Effect of Mind Maps on Test Scores in Ecology in Public Secondary Schools of Kenya

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Abstract
This study sought to find the effect of mind maps in learning the concepts of ecology in public secondary schools in Kenya. The study had a sample population of 492 respondents drawn from form three students and their respective teachers in public secondary schools in Hamisi sub-county. The study adopted a pre-test, post-test non-equivalent quasi experimental design. Achievement tests were used to collect data which was analyzed inferentially using the t-test. The study revealed that students exposed to the use of mind maps in learning had an improvement of 34% in their scores. A p value of 0.001 was obtained on an independent sample t-test which indicated that a statistically significant difference in the means existed between students who used mind maps than those who did not. This led to the rejection of the null hypothesis. The study concluded that mind maps were an effective way of teaching concepts in ecology. Mind maps were therefore highly recommended for effective teaching of ecology.

Key words: Achievement, Ecology, Misconception, Conventional Methods

Introduction
According to the Kenya National Examination Council, concepts in the topic of ecology are frequently tested yet candidates record dismal scores in the examinations. Ecology provides basic information on conservation, pollution, waste management and interrelationships in the environment, laying the foundation for achievement of MDG on environmental sustainability and vision 2030 for environment. To Abimbola (2013), ecology deals with the way in which organisms function in harmony with the non-living physical environment. Ecology is thus important in dealing with nature and the environment in a responsible way. Understanding ecology concepts is a pre-requisite for high achievement in biology education (Chimoita, 2014). Despite the aforementioned importance of ecology, students still perform poorly in ecology (Ugulu, 2008). The low performance in ecology is global. According to the West African Exam
Council (WAEC) reports 1998-2000, ecology is one of the difficult concepts to both teachers and students. The examiners’ report on ecology revealed low achievement in ecology by students (WAEC, 2004). Documentary analysis of patterns and trends of performance in biology subject by the Kenya National Examination Council (KNEC, 2010) revealed misconceptions and low understanding of ecological concepts by students. Adeniyi (1985) ascertained that misconceptions which students hold about some ecology concepts affected their overall performance. Despite the government’s effort to improve the pedagogical approaches in biology, Owino (2014) asserts that performance in biology is not impressive. SMASSE (2003) reported that inappropriate teaching methods and approaches were major reasons for poor understanding and, performance of students in science and mathematics education.

Research studies on mind mapping have been done globally and findings have revealed that it is a powerful teaching technique. Use of mind mapping technique enables all students to participate actively in the lesson leading to better understanding of concepts. Budd (2004) supported the idea that students are engaged in active learning when mind maps are used. A study by Toi (2009) on Singaporean children revealed that mind mapping increased memory by up to 32%. Al-jarf (2009) proved that mind mapping offers a powerful approach for improving on the ability of students to generate, visualize and organize ideas. According to Gadne’s information processing theory, retrieval of information depends on its organization and presentation in the memory. Mind mapping may provide information organization and presentation in the brain for effective retrieval. Mind maps, in addition to information organization and engaging students, also improve on memory of learned concepts. The tool may therefore be an excellent teaching technique whose application is long overdue.

However the use of the mind mapping technique has received little application in secondary schools in Kenya and specifically in Hamisi Sub County. This study therefore investigated the effect of incorporation of mind mapping technique in biology instruction on student achievement. The study was carried out in Hamisi Sub-County, Vihiga County which has consistently

**Statement of the Problem**

Use of mind maps although effective, is an approach that is hardly used by teachers in the learning processes. The approach appeals to mastery of high level of knowledge in the domain of evaluation and synthesis. The application of this approach to learning simplifies the abstract concepts with ease. In Kenyan secondary education, students find it elusive to master concepts in ecology. Ecology is a topic covered in form three in the current biology syllabus. In post examination analysis, the Kenya National Examinations Council (KNEC) perennially reports dismal achievement for candidates specifically in this topic and generally in biology. Topical analysis for biology in national examinations indicates greater apportionment of marks to this topic despite the elusiveness to most teachers and learners. Moreover, there are misconceptions on the topic that mislead learners in various course books. The efforts by the government to enhance effective pedagogy in biology by platforms like Strengthening of Mathematics and Science in Secondary Education (SMASSE) have yielded very little. Although, some teachers advocate the extensive use of mind maps to improve mastery and achievement in biology, such assertion lacks empirical backing.
The purpose of this study was to evaluate the effectiveness of mind maps in the teaching and learning process and consequently student achievement in ecology concepts.

**Study Objective**
To investigate the effects of mind maps on test scores in ecology in public secondary schools in Hamisi sub county, Kenya.

**Research Question**
What effect do mind maps have on test scores in ecology among secondary schools in Hamisi Sub County?

**Hypothesis**
HO1: There is no significant difference in test scores in ecology when mind maps are used and when they are not used in public secondary schools in Hamisi sub county, Kenya.

