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A comparative evaluation of computer-based collaborative concept mapping (CBCCM) on students' attitude in secondary schools in Uasin Gishu County, Kenya.

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Abstract
Background: *The careers in STEM discipline are influenced largely by attitudinal component,which in turndetermines the achievementoutcomes. In Kenya, the performance in Biology subject in KCSE averages 55% and this has been attributed to the students' negative attitude towards science subjects. Thus, these performance level call for a review of the affective characteristics of the students. Extant literature revealed thatthe integration and use of ICT in teaching is postulated to lead to a rise in positive attitudes. Despite the increasing adoption of ICT in science education in schools in Kenya, evidence to support the application of collaborative mindtools in teaching and learning is limited and inconclusive. Therefore, due to the dearth of studies examining the application of collaborative mindtools, the research examined how computer-based collaborative concept mapping (CBCCM) influences students' attitudes towards biology in selected secondary schools in Uasin-Gishu County, Kenya.*
Materials and Methods: *The study used the Solomon Four Group design which manipulated the variable of interest, computer-based collaborative concept mapping in the experimental groups. The target population were from form-two secondary school students from eight secondary schools; four boys' and girls' extra-county school in Uasin-Gishu County, Kenya.There were two experimental and control groups based on the presence or absence of computing facilities in the schools with a total of 345 students, split into167 students in the experimental group and 178studentsin the control group. At the onset of the experiment, the study measured the attitudes towards biology using a conventional tool before assigning the students to these groups.*
Study procedures: *The experimental groups were taught using CMapTools software in the computer laboratory while the control group learned conventional learning approach. First, the researcher trained the biology teachers on construction and use of concept maps who were in turn, train their students on construction and use of computer-based concept maps. In the end, the research assistants were left with an expert concept map detailing the topic of respiration and a scoring rubric to be used to correct learners' concept maps and to give feedback during the actual treatment period. The training of students was done a day after the pre-test and took five days of one hour each day.*
The control group were taught using the conventional methods that include, teacher demonstrationand feedback. The experimental group constructed concept maps on each sub-topic and the maps would be scored by the research assistants using the scoring rubric provided by the researcher. After the end of the study period, both the experimental and control groups took a post-test questionnaire on attitudes towards Biology. The data generated were entered into statistical software and analyzed using descriptive and inferential statistics. Importantly, $\chi 2$ and t-test were conducted at ά= 0.05 level of significance.
Results:*At the pre-test period, the $\chi 2$ - statistic($p>0.05$) for the attitudinal component items (Table 2) showed that there was no significant difference in attitudes between the groups. At the end, the$\chi 2$ - statistic($p>0.05$) indicated that there were no significant differences in attitudes between the experimental groups. Thus, it can be inferred that the attitudinal component of the two experimental groups (group one and group three) was more or less similar. Thus, the study concluded that CBCCM has a significant effect on the students' attitudes.*
Conclusion: *The application of mindtools, in particular, concept mapping is an effective strategy for modifying students' attitudes towards the subjects and is, therefore, a more effective tool to realign students' attitudes towards science education in secondary schools in Kenya. The study recommends instructors and teachers should adopt and incorporate collaborative and computer-based systems to improve students' attitudes towards science education and consequently learning outcomes in science education.*
Key Words:*Mind Mapping; Mindtools; Concept mapping; Student Attitudes; Learning outcomes.*

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I. Introduction

Science subject in secondary school is central to many science-related courses such as medicine, pharmacy, agriculture, nursing, biochemistry and many others (Yusuf & Afolabi, 2010) and is a crucial component in education as it explains everyday experience (Christidou, 2011). However, the conventional approach to teaching science education in schools hasfailedin presenting science as a fascinating, interesting and rewarding subject (La Velle, McFarlane & Brawn, 2003). This is because science education in secondary schools contains many theoretical and abstract concepts, which may be difficult to understand, therefore students need visualization and modelling (Tekbiyik&Akdeniz, 2010).

Past research has critiqued the conventional approach to learning, for example, Savelsbergh*et al.,* (2016) reported that different teaching approaches have a significant effect on the general attitudes of the students towards science education(Schroeder *et al.,* 2007). Since, the student's approach to learning predicts learning outcomes (García *et al.,* 2016; Sengodan&Zanaton, 2012), the importance of STEM (science, technology, engineering, and mathematics) discipline to the nation's economy, calls for improvements in techniques for teaching mathematics and science education (Maltese & Tai, 2011).

