JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website: www.jriiejournal.com ISSN 2520-7504 (Online) Vol.5, Iss.4, 2021 (pp. 207 – 216)

Effect of Mind Mapping on Gender Difference in Mathematics Achievement among Students in Public Secondary Schools in Nandi County, Kenya

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Abstract: *The teaching of mathematics still follows the traditional pattern which is identified to be ineffective and a factor responsible for the poor performance. The aim of this paper was to determine the effect of mind mapping in mathematics instruction on learner achievement, motivation and attitude in secondary schools in Nandi County, Kenya. The study used Quasi-experimental research design using pre-test and posttest. The target population for the study was 4761 form 2 students and 212 Mathematics teachers. The study adopted purposive sampling in selecting county schools followed by simple random sampling. Data was collected using Mathematics performance tests. Reliability was determined through test-retest approach and a reliability coefficient of 0.82 was obtained. Data was analyzed using mean, Standard error and t-test. The results showed that in both the pretest and posttest examinations, there was a significant difference in students' performance when subjected to both mind mapping teaching strategy and the traditional methods of teaching mathematics since the p-values were less than 0.05. This shows that generally, the use of mind maps enhances students' performance in mathematics but does not favour any gender. The study concluded that despite the difference in male and female student achievement in mathematics, greater difference was achieved when mind maps were used. It was recommended that the use of mind mapping need to be encouraged in teaching and learning owing to its positive effects on boosting students' academic achievement.*

Key words: *Gender, Mind map, Achievement, Mathematics, Students*

How to cite this work (APA):

Kibet, P. K., Simiyu, J. & Mubichakani. Effects of mind mapping on gender difference in mathematics achievement among students in public secondary schools in Nandi County, Kenya. *Journal of Research Innovation and Implications in Education, 5*(4), 207 – 216.

1. Introduction

Teachers must employ the approach and methodology that best suits the student, the objectives, and the expected outcomes in order to transmit knowledge. The traditional way to learning, according to Tebabal and Kahssay (2011), is the least practical, more theoretical, and less remembering for students. This is due to the fact that most old approaches were teacher-centered, with no participation for the students, leaving them passive and reliant on the teacher for knowledge without boosting their degree of involvement with the subject area. Further, Blaschke (2018) acknowledged that learner-centered strategies which are more efficient are highly encouraged because they seem to embrace the idea of discovery learning. Indeed, most teachers currently seem to use the learner-cantered approaches which are associated with student inspiration, interest, satisfaction and critical thinking leading to better achievement (Stirling & Moro, 2020).

Mind mapping is an appropriate strategy for exercising various brain processes such as memory, creativity, and learning because it is a visual and graphical integrative thinking approach (Polat, Yvuz, Tunc, 2017). Gargouri and Naatus (2017) argue that mind map used to provide clarity of reasoning based on supporting evidence to achieve meaningful conclusions that improve decision-making skills. The study was quasi-experimental, a total of 14 students participated, and it lasted for a semester. The assessment criteria that was initially determined by the Novakian concept maps, this was, however, further refined by Davies (2011). The results of the research indicated that integrating mind maps into assessments has the potential of tapping into the thought process of students which, in turn, improves their understanding and cognitive development. Other than the small sample size, the other limitation of the study was the lack of longitudinal data that would have helped in the overtime comparison between the variables of the study. The first theme that stood out based on the literature reviewed is on cognitive and critical thinking skills.

At all stages of education, the use of an effective teaching method will improve students' acquisition of content (Zouhor, Bogdanovi, Skuban, & Pavkov-Hrvojevi, 2017). As a result, teaching approaches based on a constructivist approach to teaching and learning have emerged in recent decades (Dhindsa & Anderson, 2011). These strategies aim to increase student performance by taking the working memory limit into consideration and allowing students to actively engage in the construction of their own information. When knowledge is considered as a link between concepts and propositions, it is evident that strategies for visualizing knowledge are required (Meyer, 2010). There are numerous approaches for visualizing content, according to Parikh (2015). These include concept maps, mind maps, conceptual diagram, visual metaphor and semantic networks.

