Mind Mapping Technique and Student Achievement by Gender in Ecology Concepts in Hamisi Sub County, Kenya

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Abstract
This study sought to investigate the effect of mind mapping technique on students’ academic achievement in ecology concepts by gender. The study adopted a pre-test post-test non-equivalent quasi experimental design. One county and five sub-county secondary schools in Hamisi sub-county were selected from which a sample population of 230 students was selected. Ecology achievement tests and questionnaires were used to collect data. Instrument reliability and validity had been established by the spearman product moment correlation coefficient in two pilot schools. The scores and responses from the questionnaires were analyzed descriptively and inferentially using measures of central tendency and the t-test at 0.5 significant level. The findings of the study revealed that the mind mapping technique resulted into higher students’ scores in the post-test achievement test in ecology for both gender. A significant difference was revealed in the mean scores between the pre-test and post-test achievement tests. From the findings, it was recommended that teacher training institutions, Kenya Institute of Curriculum Development and teachers of biology should enact Mind mapping technique as a component of teaching/learning process in Kenyan Secondary Schools.

Key words: Mind mapping, Technique, Achievement, Ecology concepts, Misconceptions

Introduction
According to the Kenya National Examination Council reports, ecology is among the topics in biology that has been poorly performed over the years, with most candidates revealing misconceptions and inappropriate application of ecological terms and concepts. Secondary school 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. It is important in dealing with nature and the environment in a responsible way. According to Chimoita (2014), understanding ecology concepts is a pre requisite for high achievement in biology education. Understanding ecology does not only enable students to pass the biology examination well, but to also realize its useful applications aimed at maintaining a healthier and more productive biosphere for the life of humans and other living organisms. Despite the aforementioned importance of ecology, students still perform poorly in ecology (Ugulu Aydin, Yorek, & Dogan, 2008). Kenya National Examination Council Report (KNEC, 2010) revealed misconceptions and low understanding of ecological concepts by students. The low performance in ecology is global. The West African examination council examiners’ report revealed low achievement in ecology by students (WAEC, 2004). Earlier reports by Adeniyi (1985) ascertained that misconceptions which students hold about some ecology concepts affected their overall performance. Sander, Kattmann, & Jelemensksa (2006) observed that one of the obstacles in teaching ecology is the fact that there are many uncertainties as to how certain concepts, facts and terms should be understood.

Strengthening of Mathematics and Science in Secondary, SMASSE (2003) report revealed that inappropriate teaching methods and approaches were major reasons for poor understanding and, performance of students in science and mathematics education. To Resnick and Kafai (1989) “learning occurs not by recording information but by interpreting it” (p. 2). Learning therefore occurs when people select relevant information, organize it into a coherent structure and interpret it through what they already know.

Research studies on mind mapping have been done globally and findings have revealed that it is a powerful teaching technique. 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 provide information organization and presentation in the brain for effective retrieval. The tool may therefore be an excellent teaching technique whose application in Hamisi Sub County is long overdue. This study therefore investigated the effect of incorporation of mind mapping technique in instruction on student achievement in ecology by gender. The study was carried out in Hamisi Sub-County, Vihiga County where low performance was evident for the period under review. The main aim of this study was to establish the validity of earlier research findings with regards to the study of ecology by gender in Hamisi Sub County.

**Statement of the problem**

Performance in biology has remained low in Hamisi Sub-County for the past five years as reflected in table 1.2.

<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>Mean score</td>
<td>4.271</td>
<td>4.174</td>
<td>4.170</td>
<td>4.197</td>
<td>4.217</td>
</tr>
</tbody>
</table>

Source; KNEC Reports 2011-2014
The performance for the five years under review clearly indicate that a large proportion of students who leave secondary school in Hamisi sub county do not attain the basic mastery level of the secondary school biology course. At secondary school level, biology deals with most aspects of human life necessary for quality living even beyond school. Chimoita (2014) asserts that ecology is a pre-requisite area for good performance in biology among students. Despite knowledge of the importance of ecology in biology, a high number of misconceptions are still being reported among both the teachers and students in the topic (KNEC, 2010). Adeniyi (1985) ascertained that misconceptions which students hold about some ecology concepts affected their overall achievement in biology. Unless this is reversed, the prospects of attaining the goal of Kenya vision 2030 may not be achieved.

A survey by Strengthening Mathematics and Science in Secondary Education SMASSE (2003) revealed that inappropriate teaching methods and approaches are the major reasons for poor understanding and performance by students in science and mathematics education. Sander, Kattmann, & Jelemensksa (2006) observed that one of the obstacles in teaching ecology is the fact that there are many uncertainties as to how certain concepts, facts and terms should be understood. The demand for diversified teaching techniques to bring about improved understanding and performance on ecology concepts and therefore biology is paramount.

