model that tends to identify major ideas or concepts within a particular area, organize the various information into categories, then use lines and arrows to show the various relationships between the various ideas and ensure that it summarizes what an individual has read.

A few studies in the area of online concept maps done in other disciplines such as computing and informatics sciences have reported encouraging results. In his study, Thiiru (2011), investigated how adaptive web-based learning software prototype uses concept maps to elicit the student's prior knowledge, provide personalized support for learning, and evaluating the student's level of knowledge. The findings of the study showed that experimental group that used the adaptive concept maps software got more scaffolding support than the control group that used the non-adaptive one. The study therefore proposed the introduction of e-learning web based concept maps. In a slightly different study involving online concept maps, Aydogdu and Guyer (2019) investigated digital concepts in online learning environments in determining measurements of success and disorientation among students navigating using content tree and concept maps. Their study found out that students who navigated with a content tree were more successful than students who navigated with a content map. The researchers further observed that students who navigated with a concept map became less interested in the lesson that students who navigated with a content tree who looked very curious. This study points out to more interesting ways of making digital learning more interesting

and lively. The researchers in this study went into depths to develop and use content tree which is a self-navigating digital tool as well as the concept maps.

Not many researchers have delved into the area of online concept mapping probably due to the immense digital infrastructure required in the area of study. There are a number of studies which have reported lack of digital infrastructure in many schools in Kenya, hence due the existing gap, this study sort to investigate the effect of online concept maps on students' performance.

Statement of the Problem

Poor Performance in Biology as evidenced in KNEC Results for the past five years (2017-2021) Teaching and learning of biological concepts should take into account that students are from varied backgrounds and that they do not all learn in the same way. Hence teaching should not be considered as a linear process with a one-way delivery of knowledge but rather a combination of learner-centered learning and an interactive process between students and teachers. This has been brought about by a limited concentration span and modern youths requiring more engaging learning, yet teachers continue to use more passive learning such as the lecture method. This as a result has led to the performance dropping and the lack of interest in Biology (Ngesu, 2014). As a result, it has led to the current repeated dismal performance in Biology. This effect is evidenced by the current poor performance in Biology for Endebess Sub-County for the last five years .

Table 1: Biology Results for Endebess Sub-County for the Past Five Years (2017-2021)

Year	Cumulative Results Average For Endebess Sub-County	Cumulative Results Average For Kenya
2017	18.92%	23.26%
2018	25.69%	29.61%
2019	24.36%	28.32%
2020	22.31%	25.89%
2021	20.34%	25.87%

Source: KNEC (2021)

Objectives of the Study

The following objectives guided the study

To investigate the effect of online based concept maps on secondary school student's performance in Biology in Endebess Sub-county.

Research Hypothesis

H_{o1}: There is no significant difference between learners taught using online based concept maps and those taught using traditional approaches on secondary school students' performance in Biology in Endebess sub-county;

METHODOLOGY

The study employed quasi experimental design, Pretest Posttest Non Equivalent group design, pre-test post-test designs as argued by Dimitrov and Rumrill (2003) found its use at comparing/measuring groups change that are as a result of experimental treatments used on experimental groups. Representation of the design is as shown in a concept map as in figure 1.

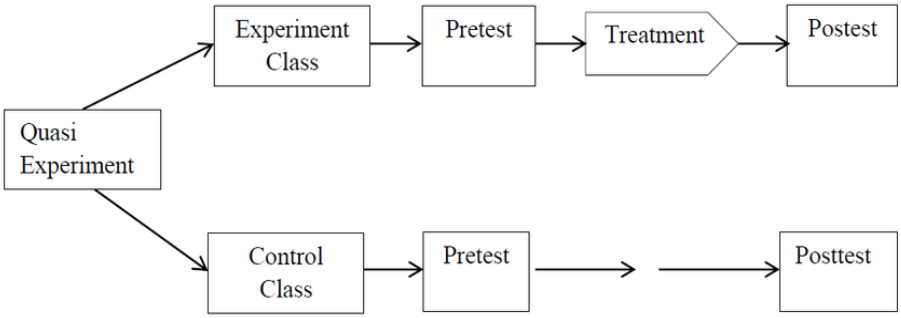

Figure 1: Pre-test Post-test Non-Equivalent Group Design
Source: Rudibyani, (2019)

The study employed both quantitative research methodology. In this study the relationship between effects of online based concept maps was the dependent variable and was measured on the independent variable which was the secondary school students' performance in Biology among form one students in Endebess Sub-County of Trans-nzoia County, which warrants the use of quantitative research method. The quantitative data was collected from the pretest and posttest scores which were analyzed by the use of inferential statistics.