A mind map is a non-linear graphic representation of thoughts and relationships (Keller, 2012). Furthermore, a mind map, according to Johnson (2014), is a learning approach in which a non-linear technique is employed for learning and the learner is encouraged to research and explore different topics using various relationships that can be interconnected from a central theme to outer branches. As a result, creativity (imagination) and idealization are successfully improved during this educational process (Chen, Xiao & Lin, 2018). In reality, a mind map is an interactive learning strategy that encourages students to pay closer attention in class. As a result, pupils no longer find learning classes to be a laborious activity, but rather one that is exciting and productive (Ghanbari, Javadnia, & Abdolahi, 2010).

Buzan created mind maps in the late 1960s to assist students take notes using only relevant phrases and graphics, but they may also be used by professors to creatively convey concepts (Tee, Yunos, Mohamad, Othman, Yee & Mohamad, 2012). Mind maps are supposed to be faster to develop and much easier to recall and examine due to their visual character. Because mind maps are non-linear, linking and cross-referencing different components of the map is simple (Tucker, Armstrong & Massad, 2010). Memory Maps are also simple to learn because they allow you to refresh knowledge in your head with a single glance. Mind Maps can also be effective mnemonic aids, and understanding their design and structure can help you remember the information contained within them. They require significantly more of the brain in the process of assimilation and linking information than traditional methods of instruction (Tee *et al.,* 2014).

The central idea behind mind mapping is that we can understand and remember more easily if we use all of our visual and sensory resources. Pictures, music, colour, and even touch and smell all play a role in our learning arsenal, allowing us to remember knowledge for longer periods of time (Kotcherlakota, Zimmerman & Berger, 2013). The most important aspect is to create mind maps that take advantage of these features by leveraging an individual's creativity, thinking, and cross-linking of ideas in their heads. According to recent studies, any information provided in the form of graph charts has a strong psychological impact on people. Teachers should endeavor to visualize and demonstrate things to their pupils while keeping this in mind (Buran & Filyukov, 2015).

Graphical presentations of information during the teaching process are found to be efficient methods for the development of creativity among students. Kuveri (2013) discovered that idea mapping had a high-level effect on scientific creativity among learners in an experimental investigation. Mind maps may also have a favorable impact on learners' individual creativity. The creation of a mind map assists students in comprehending the interconnectedness of mathematical ideas and how they are layered upon one another to form a logical whole. Mind mapping is a powerful graphic technique that provides a universal key to unlocking the full capacity of your brain. They allow you more creativity when capturing thoughts and information with graphic representations. It teaches the brain to understand the big picture as well as the finer points, allowing logic and imagination to work together. When thoughts and information are captured with visual representations, it enables for more creativity. Images are more effective than words at eliciting a wide range of associations, which improves creative thinking and recall. Rather than standard linear notes, multi-colored, multi-dimensional mind maps are easier to recall (Buzan & Buzan, 2015).

Many people believe that boys perform better in mathematics than girls because of their gender. Girls'

attitudes toward mathematics are influenced by this conviction. Farooq and Shah (2008) found no significant difference in male and female students' confidence in mathematics at the secondary school level in a survey of Pakistani secondary school students. However, the researchers discovered that students' success in Mathematics was strongly dependent on their attitude toward the subject.

Although mathematics is a significant subject in the school curriculum, the performance of students in the subject at KCSE level has been dismal over the years in Nandi County as compared to other examinable subjects. Low achievement in mathematics is attributed to poor interpretation of questions, poor grasping of concepts and failure to relate Mathematics knowledge to real life situation (KNEC, 2018).