The pervasive developments and advances in technologies have enabled various new learning approaches that situate students in environments and allows collaborative and shared learning experiences (Hwang, Shi & Chu, 2011).The ubiquitous application of Information and communication technology (ICT) has been at the centre of national education policies and all levels of education and is influenced by several trends namely: the futuristic preparation of students towards workplace setting; introducing efficiency and effectiveness into learning spheres and lastly as a reformation of the education sector (Kirschner & Erkens, 2006).

Scholars in the education sector have indicated that technologies should be used to not only support learning in instructing learners but also in aiding knowledge construction (Hwang et al., 2014). Using technologies in teaching induces a change in pedagogical practice (La Velle*et al.,* 2003; Serin, 2011) as thecognitive tools embedded in ICT and the pedagogical content knowledge provide a powerful driver for the knowledge transformation (La Velle*et al.*, 2003). These technologies are referred to as context-*aware ubiquitous learning* which not only supports learners with an alternative way to problem-solving but also enables interactive and collaborative learning (Chu, Hwang & Tsai, 2010; Hwang*et al.,* 2010). Thus, educators all over the world have paid attention to the application of Mindtools in various practical applications related to in-class learning, blended learning, and online learning (Lee*et al.*,2009).

The use of mindtools in an educational setting has attracted the attention of educators (Chu*et al.*,2009). Mindtool is a computer-based tool or environment that functions as an 'intellectual partner' with the learner in facilitating critical thinking and high order learning (Kazantzis&Hadjileontiadou, 2021; Kirschner&Erkens, 2006; Kirschner&Wopereis, 2003;Chu*et al.,* 2009;Hwang*et al.*,2011). Mindtool is a cognition tool that stimulates the learner's cognitive ability and enable them to construct knowledge instead of merely memorizing or recalling (Chu*et al.*,2009; Kirschner&Wopereis, 2003).

Among the existing Mindtools, concept mapping is an effective tool for assisting students to represent knowledge and learning experiences (Chu*et al.*,2010) that was developed at Cornell University by Professor Joseph D. Novak as a way a two-dimensional graphical technique that visually represents the hierarchical arrangement of concepts as well as their relationships (Novak &Gowin, 1984;Sanchiz*et al.,* 2019; Hwang*et al.*,2013). Concept maps have become widely accepted as an educational tool (Hwang*et al.*, 2013) and in several ways, including evaluation or assessment tools,cooperative/collaborative learning tools, and advanced organizer and visualization tools (Qasim*et al.*,2013).

A concept map provides a ubiquitous learning experience and serves as an extension of the mind as it can engage learners in constructive higher-order critical learning (Hwang*et al.*,2011). Concepts maps have been used for improving learning outcomes and evaluation, aiding students' critical thinking abilities and students' knowledge retention and cognitive skills. In addition, concept mapping helps reduce student's cognitive load (Abbas*et al.,* 2018).Concept mapping represents knowledge structure externalization, which aids learners to internally reconstruct learning concepts and contemplate the most appropriate methods of visually representing the conceptual structures. It is like a 'window to the mind' as it allows for self–reflection (Chu*et al.*,2009). The advancements in computerized interface technologies have enabled even more alternatives for using concept maps in teaching and learning (Hwang*et al.*,2013).

Concept mapping helps students organize and visualize knowledge and learning experiences. It serves as an effective assessment tool for evaluating students' cognitive levels and knowledge structures (Hwang*et al.,* 2014). Concept mapping promotes students' creativity and improves self-awareness through reflective thinking (Chu*et al.,* 2010).Concept mapping helps foster creativity which is increasingly seen as a key direction and focus for pedagogic approaches from nursery education through the compulsory years to higher education and work-based environments (Cheng, 2009). Concept maps stimulate metacognition and are therefore widely perceived to positively encourage reflection and its associated processes (Harrison & Gibbons, 2013). Concept mapping as a learning strategy can develop students' capacity to learn independently (Chiou, 2008).