The study was carried out in Endebess sub-county located in Trans-nzoia county Kenya. The study area is approximately 680 Km2 (Square kilometers) and is the largest of the five sub counties that make up Trans-nzoia County in terms of surface area. It borders West Pokot County to the North, Kaptama Sub-County to the south, Kiminini Sub-County to the East and Uganda to the west. The research area is a rich agricultural area with maize as the main crop planted on large scale, forming part of the countries food store. The inhabitants of the area are largely cosmopolitan with many ethnic communities of Kenya represented forming the face of Kenya. Within Endebess sub-county only one school is an extra county school category, all the rest are sub-county category schools. With the ongoing 100% transition of students as mandated by the government of Kenya through the ministry of education, it therefore implies that these schools will soon have a high number of students, where Biology teachers have to think of alternative teaching options such as online concept maps to enhance their efficiency. The researcher conducted the research in the sub county because it has continually performed poorly in Biology in the KNEC exams in the past five years as shown in table 1.

The study targeted all the Form One students of Endebess Sub County. There are 18 public secondary schools in Endebess Sub County (Endebess Sub County Education Statistics, 2021) with a population of 2845 Form One students and 18 Biology teachers. Form one was targeted for the study because this is the introductory phase to Biology subject hence concept maps would the learners organize the new information they were encountering and make meaningful connections between the main idea and other information.

Stratified, simple random sampling and purposive sampling techniques were used in the study. The researcher used purposive sampling technique to separate the schools into two strata: 12 mixed secondary schools and 6 single sex secondary schools (2 Boys and 4 Girls schools). The researcher then used simple random sampling to select

2 schools from the mixed secondary schools and 2 single sex secondary schools, then purposively target form One as intact classes participated in the study. Krejcie and Morgan Table for calculating sample sizes used for determining participants in a study was used to select 451 respondents drawn from form 1 intact classes.

Two secondary schools were selected for experimental classes while two other schools formed the control experiments classes. It's important that the two experimental set ups were in different schools so that the problem of students in the different categories mixing was sorted. The Biology teachers in the selected schools were inducted by the researcher on how to conduct the research and therefore become the research assistants automatically during the study period. Pre-test and post-test tools were developed by the researcher with the assistance of the supervisors and with the help of experts in the area of specialization. The tests were drawn from the topic of nutrition; in animals. The content to be used was selected because it has so many details that require organization to help a fresh student who has just emerged from primary school to grasp hence the online biological concept maps.

After all the participants of the study had been pretested, the experimental group was taught by used of concept maps for a period of 4 weeks as per the Biology syllabus approved by KICD to complete coverage of the subject matter while the control group were confined to the traditional method of teaching specifically lecture method. Teachers in the experimental group used developed online concept maps given by the researcher. A posttest was thereafter being administered after completion of the instructional period. The researcher then used the results of the pre-test and the post-test to find out if there was any difference between the experimental and the control groups. Descriptive and inferential statistics was used to analyse the data obtained.

RESULTS AND DISCUSSION

Effect of Online Based Concept Maps on Students' Performance

The objective sought to investigate the effect of online based concept maps on secondary school student's performance in Biology in Endebess Sub- County. The procedure for testing the respondents consisted of three stages;

1. Pre-testing to assess the learners' cognitive abilities at the beginning of the study
2. Experimental treatment and
3. Post-testing to assess the change in the learners' achievement in biological knowledge at the end of the study period.

The respondents were divided into two groups; the control group and the Experimental group.

Pre-test Scores

Student's Mean and Standard Deviation in Pre-test

The researcher administered a pre-test to both groups at the beginning of the research period. The results obtained were as follows:

Table 2: Student's Mean and Standard Deviation in Pre-test

	Type of Group	N	Mean	SD
Pre-test Score	Control Group	246	17.94	7.652
	Experimental Group	205	17.23	7.379

Source: Researcher, 2023

Table 2 shows the means and standard deviations of the control and the experimental group during the pre-test. The mean score recorded by the control group during the pre-test was 17.94% while that of the experimental group was 17.23%. This distribution of scores is represented in Figure 1