Students are exposed to mathematics problems of varying difficulty levels in school, ranging from easy to complex. As a result, teachers and teaching methods employed are critical in ensuring that students receive an effective delivery of the idea of mathematical knowledge (Bahri, Idris, Muis, Arifuddin, & Fikri, 2021). During the teaching and learning process, teachers can use a variety of approaches to convey knowledge, and successful teaching can have a substantial impact on the learning process. According to the researchers, a few prerequisites are required to establish an efficient teaching, such as a thorough awareness of the teaching process, students' traits and stages of growth, and motivational elements. Furthermore, Sulaiman, Suid, and Idris (2018) state that effective teaching approaches take psychological and professional factors into account.

According to Ogunleye and Ojekwu, (2019), there is widespread agreement that the adoption and proper utilization of mind maps during instruction facilitates meaningful learning. This is based on the premise that visual stimulation (in terms of pictures, graphics items, and colors) excites the visual-spatial sketchpad in the memory, therefore enhances student's interest to understand new knowledge through the association of visual stimuli to spoken words.

High school students' lack of mathematical reasoning skills is a big issue in mathematics education. One of the aims of mathematics education is to foster creative activity, curiosity, attention, and interest in mathematics, as well as a tenacious approach to problem solving. According to the preceding ideas, all children from elementary through high school should have a math lesson so that they can reason, think logically, be analytical, systematic, critical, creative and become a problem solver. The current paper determined the effect of mind mapping on gender difference in mathematics achievement in public secondary schools in Nandi County, Kenya.

2. Literature Review

Mathematics, as a topic, has an impact on all elements of human life at various levels. Mathematics is regarded by society as the cornerstone of scientific technological knowledge, which is critical to a nation's socioeconomic progress. Because of the vast uses of mathematics, Eraikhuemen *et al.,* (2020) argue that a disciplined and orderly pattern of life can only be accomplished through mathematics culture.

Polat, Yavuz and Tunc, (2017), conducted an experimental study on use of mind maps in for teaching mathematics and science with an aim of examining the influence of mind mapping activities on the mathematics and science skills of learners aged 48 -60 months. The research was conducted utilizing a hybrid strategy that included both qualitative and quantitative screening. The study discovered that children who used mind maps were more successful in developing mathematics and science skills than children who did not use mind maps. Despite the fact that it was done in pre-schools, these findings appear to be similar to those of the current study. The tools of analysis were Mann Whitney U test and Wilcoxon while t-test was used in the current study. Additionally, this was an experimental study which was conducted for a period of 10 weeks while the current study was quasi-experimental which was conducted for a period of one week among secondary school students.

There is literature on gender and academic achievement in mathematics, with various points of view and findings. Boys outperformed girls in mathematics, according to studies conducted in northern countries (Muthukrishna, 2010). Asante (2012) demonstrated that boys outperformed girls on mathematics evaluation. Still, an intriguing corpus of international data indicates that girls outperform boys (Ajai, & Imoko, 2015).

A study conducted in the United States by Hydea and Mertzb, as cited in Ajai and Imoko, (2015), indicated that female learners achieved similarly with male learners in mathematics ability, including at the high school level, where a difference existed previously. They confirmed that girls outperform boys in tasks requiring advanced problem solving.

The results of the research by Davies (2011) indicated that integrating mind maps into assessments has the potential of tapping into the thought process of students which, in turn, improves their understanding and cognitive development. Other than the small sample size, the other limitation of the study was the lack of longitudinal data that would have helped in the overtime comparison between the variables of the study. The first theme that stood out based on the literature reviewed is on cognitive and critical thinking skills.

Neuville and Croizet (2007) discovered that when gender identity is prominent, females do better than boys on easy subjects in a study of 7-8 year olds conducted in France. Boys' math performance, on the other hand, was not influenced by their gender. They were not exposed to the stereotype threat, which led to negative assumptions about their mathematical abilities, and as a result, they performed better on the more difficult problems. Gender inequalities in arithmetic instruction, learning, and achievement have also been linked to differences in cognition and brain lateralization (Andamon & Tan, 2018).

In a similar vein, Luttenberger, Paechter, and Ertl (2019) contend that male and female pupils perceive the environment differently. For starters, they are in distinct social positions. The second factor is their various learning styles, as well as how they perceive and absorb reality. According to these researchers, most mathematics classroom discourse is structured to accommodate male learning habits, which explains their superior proficiency in mathematics.