**Literature Review**
Teaching of biology emphasizes hands-on, minds-on activities. Hassard (2009) emphasizes a humanistic, experimental and constructivist approach to teaching and learning, which integrates varied pedagogical tools. However, Mukachi (2005) notes that many schools use expository learning practices, where the teacher dominantly talks throughout lesson, leaving little room for pupil activities. Teachers further use text books and past papers for references in class. This denies students a clear understanding of basic concepts and suppresses the development of critical thinking among the students. Analysis of mean score trends in biology, by the Kenya National Examination Council (KNEC, 2005), indicates dismal achievement. The low scores were prevalence notwithstanding the great fondness the subject enjoys by majority of students. The dismal attainment in biology is not any different in secondary schools of Hamisi Sub County as shown in the table 1.1 below.

**Table 2.1: KCSE performance in Hamisi sub-county**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology mean score</td>
<td>4.271</td>
<td>4.174</td>
<td>4.170</td>
<td>4.197</td>
<td>4.217</td>
</tr>
<tr>
<td>Overall (KCSE) mean score</td>
<td>5.468</td>
<td>5.4723</td>
<td>5.4695</td>
<td>5.575</td>
<td>5.7601</td>
</tr>
</tbody>
</table>

Source; KNEC Reports (2010-2014).

The mean scores attained in biology at KCSE for the years under review clearly negates that students have attained the basic mastery level of the secondary biology course. Unless this trend is reversed, the prospects of attaining the goals of Kenya vision 2030 may not be achieved.

According to Waldron and Doherly (2009) students learn best if they are actively engaged and if their activities are linked to understanding scientific concepts. Mind mapping technique has been studied globally and found to be useful in a variety of ways in the teaching process. Evidence collected by Budd (2004) proved that mind mapping engages students in active learning. In particular, students with higher scores for a ‘doing’ learning style benefited from mind mapping activities. This idea is in line with earlier findings by Goodnough and Woods (2002) that mind
maps are interesting, motivating and engaging to learners. Mind maps, being visual diagrams that combine imagery, color and visual-spatial arrangement encourage students to participate actively in class leading to better understanding of concepts. A study by Polsen (2004) proved that using mind mapping as a pedagogical strategy led to improvement in pupils learning. The study also revealed that the applications and advantages of mind mapping have cross curricular qualities, and can be potentially applied across all age ranges and learning abilities. To Boyson (2009), using mind maps for lesson planning can help teachers identify logical plan or teaching route and increase recall of subject matter. This can boost teacher confidence and facilitate the smooth running of the lesson. This is in line with findings from a study by Mento et al (1999) who observed that a number of executives who used mind maps made clear presentations without fumbling about with notes.

The use of mind maps would therefore enable the teacher make lesson presentation with confidence because mind maps provide a unique representation of information for better internalization. Goodnough and Long (2002) found mind maps as a useful strategy for introducing new concepts, that focus the class to the concepts. In a mind map, information is structured in a way that mirrors exactly how the brain functions- in a radiant rather than linear manner. It ‘maps’ out an idea using associations and triggers that extract and connects the information in the head into something visible and structured. In schools, lesson introduction mostly involves review that occurs verbally, where a teacher asks questions and the learners answer to link to the previous lesson. Mind maps would bring out the review in a much better way as the visual link in colorful presentation would capture the whole class and improve on concept linkage. Mind maps do not rely on a large amount of written text. This makes them effective in making summary notes and conclusion for a concept or lesson. Mind maps would therefore stimulate the learners, engage them and enable them organize ideas in their minds in a manner that they can easily retrieve.

Studies by Resnick (1989), revealed that learning occurs when people select relevant information, organize it in a coherent structure for interpretation by what they already know. The “learning occurs not by recording information but by interpreting it.” Therefore for learning to occur, in-depth understanding of concepts is necessary. The mind should structure the information in a way that it can be easily retrieved. Trawbridge (2004) asserts that ‘learning is best achieved by active, personal involvement with materials. Mind maps would provide this. A study by Abi-El-Mona and Adb-El-Khalick (2008) revealed that science students who used mind maps achieved substantially higher gains in conceptual understanding and practical reasoning than students who used conventional study techniques. Mind mapping has also been found to engage learners in active learning and to improve their memory. A study by Toi (2009) showed that mind mapping can help children recall words more effectively than using lists, with improvement in memory of up to 32%. This concurs with earlier findings by Farrand, Hussain and Hennessey (2002) that mind mapping improves the long term memory of factual information by 10%. Mind maps can therefore promote learning through improved recall ability and memory of factual information. Biology is a science built on many facts, ideas and concepts that demand good memory.
According to Gadne’s information processing theory, retrieval of information depends on its organization and presentation in the memory. Gestalt’s theory of insightful learning indicates that learning is enhanced when similar concepts are brought together (similarity) and arranged next to each other (proximity). The use of mind maps would bring about similarity and proximity enhancing learning of related concepts. Findings from an investigation by Al-jarf (2009) revealed that the written work produced by using mind maps included more relevant details and better organized and connected ideas. The use of mind maps could therefore bring about effective learning when used with other techniques. However, most schools do not use mind mapping technique in the learning processes. This has denied students an opportunity to utilize the unique features of mind maps in personal study that would encourage a deeper level of information processing for better memory formation. This study investigates the effect of mind mapping technique on learning through observation of student scores in achievement tests.