The impact of use of the mind mapping technique on learners’ achievement in biology was investigated in this study. The researcher specifically set out to investigate the effect of mind mapping technique on biology students’ achievement in ecology by gender in Hamisi Sub County.

**Study Objective**
To investigate the effects of mind mapping technique on student achievement in ecology by gender in public secondary schools in Hamisi sub county, Kenya.

**Research Question**
What effect does the mind mapping technique have on student achievement in ecology by gender in public secondary schools in Hamisi Sub County?

**Hypothesis**
HO1: There is no significant difference by gender in ecology achievement test scores when mind mapping technique is used compared to when the conventional techniques are used in public secondary schools in Hamisi sub county, Kenya.

**Literature Review**
Learning occurs when people select relevant information; organize it in a coherent structure for interpretation by what they already know. To Resnick and Kafai (1989), learning occurs not by recording information but by interpreting it. According to Waldron and Doherly (2009) students will learn best if they are actively engaged and if their activities are linked to understanding scientific 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.
Survey 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. 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. A study by Abi-El-Mona and Adb-El-Khalick (2008) revealed that science students who used mind mapping 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 in their participants by 10%. Mind maps can therefore promote learning through improved recall ability and memory of factual information.

In Kenya both boys and girls in secondary schools find science concepts difficult to understand. This is reflected in the low scores obtained in KCSE by the candidates (KNEC, 2013). However, according to Eshiwani (1983) girls under-achieve in science and mathematics at secondary school level. To Trawbridge (2000), under performance of girls in science is partly due to teacher bias in favor of boys. School science has been a reserve for male students for long (Hicks, 2001). However studies on performance by gender in different science subjects provide varied findings on performance in different science subjects. Rua, Jones & Howe (2000) revealed that, unlike chemistry or physics, girls showed more positive attitude towards biology than boys. According to Osborne, Simon, & Collins (2003), a student’s attitude towards a particular discipline may affect his or her motivation to excel. Major findings of a study by Wasanga (1997) revealed that students have moderately positive attitude towards science. However differences were found in the area of gender, school type and teachers’ gender. Male students were found to have more positive attitude towards all aspects of science apart from perception of science as a male domain. Some of the factors identified to have an influence on the attitude of female students included; the opinion that science is very difficult, poor teaching approaches and stereotypical attitude towards science related careers and low achievement in examination.

In addition, male students showed more confidence in learning science which is perceived to be more useful in motivation. A number of studies have been carried out to find out whether male superiority is real, but the results obtained are varied. Jones, Howe, and Rua (2000) research reports reveal that attitude and perception towards science differ by gender with boys reporting a wider range of science interests and out of school experiences with science than girls. To other researchers, teachers play a key role in students’ attitude and performance in a subject. A teacher who suffers from career dissatisfaction is likely to contribute negatively in terms of performance of the learner in biology as the teacher will have low self-esteem and high level of anxiety. Such a teacher would develop negative attitude towards students and in his interaction with his students be negative and this may contribute to a negative attitude of a student towards biology. A teacher should be positive to provide a positive attitude to learners of both gender. This would enable the teacher cater for individual differences that include gender. The researcher sought to determine whether there a difference in performance by gender in ecology when mind maps are used in teaching and when they are not used.
Methodology

Research Design

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

\[ O_1, M, O_3 \]

\[ O_2, F, O_4 \]

Key: \( O_1 \) and \( O_2 \): Pre-tests
\( O_3 \) and \( O_4 \): post-tests

The students in the sample were exposed to 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, 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 the selected concepts in ecology by the conventional method. The test scores were recorded as \( O_1 \) and \( O_2 \) for the male and female students respectively. The use of mind maps on components of the ecosystem; population and human diseases were integrated in the instructions to all students in the sample. The post-test was then administered to both groups after completion of the concepts. Test scores were recorded as \( O_3 \) and \( O_4 \) for the male and female students respectively. The researcher then calculated gain for the male and female students before inferring conclusion. The research design enabled concrete conclusion by comparing the effects of mind maps on both male and female students.

Sample Size

The study involved a sample of 236 respondents who consisted of 230 students and 6 teachers from public secondary schools in Hamisi sub-county. The student sample consisted of 124 male students and 106 female students which represented 53% male and 47% female students respectively. 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.

Findings and discussion

Students in the sample population were given a biology achievement pre-test after being taught using conventional techniques selected ecology concepts. A post-test achievement test was given to the same group after being taught other ecology concepts using the mind mapping technique. The scores obtained were recorded in the table 3.1.