According to Eze, Ezenwafor, and Obi (2015), most research suggest that girls outperform guys in school. This backs with an earlier report by Ushie and Edinyang (2018), who discovered that while girls join Turkish colleges with low marks, they outperform their male colleagues once there. Other key characteristics that emerge from gender and mathematics studies are cultural, familial effects, parental socioeconomic level, and cultural and traditional influences (Afari & Khine, 2018).

According to Asante (2012), schools create figurative disagreements between girls and boys by gendering knowledge and classifying some disciplines as masculine. Female students, on the other hand, are socialized to feel that mathematics is a masculine subject and that it is appropriate for them to leave it. Finn, Duncan, and Marope conducted studies in Botswana, which were reported in Afari and Khine (2018) and revealed that societal cultural expectations might affect variations in math achievement between female and male students.

It has been said in Nigeria that nurture entrenches masculine domination over female gender (Owan, Bassey, & Ini, 2020). Abubakar and Oguguo (2011) found no significant differences in performance between boys and girls in their study. Odagboyi's (2014) result that there was no significant difference in performance between boys and girls is consistent with this. Despite the fact that the research outcomes are conflicting, it's worth noting that none of the published studies used the jigsaw method.

There are various studies that have been undertaken on the relationship between students' and mathematics performance based on gender. Some of these studies found no significant difference in pupils' mathematical performance between male and female students, while others found a substantial difference in performance between boys and girls. As a result, the data on gender differences in mathematical achievement are inconclusive. Therefore, the current study investigated gender difference in mathematics achievement between students exposed to mind mapping and those exposed to conventional strategies in public secondary schools in Nandi County, Kenya.

3. Methodology

The study was carried out among form two students in selected secondary schools in Nandi County, Kenya. The county was selected owing to the fact that Students' performance in mathematics in secondary schools in Nandi County is deemed to be poor in comparison to other subjects. The study adopted the Quasi-experimental research design. Three schools were used as experimental group while three other schools were used as the control group. The three categories were pure boys, pure girls and mixed schools. One intact class from the pure boys and pure girls' school categories were selected totaling to four (4) classes while in the mixed schools two classes were selected from each school totaling to four (4) intact classes. In this study the pretest was administered at a minimum of one week prior to the treatment session so as to decrease the likelihood that the effects of the treatment are confounded by testing effects that may arise from completing the pretest as pointed out by Hulstijn *et al.*, (2014). The post-test was administered immediately following the treatment phase of the experiment.

The target population for the study was all form 2 students in various secondary schools in the county. The county has 34 County secondary schools with 212 Mathematics teachers and 4761 form 2 students. The county schools were selected owing to the fact that they have better teaching and learning facilities in comparison to sub-county schools yet they still perform poorly in mathematics in national examinations. The extra-county and national schools perform better in mathematics in National examinations thus were not included in this study. Therefore, the target population of this study was 4761 form 2 students and 212 Mathematics teachers. Form two students participated in the study since measures of central tendency as a topic in mathematics is taught in the first term of Form two.

The study purposively selected public County secondary schools followed by intact Form two classes and finally students. In selecting schools to participate in the study, all the county schools were first categorized as; pure girls, pure boys and mixed schools. Two schools from each category were selected to participate in the study through simple random sampling technique. The choice of the two schools with similar characteristics was to allow one

school in each category to be used as an experimental school while the remaining was used as the control school. Through lottery method, two schools in each of the three categories were randomly selected where the first school (School A) was the experimental group while the second school picked (school B) was the control. Therefore, there were three (3) experimental and three (3) control groups. Random sampling involves a pure chance selection and assignment of subject hence eliminating systematic bias and minimizing the effects of extraneous variable. However, since the nature of the research was a quasi-experimental, which does not allow for randomness in selecting the study participants, one (1) intact class was used.