The studies on concept mapping have reported that it improves learning outcomes (Sanchiz*et al.*, 2019).In an experimental study, Hwang, Wu and Ke (2011) revealed that concept mapping has a significant influence on learning perceptions and attitudes of university students towards science courses. Further, the students found the concept mapping to be interactive and enjoyable (Abbas, Eldin&Elsayed, 2018). Studies also indicate that concept map-based approaches can be used to diagnose learners' knowledge structures and misconceptions (Hwang*et al.*,2013). For instance, Kaddoura, Van-Dyke and Yang (2016) explored the impact of concept mapping through an experiment among nursing students. The study revealed that students taught through concept mapping had higher cognitive scores than the control group.

An empirical study by Hay (2007) reported that deep, surface and non-learning outcomes could be observed directly from learners using concept mapping at the university level.Chiou, (2008) revealed that concept mapping significantly improves students' learning achievement compared to using a traditional expository teaching method.Wu, *et al.*,(2013) affirmed that map-based collaborative learning enhanced student's innovative performance.Chen*et al.*,(2011) also observed that the students who were taught through concept mapping performed better than the control group.

A meta-analytical study reported that the use of the concept mapping technique was associated with increased knowledge retention (Nesbit &Adesope, 2006). The study examined past empirical studies from Grade 4 to university level in different disciplines and showed that the effect size varied distinctively depending on the application of the concept mapping and the type of comparison treatment.Hwang*et al.*, (2013) reported observed that concept – mapping positively impacts students' attitudes towards learning science course. Further, a study on the use of concept mapping by university students pursuing engineering revealed that there were significant differences in learning outcomes with the experimental group having higher scores (Martínez*et al.*, 2013).

Empirical evidence shows that the learner's existing knowledge in science and engineering course often contains deeply rooted misconceptions that make new learning difficult, therefore, the use of concept maps help highlight issues of knowledge, knowledge structure, and their interrelatedness (Martínez*et al.*,2013).Every other student holds abilities but not every other student can develop them because the existing education system does not provide an effective learning environment to enable students to develop creativity. Therefore, the promotion of student's creative potential through creative thinking instruction is important in the current education system (Wu*et al.*,2013).

Literature on concept mapping shows that it has been widely adopted and has been implemented o different learning platforms. The simple and basic approach includes the use of keyboards and mouse with the most efficient ones being touch-based computers. Accordingly, touch technologies provide flexible ways for learners to interact with instructional contents and thus support free and enjoyable interactions that contrast with the well-established practices of paper-and-pen-based (Hwang*et al.*, 2011). A concept map begins with the main idea (or concept) and then branch out to show how that main idea can be broken down into specific topics (Sanchiz*et al.*, 2019).

II. Problem statement

The performance in Biology subject has not been satisfactory and has indicated by the reports the average scores (standard deviation) for the last four years are 58.37(35.16), 37.85(23.45), 51.38(23.26) and 55.32(20.65) marks (KNEC, 2020). This indicates an average pass mark for all the students taking biology as a subject in secondary schools in Kenya. A report indicated that the performance in the biology subject for three consecutive years has been on a downward trend with only a small number getting grade B and above. The trend is raising concerns that many bright students will be locked out of studying science courses(Chebotib&Kering, 2021).

Although previous studies have reported the effectiveness of the concept mapping approach, it remains an open issue for investigating its effects on students' learning attitudes. There is a general tendency across studies on innovative teaching approaches to simulate positive effects, there is little clarity on how these interventions cause effects on outcome, and under what conditions (Savelsbergh*et al.*, 2016). And as elaborated by the foregoing reviews, there is a need to evaluate the different pedagogical practises used in science education at the high or secondary school level.

Several studies (Wu & Ke, 2011; Abbas*et al.*, 2018; Kaddoura, Van-Dyke & Yang, 2016; Wu*et al.*,2013; Chen*et al.*,2011) have highlighted the positive effects of concept mapping in the education setting. More so, at the university level as well as different disciplines (Hwang*et al.*,2013; Amadieu*et al.*,2010; Kaddoura*et al.*,2016). However, there have been relatively few research studies that have evaluated the usefulness of concept mapping at the basic education level. Thus, the study explored how computer-based collaborative concept mapping can be applied in teaching biology conceptsof respiration to students in selected secondary schools in Uasin Gishu County, Kenya.

III. Material and Methods

Study Design: The study used the Solomon four non-equivalent control group and applied two assessments of attitudes and test at the onset(pre-test) and the end(post-test). A student attitudinal test (SAT) was given to both groups to gauge their attitudes towards biology. Data were collected at three points during the study between May 2019 and July 2020 and the baseline data generated from a student attitude questionnaire and biology achievement test were collected from all participants before the teaching intervention.