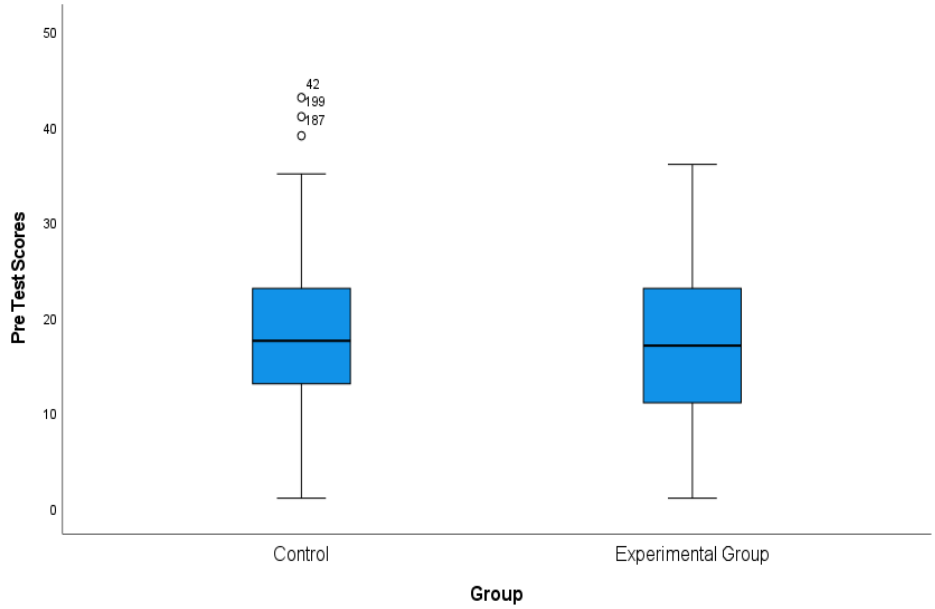

Figure 2: A boxplot showing the distribution of Pre-test Scores
Source: Researcher, 2023

Figure 2 contains boxplots which help to visualize the distribution of scores for both the experimental and control groups. The thick black line in the middle of the boxplots represents the means. The lower and upper boundaries of each box represent the 1st and 3rd quartiles respectively. The extreme lower and upper ends represent the least and highest scores respectively. From Figure 2 it can be seen that the distribution of the scores in the box plots of the control and experimental groups were almost the same. However, in the control group there are three outliers represented by three dots. This represents learners with exemplary performance as compared to the other learners in the control group.

The researcher further subjected the pre-test scores of the control and experimental groups to a t-test to establish the equality of their means. The results were as presented in table 3 that follows:

Table 3: T-test for Equality of means in Pre-test

	t-test for Equality of Means						
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Pre-test Scores	0.990	449	0.323	0.705	0.712	-0.694	2.104

Source: Researcher, 2023

Table 3 contains the results of a t-test that was comparing the mean scores of the pre-test between the control and experimental groups. The p-value that was obtained is 0.990. Since the p-value is greater than 0.05, it was inferred that there was no significant difference in the means of the control and experimental groups during the

Pre-Test. It was therefore concluded that students were of equal ability which was a necessary condition for the research to have proceeded.

Treatment Period

After pre-testing the learners, the researcher administered treatment to the experimental group who were taught by the use of online based concept maps while the control group were taught using the traditional methods for a period of one month.

Post-test Scores

At the end of the treatment period a post-test was conducted to the same respondents to test for the difference in academic achievement in the area of Biology. The results are illustrated in Table 4.

Table 4: Students' means and standard deviation in Post-test

Type of Group	N	Mean	SD
Control group	246	49.76	16.847
Experimental Group	205	69.00	6.618

Source: Researcher, 2023

Table 4 contains the means and standard deviations of the scores during the post-test for both the experimental and control groups. The mean score of the control group was 49.76% while that of the experimental group was 69.00%. It was observed that both post-test means in the control and experimental groups improved from the previous pre-test means as shown in Table 5.

The standard deviation for the experimental group 6.618 is less than that of the control group 16.847. An indication that the gap between the top achievers and low achievers was smaller in the experimental group.

Table 5: Mean Deviations – Pre Test versus Post Test

Type of Group	Pre-test Mean	Post-test Mean	Mean Deviation
Control group	17.94	49.76	+31.82
Experimental Group	17.23	69.00	+51.77

Source: Researcher, 2023

As per Table 5 it could be noted that both the traditional approach and online concept maps provided an improvement in the percentage mean scores. The experimental group improved because of the treatment given. The control group improved possibly due to the fact that the respondents were aware that they were participating in a study and their teachers could have improved in the content delivery. Worth noting is that the improvement in the experimental group is higher than the control group. The distribution of scores in the post-test would better be visualized in Figure 3.