Methodology

Research Design

The study adopted a pre-test, post-test non-equivalent quasi experimental design as illustrated below;

\[
\begin{align*}
O_1 \times O_3 & \quad \text{Key: } O_1 \text{ and } O_2: \text{Pre-tests} \\
O_2 \times C \times O_4 & \quad O_3 \text{ and } O_4: \text{post-tests} \\
X \text{ Gain} = O_3 - O_1 & \quad X: \text{Treatment (incorporation of mind mapping in teaching)} \\
C \text{ Gain} = O_4 - O_2 & \quad C: \text{Control (using conventional techniques in teaching)}
\end{align*}
\]

The learners undertook two sets of tests; biology achievement pre-test and biology achievement post-test. The biology achievement pre-test consisted of questions on terminologies in ecology. They also tested aspects on energy flow in an ecosystem and pollution. The ecology achievement post-test on the other hand tested on factors in an ecosystem; population and human diseases. The pre-test was given to all students after exhaustively studying concepts in ecology by the conventional method. The test scores were recorded as \(O_1\) and \(O_2\) for the treatment and control groups respectively. The use of mind maps on components of the ecosystem; population and human diseases were integrated in the instructions given to the experimental group. The control group alternatively learnt the same concepts using conventional methods. The post-test was subsequently administered to both groups after completion of the concepts. Test scores were recorded as \(O_3\) and \(O_4\) for the experimental and control groups respectively. The researcher then calculated gain for the control and experimental groups before inferring conclusion. The research design enabled concrete conclusion by comparing the effects of mind maps on tests on the experimental and the control groups respectively.

Sample Size

The study involved a sample of 492 respondents who consisted of 480 students and 12 teachers from public secondary schools. The schools under study had undertaken KCSE examination
between 2010 and 2014 as proof that indeed the mean score in biology and for the school was low.

Table 3.1 Samples of Schools

<table>
<thead>
<tr>
<th>School category</th>
<th>Target population</th>
<th>Sample population</th>
<th>Sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>County</td>
<td>7</td>
<td>3</td>
<td>42.9%</td>
</tr>
<tr>
<td>Sub County</td>
<td>26</td>
<td>9</td>
<td>34.6%</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>12</td>
<td>27.5%</td>
</tr>
</tbody>
</table>

Table 3.2 Sample of Students

<table>
<thead>
<tr>
<th>Students</th>
<th>Targeted population</th>
<th>Sampled population</th>
<th>Sample(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>County</td>
<td>315</td>
<td>126</td>
<td>25</td>
</tr>
<tr>
<td>Sub County</td>
<td>1263</td>
<td>354</td>
<td>35.7</td>
</tr>
<tr>
<td>Total</td>
<td>1578</td>
<td>480</td>
<td>32.9</td>
</tr>
</tbody>
</table>

Findings and discussion

Students in the experimental and control classes were given pre-test and post-test examinations in ecology. The scores were obtained recorded in table 1.5

Table 3.3 Students’ scores in biology tests

<table>
<thead>
<tr>
<th>Scores</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
<td>Control</td>
</tr>
<tr>
<td>1-5</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>6-10</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>11-15</td>
<td>55</td>
<td>59</td>
</tr>
<tr>
<td>16-20</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>21-25</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>26-30</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>214</td>
<td>222</td>
</tr>
<tr>
<td>Mean</td>
<td>10.01</td>
<td>10.00</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>6.175</td>
<td>5.935</td>
</tr>
</tbody>
</table>

From table 1.5, the experimental group realized a mean of 10.01 in the pre-test and 20.33 in the post-test which translated to 33% and 67% of the expected score respectively. The standard deviation obtained was 6.175 and 15.053 for the experimental group in the pre-test and post-test respectively. The control group realized a mean of 10.00 in the pre-test and 10.62 in the post-test that translated to 33% and 35% respectively. The standard deviation for this group in pre-test and post-test was 5.935 and 11.040 respectively. There was therefore a mean difference (gain) of
10.32 and 0.62 for the experimental and control groups respectively which indicated a higher gain in the experimental group compared to the control group. Mind mapping technique therefore may have improved on the students’ score by 34%. In the post test, the mean difference between the experimental and control groups was 9.71 which translated to 32%. The study therefore sought to establish whether there was a significant difference in students achievement between the students exposed to mind maps in learning ecology against those who were not.