Study Participants: The study was located in eight schools in Uasin Gishu County, Kenya with a total of 345 form-two students drawn from the extra-county schoolsbecause the school are well-equipped with computing facilities for learning. Next, theresearcher clustered the schools according to the school type(single) and status(public).The 345 students enrolled in the experiment were randomly split into 167 students in the experimental group and had 178 studentsin the control group through the whole class allocation.The two groups were then taught separately, with the experimental group using the computer-based concept mappingtechnique while the control group using the conventional methods. The concept mapping on respiration concepts in the experimental group was taught outside the normal class hours (5.00 pm-6.00 pm) in the computer laboratory before the groups was taught within their respective classes.

Study Procedures: The two teaching techniques were designed to facilitate the acquisition of concepts of respiration and comparisons made based on its effects. The respiration topic was split into six sub-topics; definition and significance of respiration, types of respiration, phases of aerobic respiration, oxygen debt, the economic importance of anaerobic respiration and respiratory quotient (RQ) and its significance.

Conventional module: The control group (n = 178) were taught in a normal classroom setting by the subject teacher. This process involved the preparation of a lesson plan using the standard teaching pack consisting of a secondary school biology curriculum, a set of secondary school biology, shorthand notes, chalks and a board. The shorthand notes detailing the respiration were drawn from the various textbooks; secondary school biology book four by Kenya literature bureau, longhorn biology book two and principles of biology volume two. All the illustrations on the concepts were done on the board and the books. Any questions about the subject matter during the session were dealt with by the researcher who was also a science teacher.

The whole concept of respiration was taught in five lessons each lasting for one hour daily over a period of five days (300 minutes). Ideally, the biology lesson is always allocated seven lessons, each taking up 40 minutes. In total, the whole concept is covered in 280 minutes. The evaluation questions at the end of each lesson were prepared using the same textbooks. The researcher tried as much as possible to operate within the time allocated.

Concept mapping: In the experimentalgroup, the researcher and her assistants first explained why concept mapping is a useful tool for learning and how concept mapping can be used to show relationships among concepts, and then spent hours training students to draw concept maps in accordance with the procedures.The experimental group (n = 167) were taught using computer-based concept maps for the first three days over a period of one week. The lesson was developed in line with the objectives outlined in the Kenya Institute of Curriculum Development (KICD) syllabus. First, the participants in the group were inducted into the use of computing technology and after which they were expected to complete the study following the instruction of the researcher. The content for the lesson included CMapTools which were downloaded freely from http://cmap.ihmc.us and loaded into all the personal computers in the computer lab.

Each lesson lasted for one hour over the three days.The concepts to be included were; respiration, cells, food, energy, muscle contraction, conduct nerve impulses, tissue repair, growth, organ function, mitochondria, cristae and enzymes. With the aid of the software, the students began by placing the general idea(respiration) at the top of the map. The students then work down the list and added more concepts as needed, each time placing the selected two, three, or four sub-concepts to place under each general concept. No more than three or four concepts were placed under any other concept. Having listed all the concepts in a hierarchy, the next step was to connect the concepts by lines. The lines were labelled with one or a few linking words which defined the relationship between the two concepts so that it reads as a valid statement or proposition.

The students would then restructure their map, in several ways which included adding, subtracting, or changing superordinate concepts. The students seemed to enjoy this part and they would do this reworking several times in turns until they came up with a refined map. This process went on indefinitely as an individual or as the group gain new knowledge or new insights. This was evident because while the groups were working on the fourth or fifth map, some groups would be seen going back to restructure the first or any other preciously constructed map.