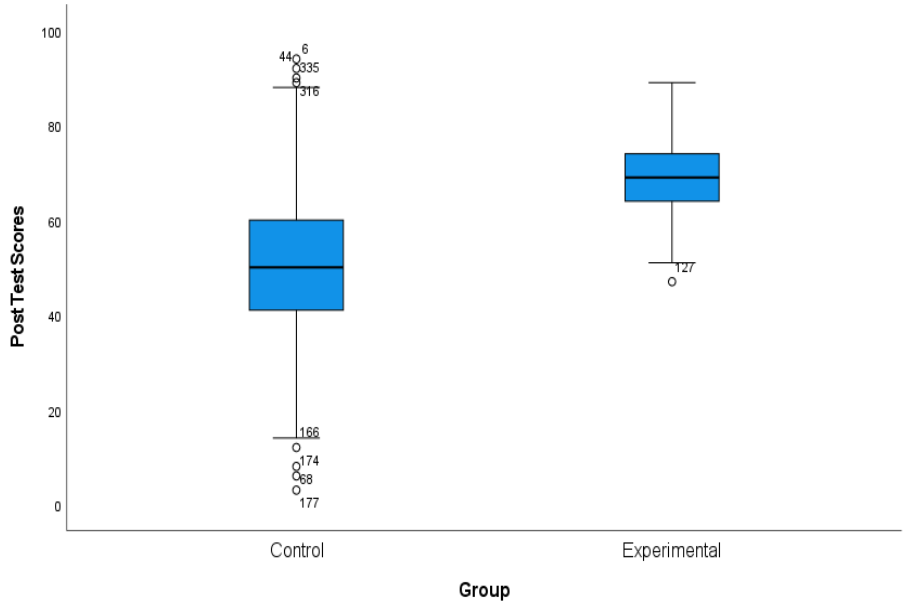

Figure 3: Distribution of Post Test Scores
Source: Researcher, 2023

Figure 3 contains boxplots which indicate the distribution of scores for both the control and experimental groups. In relation to figure the following would be observed: the lowest score in the experimental group was above the first quartile of the control group, the first quartile of the experimental group was above the third quartile of the experimental group, the mean of the experimental group was above the third quartile of the control group and the third quartile of the experimental group was better than the third quartile of the control group. The maximum values are relatively close. This suggests a significant difference in the two distributions. To further substantiate this claim, the results of a t-test are presented in table 6:

Worth noting too is the fact that the number of outliers in the control group are 8 (4 very low scores and 4 very high scores) while in the experimental group there is 1 (Very low score).

Table 6: t-test for equality of means in the Post-test

	T-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Post-test Score	-15.391	449	<0.001	-19.241	1.250	-21.968	-16.784

Source: Researcher, 2023

Table 6 contains results of a t-test that was carried out after a post-test had been administered to the respondents. The p-value that was obtained was less than 0.001. Since, the p-value was less than alpha at 0.05, the null hypothesis was rejected. Hence, it was concluded that there was sufficient evidence to reject the null hypothesis since

there was a significant difference in academic achievement between learners taught by Online based concept maps and those taught using traditional methods of teaching. Moreover, the mean score of the experimental group was higher than that of the control group. This implies that online based concept maps were more effective as compared to the traditional methods of teaching. The findings of this study showed that the experimental group taught by the use of Online concept maps as the treatment, had better mean performance in the posttest than the control group. This clearly indicates that Online concept maps was a more superior strategy in the delivery of content than the traditional approaches of teaching. The findings of this study agrees with Njenga (2011) who in their study noted that concept maps incorporate individualized learning where learners are presented with concept maps that matches students level of understanding. In this way, learners get to improve on their understanding as more online concepts are added. This enables the learner to build concepts and understanding systematically which leads to improvement in the performance in Biology as evidenced in this study.

CONCLUSION AND RECOMMENDATION

From the study it can be concluded that online based concept maps are a superior strategy because learners taught by online based concept maps improved because of the intervention that was taken. Online based concept maps hence have the ability to significantly lead to an effective increase in understanding of biological concepts and enhancing even the learners' practicability to even use the content delivery method to revise on contents easily. This has easily been evidenced by the post-test results. The study recommends that the Kenya Institute of Curriculum Development to provide adequate Online concept maps content to be used to enhance learning and content retention to promote performance in Biology.

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