<table>
<thead>
<tr>
<th>Marks</th>
<th>Male Pre-test</th>
<th>Female Pre-test</th>
<th>Male Post-test</th>
<th>Female Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>27</td>
<td>25</td>
<td>3</td>
<td>02</td>
</tr>
<tr>
<td>6-10</td>
<td>38</td>
<td>33</td>
<td>6</td>
<td>09</td>
</tr>
<tr>
<td>11-15</td>
<td>25</td>
<td>30</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>16-20</td>
<td>14</td>
<td>08</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>21-25</td>
<td>05</td>
<td>05</td>
<td>28</td>
<td>31</td>
</tr>
<tr>
<td>26-30</td>
<td>03</td>
<td>01</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
<td>102</td>
<td>111</td>
<td>99</td>
</tr>
<tr>
<td>Means</td>
<td>10.28</td>
<td>9.70</td>
<td>21.55</td>
<td>18.86</td>
</tr>
<tr>
<td>δ</td>
<td>6.43</td>
<td>5.88</td>
<td>19.40</td>
<td>6.61</td>
</tr>
</tbody>
</table>

Table 3.1 Student achievement scores by gender
A total of 214 students consisting of 112 boys and 102 girls participated in the pre-test while a total of 210 students comprising of 111 boys and 99 girls participated in the post test exams. Mean scores of 10.28 and 9.70 were obtained in the pre-test by boys and girls respectively while mean scores of 21.55 and 18.86 were obtained in the post-test by the boys and girls respectively. Mean differences of 0.58 and 2.69 were observed between the boys and girls in the pre-test and post-test scores respectively. Boys had a mean difference of 11.27 while the girls had a mean difference of 9.16 between the pre-test and post-test scores. These results clearly indicated that there was an improvement of 38% and 32% for boys and girls respectively. The figures indicated a significant improvement for both gender. Further analysis was carried out to establish if the difference in the means was significant by carrying out an independent sample t-test using the SPSS computer programme. The output was as indicated in the table 3.2.

Table 3.2 Output: independent sample t-test on pre-test and post-test scores by gender
From the table 3.2, a p value of 0.167 was obtained. Based on the alpha value set (α=0.05) there was no significant difference in the mean scores between boys and girls. The null hypothesis HO that there is no significant difference in performance by gender in ecology achievement test when the mind mapping technique is used compared to when the conventional techniques are used was accepted. The technique is therefore suitable for both gender. Toi (2009) found that mind mapping can help children recall words more effectively.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scores</td>
<td>61</td>
<td>76</td>
<td>62</td>
<td>72</td>
<td>63</td>
<td>73</td>
<td>64</td>
<td>74</td>
<td>65</td>
<td>75</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>Mean</td>
<td>7.0</td>
<td>7.6</td>
<td>6.0</td>
<td>6.6</td>
<td>5.0</td>
<td>5.6</td>
<td>4.0</td>
<td>4.6</td>
<td>3.0</td>
<td>3.6</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>SD</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Difference</td>
<td>0.64</td>
<td>0.77</td>
<td>0.64</td>
<td>0.77</td>
<td>0.64</td>
<td>0.77</td>
<td>0.64</td>
<td>0.77</td>
<td>0.64</td>
<td>0.77</td>
<td>0.64</td>
<td>0.77</td>
</tr>
<tr>
<td>t</td>
<td>1.04</td>
<td>1.16</td>
<td>1.04</td>
<td>1.16</td>
<td>1.04</td>
<td>1.16</td>
<td>1.04</td>
<td>1.16</td>
<td>1.04</td>
<td>1.16</td>
<td>1.04</td>
<td>1.16</td>
</tr>
<tr>
<td>df</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>p</td>
<td>0.30</td>
<td>0.26</td>
<td>0.30</td>
<td>0.26</td>
<td>0.30</td>
<td>0.26</td>
<td>0.30</td>
<td>0.26</td>
<td>0.30</td>
<td>0.26</td>
<td>0.30</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Equal variances assumed

Levene’s Test for Equality of Variances

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>20</td>
<td>6.5</td>
<td>2.5</td>
<td>0.5</td>
<td>(5.9, 7.1)</td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>6.6</td>
<td>2.6</td>
<td>0.5</td>
<td>(6.1, 7.1)</td>
</tr>
</tbody>
</table>

Independent Samples Test
than just using lists and can improve on memory by up to 32%. Gagne’s information processing theory asserts that retrieval of information depends on its organization and presentation in the memory. Mind Maps thus provided effective information organization and retrieval for both genders it seems.

**Conclusion**

Both male and female students who used mind maps obtained higher scores in the post-test compared to the pre-test achievement test. Mind mapping technique produced a significant improvement in students’ score when mind maps were used for both male and female students in the post-test achievement test. The use of mind mapping engaged students providing active personal involvement with the concepts. This resulted in improved memory that facilitated effective recall of learnt concepts for both gender. However, mind mapping as a teaching and learning technique is hardly used in secondary schools in Hamisi Sub County. It is imperative that the technique be utilized to realize greater understanding of ecology concepts among other concepts in biology. 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 acquit 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 achievement of the learning objectives and therefore effective application of learnt concepts.

**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 for both gender. 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 mind maps need to be encouraged to expedite retention of facts and high achievement in the impending examinations.

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