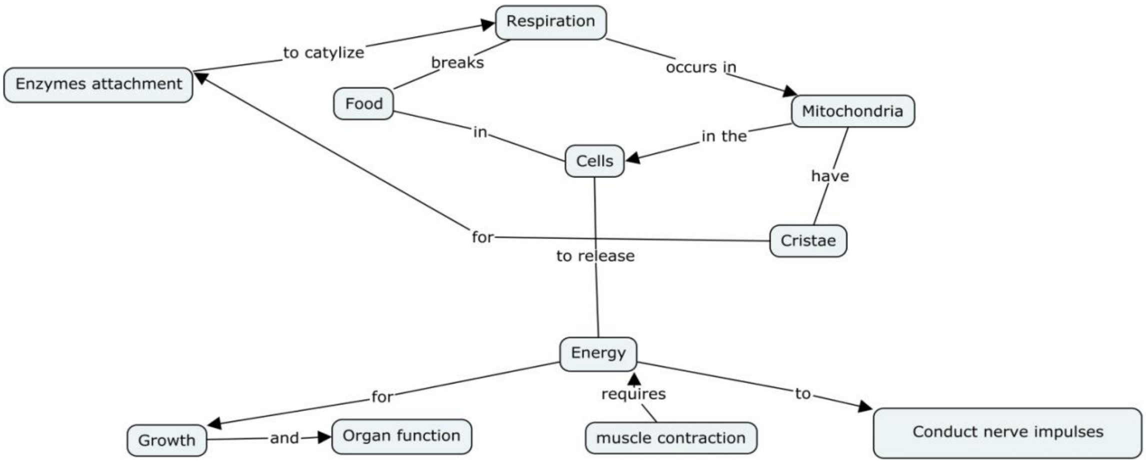

Figure 1: Sample of a generated concept map

Attitudinal aspects

Though, the definition of attitude is rarely made explicit (Goldin *et al.*, 2016), several constructs have been developed and used (Potvin&Hasni, 2014). Attitudes are commonly seen as quality with two opposite directions, ranging from unfavourable or either negative or positive attitudes towards an issue (Schreiner &Sjøberg, 2010). The most baseline attitudinal test was purposefully developed and consisted of questions on an agreement continuum ('Strongly disagree' 'Strongly agree'). This test consisted of twenty – questions with a five-point Likert type scale that evaluated the students'attitudes based on the levels of agreement/disagreements (strongly agree, agree, indecisive, disagree, and strongly disagree).

Statistical Analysis

The data analysis plan was based on the Solomon four non-equivalent group design using the SPSS (version 20) statistical software package. First, the analysis involved both descriptive and inferential statistics.. The χ^2 analysis tested for any significant differences between the two study groups, while the t-test checked for statistically significant differences in the attitudes scores between the groups at each phase of the study.

IV. Result

Biology Attitudinal change

Table 1: Differences between Pre- Experimental Attitudes towards Biology between control groups

Variable	n	Mean	SD	χ^2	p
Biology is interesting	178	4.3933	1.0042	5.455	.065
Biology is not interesting	178	1.6404	1.0223	10.55*	.005
Always under strain in biology class	178	2.0674	1.2649	8.718*	.013
Biology is fascinating and fun	178	3.8933	1.2777	2.446	.294
Biology makes me feel secured and stimulated	178	3.5843	1.3046	1.351	.509
Biology makes me feel uncomfortable and restless	178	1.5169	0.9462	6.745*	.034
I have good feelings towards biology	178	4.3258	1.0226	8.248*	.016
I have bad feelings towards biology	178	1.5506	1.0029	5.994*	.050
Biology feels me with enthusiasm	178	3.1854	1.3253	1.887	.389
Biology gives me a feeling of dislike	178	1.7135	1.0207	9.691*	.008
I approach biology with hesitation	178	2.4663	1.3494	8.906	.012
I really like biology	178	4.2303	1.1922	8.874	.012
I don't like biology at all	178	1.5393	1.0475	5.689	.058
Always enjoyed studying biology	178	4.0899	1.2133	2.964	.227
Given a chance I would drop biology	178	1.9663	1.3692	18.92*	.000
Think about biology experiment makes me nervous	178	2.3258	1.3882	0.393	.821
Always look forward to biology experiments	178	3.9607	1.2728	4.866	.088
Feels at ease with biology I like it very much	178	4.0449	1.2924	5.618	.060
Feel definite positive reaction to biology its enjoyable	178	4.1011	1.2401	5.618	.060
Biology is awful I hate it	178	1.4157	0.9305	5.455	.065

Table 1 shows the attitudinal aspects of the participants during the pre-test period which included the affirmative and their negated equivalent statements. Regarding biology as a subject, the respondents strongly affirmed that they found the biology subject interesting (Mean = 4.3933, SD = 1.0042) and were fascinated by the biology subject (Mean = 3.8933, SD = 1.277). Many respondents liked biology subject (Mean = 4.2303, SD = 1.1922), and the majority of the participants look forward to biology lessons. The participants enjoyed learning biology subject (Mean = 4.0899, SD = 1.2133) and always look forward to biology experiments (Mean = 3.9607, SD = 1.2728).