Table 3.4 Effects of mind maps on student achievement

<table>
<thead>
<tr>
<th>Group Statistics</th>
<th>Treatment Given</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCORES BEFORE</td>
<td>Experimental</td>
<td>214</td>
<td>10.01</td>
<td>6.175</td>
<td>.422</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>221</td>
<td>9.90</td>
<td>5.793</td>
<td>.390</td>
</tr>
<tr>
<td>SCORE AFTER</td>
<td>Experimental</td>
<td>210</td>
<td>20.33</td>
<td>15.053</td>
<td>1.039</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>214</td>
<td>10.62</td>
<td>11.040</td>
<td>.755</td>
</tr>
</tbody>
</table>

Table 3.5 Two-sample independent t-test on student achievement

<table>
<thead>
<tr>
<th></th>
<th>Lavene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Score Before</td>
<td>Equal variances assumed</td>
<td>.331</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td>.190</td>
</tr>
<tr>
<td>Score After</td>
<td>Equal variances assumed</td>
<td>.283</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td>7.564</td>
</tr>
</tbody>
</table>

From table 1.7, a p value of 0.001 was obtained. Based on the alpha level set (α=0.05), there was a significant difference in the mean scores between students who used mind maps and those who did not. The result therefore revealed that use of mind maps had a significant effect on student achievement in the topic of ecology in public secondary schools in Hamisi sub-county.

The use of mind maps exposed students to the detailed aspects of learning; which when tested, given the high retainability of concepts, enables learners to score highly. The students who effectively used mind maps were able to create knowledge at the highest domain of learning in regard to Bloom’s taxonomy. In their endeavors to pass examinations, the students distill notes from the original ones. The distilled notes incorporate the learning concepts that are highlighted by images, color or words. Since the art of mind mapping is student oriented, learners tend to
personalize the mind maps with unsurpassed possessiveness that serves as a motivator to routine revision. This enables the retention of concepts in the long term memory of the brain, which further enhances memorization and recall of the facts learnt. Emotionally, students appreciate the efficacy in use of mind maps for learning and exemplary achievement.

The null hypothesis $H_0$ that there is no significant difference in test scores on ecology between students taught using mind maps and those taught using conventional techniques was rejected and the alternative hypothesis accepted. It was therefore concluded that there is a significant difference in test scores in ecology between students taught using Mind Mapping technique and those taught by conventional techniques. The findings of the present study are in line with those established by Budd (2004) that mind mapping engages students in active learning which promotes understanding of abstract concepts. This compares positively with the assertion of Trawbridge (2004), that learning is best achieved by actively involving students with the learning materials. Therefore the usage of mind maps by students in learning activities improves recall of factual information tremendously.

**Conclusion**

Students who used mind maps obtained higher scores in the post-test compared to students who used the conventional techniques. Mind mapping technique produced a significant difference in students’ achievement between students taught using the mind mapping technique and those taught using the conventional techniques in the learning of ecology concepts in secondary school biology course.

The use of mind mapping technique effectively manages knowledge by fine tuning the learning and the evaluation process that invokes the high thinking order of the student. This linkage in learning subsequently enhances student achievement. Though mind mapping as a teaching and learning technique is hardly used in secondary schools in Hamisi Sub County. It is imperative to use the technique for close monitoring of learner creativity that is associated with it.

Institutions charged with teacher training can enhance learning by incorporating the value of this technique in the training modules. The pedagogical competencies of serving teachers can be appraised through refresher courses to acquaint them with skills in designing mind maps. The mind mapping design is suitable in creating a wholesome link in teaching concepts that cut across other disciplines in school. This will enable a wide understanding of knowledge in interrelated topics. The use of mind mapping technique isolates the ability of learners from those with low understanding order to those with high thinking order. In this regard, it enables identification and placement of respective learners to suitable careers depending on their level of achievement.

**Recommendations**

The findings of this study suggest that Mind mapping technique can be an effective approach in enhancing students’ achievement in learning ecology. Based on these findings the following recommendations are proposed:

- Teacher education institutions need to incorporate mind mapping as a valuable technique in the teaching learning process. Training should be designed to produce teachers capable of constructing and using Mind maps.
• In-service training should be conducted for serving teachers to sensitize them on the use of mind mapping technique to enrich their pedagogy.
• Education authorities should encourage biology teachers to construct, guide students to construct and use mind maps in the teaching/learning process.
• In pursuit of revision for candidates to national examinations, the use of revision notes and course textbooks be discarded. Instead, the candidates should employ the use of mind maps to expedite retention of facts and high achievement in the impeding examinations.

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