This study collected data using pre-test and post-test. The test items were selected from the form two topic "measures of central tendency". A pre-test was administered to all students before intervention period and a post-test was later administered at the end of the intervention period. The intervention period for the study was one week where students from the experimental group were taught measures of central tendency using mind mapping strategies while students in the control group were taught using conventional methods of mathematics teaching (without any treatment).

A pilot study was conducted in the neighboring county of Uasin-Gishu, which has similar features to the study location. The researcher chose 30 students to participate in the pilot trial. The pilot study findings were included into final instrument changes to increase content validity, as well as question, format, and scale reliability (Vogel, & Draper-Rodi, 2017). In order to ensure construct validity, the researcher assumed that students' achievement has a positive link with the usage of mind mapping as a teaching approach, as determined through hypothesis testing. In this study, students' pre-test scores were not released to students so as to avoid the effect of pre-test on posttest. Additionally, the posttest was administered immediately after the intervention period and the students were not informed of the exact period of the examinations.

To test the research instruments' reliability, the researcher administered and re-administered the research instruments to a group of respondents over a two-week period. The respondents were chosen from one school in the surrounding Uasin-Gishu County and were not part of the main data collection participants. The Cronbach Alpha Coefficient was then determined to determine the research equipment' dependability. Cronbach Alpha is normally used as a degree of internal consistency. Cronbach Alpha Coefficient of 0.82 was obtained and therefore was considered to be reliable for data collection.

Quantitative data from the pre-test and posttest were analyzed using means, standard error of the mean and t-test to determine the effect of mind mapping on students' achievement. The analyzed data was presented in tables and graphs. The researcher observed all the rules and regulations in carrying out research in Kenya. Privacy, confidentiality and openness in data collection was ensured throughout the study. The major ethical issues of concern were informed consent, privacy and confidentiality on information supplied, anonymity to safeguard the identity of the respondents and the researcher's sensitivity to human dignity (Suri, 2020).

4. Results and Discussion

The study further sought to determine the effect of mind mapping on gender difference in mathematics achievement in public secondary schools in Nandi County. The study analysed achievement scores of students from the pre-test conducted before the treatment. The results are presented in Table 1.

Table 1: Students' pre-test achievement scores based on Gender

Type	Gender of student	Mean	Std. Error Mean	Mean difference
Control Group	Male	45.7246	1.10043	3.7082
	Female	42.0164	1.13067	
Experimental Group	Male	44.4941	1.20429	.0848
	Female	44.5789	1.05190	

Table 1 shows that in the control group male learners had a mean score of 45.7246 with a standard error of 1.10043 while female learners had a mean score of 42.0164 with a standard error of 1.13067. Thus, the mean difference between the male and female students was 3.7082 showing that male students outperformed female students by a margin of 3.7%. In the experimental group, male students had a mean of 44.4941 with a standard error of

1.20429 while female students had a mean of 44.5789 with a standard error of 1.05190 leading to a mean difference of .0848 in favour of the girls.

In addition, the mean scores of both male and female students were analysed for the posttest results. The analysed results are presented in Table 2.

Table 2: Students' Posttest achievement scores based on Gender

Type	Gender of student	Mean	Std. Error Mean	Mean difference
Control Group	Male	53.0737	.99531	4.9199
	Female	48.1538	.85846	
Experimental Group	Male	57.8739	1.16923	4.9939
	Female	52.8800	1.25489	

Table 2 points out that in the control group male students had a mean score of 53.0737 with a standard error of 0.99531 while female students had a mean score of 48.1538 with a standard error of 0.85846. The study found a mean difference of 4.9199 between male and female students' performance when they were subjected to traditional methods of teaching mathematics. Additionally, in the experimental group, males attained a mean score of 57.8739 with a standard error of 1.16923 while the female students attained a mean score of 52.8800 with a standard error of 1.25489 resulting to a mean difference of 4.9939 among the male and female students in favour of the male students. From the above results it can be inferred that male students both in control and experimental group outperformed female students in posttest examinations. There was a gender difference in performance between boys and girls in secondary schools in Nigeria, according to the findings of a study done by Igbo, *et al.*, (2015), which looked at the role of gender stereotype as a predictor of secondary school students' academic achievement. Alordiah, *et al.*, (2015) investigated the impact of gender on students' academic achievement in Mathematics and found that male students outperformed female students.