The statistics in Table 1 examined for any association between the study variables and group using the chi-square distribution. The affirmative statements had χ^2 - statistics which ranged from 1.351 to 8.248 withp> 0.05 except the statement'I have good feelings towards biology' This indicated that there no significant differences in attitudes in both experimental and control group. On the converse, the negated equivalent statements had most p< 0.05, which indicated statistical differences between the attitudes. Considering that there were no statistically significant differences in the affirmative statements, it can be inferred that participants have a positive attitude towards biology.

Attitudinal towards concept mapping

Table 2: Differences in the attitudes towards concept mappingbetween experimental groups

Variable	n	Mean	SD	χ^2	p
Concept maps construction is interesting	167	4.3653	0.8527	0.867	0.648
Concept maps are a waste of time	167	1.6347	0.9839	0.636	0.728
Concept maps have helped me understand biology than before	167	4.1737	1.1138	1.487	0.475
Concept maps make me confused	167	1.7425	1.0583	3.595	0.166
Concept maps have made me like biology	167	3.9401	1.1958	1.593	0.451
Concept maps have made me dislike biology	167	1.5868	0.9329	0.334	0.846
Concept maps have made me creative	167	4.1796	1.1370	1.473	0.479
I prefer concept maps to assignments	167	3.6108	1.4347	0.426	0.808
I would rather do biology revision than construct concept maps	167	2.6946	1.3430	0.827	0.661
Concept maps construction helps in demonstration of what learnt	167	4.4491	0.8407	2.344	0.310
Concept maps don't make sense	167	1.4671	0.9492	2.748	0.253
Concept maps have made me learn easier	167	4.3174	0.9637	5.575	0.062
Concept maps have made me enjoy biology	167	3.9820	1.1897	0.635	0.728
Concept maps construction makes me nervous and irritable	167	1.8383	1.0716	0.249	0.883
Construct maps help me remember what was taught	167	4.2335	1.0235	0.760	0.684
Prefer reading biology to concept maps	167	2.7725	1.4086	0.967	0.617
Always looking forward to biology lesson after concept maps	167	3.8623	1.1969	1.226	0.542
Concept maps have made biology unpleasant	167	1.6647	1.0333	2.429	0.297
Concept maps construction with peers makes biology fascinating	167	4.2695	1.1324	4.471	0.107
Concept maps have helped me develop a positive feeling toward biology	167	4.4551	0.7816	3.408	0.182

Table 2displays the attitudinal aspects of the participants towards concept mapping after the concept mapping and included the affirmative and their negated equivalent statements. The respondents affirmed that concept mapping was interesting (Mean = 4.3653, SD = 0.8527) and that the maps helped them understand biology (Mean = 4.1737, SD = 1.1138). Many respondents affirmed that concept mapping have made them creative (Mean = 4.1796, SD = 1.1370), while helping them to conceptualize (Mean = 4.4491, SD = 0.8407). The participants also affirmed that concept mapping made learning easier (Mean = 4.3174, SD = 0.9637) and have helped me develop a positive feeling (Mean =4.4551, SD = 0.7816).

The statistics in Table 2 examined for any association between the study variables and sex of the student (experimental group) using the chi-square distribution. The affirmative statements had χ^2 statistics which ranged from 0.334 to 5.575 with p > 0.05 indicated that there no significant differences in attitudes in both the experimental and control group. Considering that there were no statistically significant differences in the affirmative statements, it can be inferred that participants have a positive attitude towards concept mapping concepts and this also indicated that the link between concept mapping in situated learning.