According to Ajai and Imoko's (2015) study, which investigated gender differences in Mathematics achievement and retention using a Problem-Based Learning (PBL) approach, male and female students taught algebra using PBL did not significantly differ in achievement and retention scores, indicating that male and female students are capable of competing and collaborating in Mathematics. In addition, Ursini, Sanchez, Orendai, and Butto (2004) observed that incorporating technology into mathematics classrooms appeared to increase gender equity in terms of student conduct. Thus, in the current study, the usage of mind maps in the classroom resulted in an overall improvement in student achievement.

Additionally, despite the achievement of declining gender gap achievement in English in Kenya as shown by Wasanga, Ogle and Wambua, (2011), gender gaps still persist in mathematics at both primary and secondary school levels with boys outperforming girls (Kenya National Examination Council, 2018; Wasanga *et al.*, 2011). Thus, a small number of girls tend to take courses related to mathematics in the university. In the current study, boys outperformed girls in both the pretest and posttests.

4.1 Impact of Mind Mapping Teaching Strategy on Gender Difference in Mathematics Achievement

In order to determine effect of mind mapping teaching strategy on gender difference in mathematics achievement, the study used independent sample t-test to test the following hypothesis

H_{01}: Use of Mind mapping has no effect on gender difference in mathematics achievement of students in public secondary schools

This hypothesis was also tested using the independent sample t-test. The results of the independent sample t-test for the two groups are presented in Table 3.

Table 3: Independent sample t-test for gender difference in achievement for both control and experimental group

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Marks achieved by students in the post Test (Control Group)	Equal variances assumed	6.233	.013	3.655	171	.000	4.91984	1.34615	2.26262	7.57706
	Equal variances not assumed			3.743	170.612	.000	4.91984	1.31438	2.32529	7.51439
Marks achieved by students in the posttest (Experimental Group)	Equal variances assumed	1.086	.299	2.842	184	.005	4.99387	1.75730	1.52682	8.46093
	Equal variances not assumed			2.912	171.369	.004	4.99387	1.71518	1.60827	8.37948

Table 3 shows that in both the pretest and posttest examinations, there was a significant difference in students' performance when subjected to both mind mapping teaching strategy and the traditional methods of teaching mathematics since the p-values were less than 0.05. This shows that generally, the use of mind maps enhances students' performance in mathematics but does not favour any gender. Thus, the null hypothesis was accepted showing that use of Mind mapping has no effect on gender difference in mathematics achievement of students in public secondary schools. This study's findings are congruent with those of Igbo et al. (2015), who explored the impact of gender stereotype on secondary school students' academic accomplishment and discovered that gender stereotype had a significant influence on students' academic achievement in favor of male students. The findings indicate that there is no statistically significant interaction impact of the mind mapping instructional approach and gender on students' mathematics performance (Measures of Central Tendency). This means that male and female learners who get the same treatment will not have significantly different math performance ratings. This implies that when mind mapping is used to teach mathematics, gender is not a barrier to performance. This is backed by Adodo's (2013) discovery that when both sexes were equally encouraged to use their intellectual endowments fully, there was no difference in their studies, and gender had no effect on students' learning of science or performance. The findings also correspond with those of Alao and Abubakar (2011), who found no significant difference in physics performance between male and female students.

5. Conclusions and Recommendations

The paper concluded that despite the difference in male and female student achievement in mathematics, greater difference was achieved when mind maps were used in mathematics instruction. However, there was no significant difference in terms of gender when subjected to t-test results showing that the use of mind maps does not affect gender difference in mathematics achievement. It was recommended that the use of mind mapping should be encouraged in teaching and learning of mathematics and other subjects because of its positive effects on boosting both male and female students' academic achievement.

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