Differences in Attitudinal Scores

Table 3: Comparison of attitudinal scores between study groups

	Control group			Experimental group			Statistics	
	N	Mean	SD	N	Mean	SD	t-test	p-value
Pre-test	82	2.9591	0.31799	91	2.9236	0.25037	-0.820	0.413
Post-test	73	3.2575	0.26662	78	3.2532	0.23595	0.106	0.916

The results as summarised in Table 3 shows the differences in attitudinal aspects based on the Solomon Four Group design. The mean pre-test item scores for the control group had a mean of 2.9591 and a standard deviation of 0.31799 while those for the experimental group had a mean of 2.9236 and a standard deviation of 0.25037. When the comparison was done, no significant differences emerged between the groups in the pre-test attitude scores (t = -0.820, p > 0.05). However, higher mean in post-test item scores were achieved after the experiment with the experimental group having a mean of 3.2532and a standard deviation of 0.2359, while the control group had a mean of 3.2575 and a standard deviation of 0.2666. The analysis showed that there were no significant differences in attitudes between the groups ($t = 0.106$, $p > 0.05$).

V. Discussion

The study sought to compare the effectiveness of concept mapping versus conventional teaching methods on the acquisition and retention of respiration concepts in the biology subject by students in selected secondary school in Uasin Gishu County, Kenya. The findingsshowed that there were no significant differences in attitudes between the groups. According to the Solomon Four group design, only group one(experiment) and two(control) receive the pre-test and the finding of non-significance would indicate that the were no differences in attitudesbetween the control and the experimental groups. This is taken to mean that the attitudes of the students were comparatively similar. In the post-test examination of attitudes only group three(experimental) and four(control), there were no significant differences between experimental groups thus implying that the groups were significantly not different from each other.

The findings show that the students held a positive attitude towards concept mapping as illustrated by higher attitudinal scores for the post-test (Mean = 3.25, SD = 0.25). The findings conform to those of previous studies that indicated that the application of concept mapping technologies in learning activities has the potential to inspire students' extrinsic motivation and possibly enhance learning outcomes. Most studies have shown the effectiveness of concept mapping in helping students organize and comprehend the target concepts (Hwang*et al.*,2014). For instance, Hwang*et al.*,(2011) revealed that concept mapping not only enhances learning attitudes but also improves the learning outcomes for the students. Concept mapping is an effective way in engaging students in meaningful learning and hence improves comprehension and learning achievements (Amadieu*et al.*,2010).

This finding is similar to several empirical studies which have shown that students using concept mapping have better learning outcomes when compared to the conventional learning technique. For example, Chiou (2008) employed concept mapping in a university accounting course and found that the approach was effective in helping improve learning achievements. The study of Lim, Lee, and Grabowski (2009) further showed that engaging students in concept mapping were more helpful to them than using concept maps as an instructional tool. The applications of concept mapping in education are diverse and encompass all domains of knowledge and students of all ages (Cañas*et al.*, 2012). Concept mapping has been to be an effective tool in facilitating learningthrough effective knowledge construction for helping learners organize important concepts related to a core issue (Hwang*et al.*,2014).Therefore, concept mapping enables the learners to think critically (Kaddoura*et al.*, 2016).

These findings suggest cognitive gain and knowledge retention and mastery of biology concepts implies that the study participants can learn the theoretical abstracts that may be taught using concept mapping. Concept maps help students to develop new propositions that are naturally integrated into the student's cognitive structure and this leads to meaningful learning. Concept maps have a demonstrated effectiveness as cognitive tools regardless of whether students construct them individually or collaboratively in groups, although appear to be more effective when applied in learninggroup (Martínez*et al.*,2013).Concept mapping employs concepts and propositions as central elements in structuring knowledge and creating meaning while translating complex concepts into visual representations (Cañas*et al.*, 2017).

VI. Conclusion

The mastery of respiration concepts in a biology lesson in a secondary school education setting is informed by relevant theoretical knowledge and represents an important element in the learning process. The major findings of this study confirm previous research in demonstrating the superiority of concept mapping and this is a valuable finding. Given the ongoing debate on the increasing use of mindtools, the findings provide evidence that concept mapping as effective as conventional methods when used to teach secondary school students. Therefore, Computer-based instruction should be embraced as a potentially valuable teaching tool, especially given the possibilities of self-study and distance education.

The study was limited by its smaller sample size and homogeneity which would potentially affect the generalization of study findings; thus, the findings must be interpreted with caution. Any future studies should desire a larger sample with a corresponding heterogeneous population. Despite this limitation, the strength of this study lies in the use of a rigorous design that addressed many of the flaws evident in previous research.The study contributes to the introduction and use of the concept mapping in science education in a secondary school setting in Sub – Saharan Africa and thus it provides a foundation for further studies to explore the concept.

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