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. 164 – 172)

Effect of Mind Mapping Teaching Strategy on Mathematics Achievement among Secondary School Students in Nandi County, Kenya

Keter Philemon Kibet, Prof. John Simiyu and Dr. Joseph Mubichakani,

School of Education, University of Eldoret

Corresponding Author: kpketer@gmail.com

Abstract*: The teaching of mathematics still follows the traditional pattern which is identified to be ineffective and a factor responsible for the poor performance. Students' performance in mathematics in secondary schools in Nandi County is deemed to be poor in comparison to other subjects. The aim of this study was to investigate the effect of mind mapping in mathematics instruction on learner achievement in secondary schools in Nandi County. The target population was 4761 form 2 students. The study adopted purposive sampling in selecting county schools followed by simple random sampling. Data was collected using Mathematics performance tests. Data was analyzed using mean, Standard error and t-test. The results showed that experimental group performed better than control group. There was no significant difference in scores of students between the experimental and control group for pre-test scores (p=.991). However, post-test scores showed a significant difference in scores between the experimental group and the control group (p=.000). The study concluded that use of mind maps as an intervention programme in teaching has a positive impact on students' achievement. 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. Findings of the study would be of immense benefit to Secondary school teachers as they would acquire new instructional strategy. This will make the teaching of mathematics more interesting and thus improve teachers' effectiveness.*

Keywords: *Mathematics, Mind Map, Teaching, Achievement, Students*

How to cite this work (APA):

Keter, P. K., Simiyu, J. & Mubichakani, J. (2021). Effect of mind mapping teaching strategy on mathematics achievement among secondary school students in Nandi County, Kenya. *Journal of Research Innovation and Implications in Education* 5(4), 164 – 172.

1. Introduction

A mind map is a visual, non-linear depiction of thoughts and relationships (Keller, 2012). Furthermore, according to Johnson (2014), a mind map is a learning approach in which a non-linear technique is used for learning and the student is encouraged to investigate and explore numerous concepts using various relationships that can be interconnected from a central theme to outer branches. As a result, in this educational process, creativity (imagination) and idealization are successfully improved (Chen, Xiao & Lin, 2018). In truth, a mind map is an interactive learning approach that encourages students to focus more intently on classroom issues. As a result, learning lessons is no longer a tedious task for students, but rather an interesting and beneficial one (Ghanbari, Javadnia, & Abdolahi, 2010).

Many studies, including those by Awajan (2013) and Buzan (2015), attribute the use of mind mapping to the following reasons: guiding learners to the highest degree of concentration, converting written information into

organized forms that are easy to assimilate, converting verbal communication into diagrams, images and symbols and also supporting students to establish their ideas and information in an imaginative visual method to respond to scientific data and consolidate them. The strategy also helps learners in building mind mapping both visually and mentally in an attractive way, taking into consideration learners' differences, breaking learners out of traditional technique routines, sparking learners' motivation to learn, presenting material in an engaging and entertaining manner, functioning and activating brain areas, and giving learners with a broad view of the topic

Mathematics is a compulsory subject in Kenyan secondary schools because it helps learners think analytically, improve their reasoning ability, and develop their lifetime learning skills to tackle challenges in life. Despite the importance attached to Mathematics, its performance in national examinations has been very poor and more than 50% of the students fail Mathematics in the National examinations (Njiru, 2015).

Mathematics in schools is often one lesson that is less favored by the students. Students' poor performance in mathematics subject is associated with various factors including attitude, motivation and teaching instruction amongst other factors. The poor performance in mathematics at secondary school level is usually blamed on teachers. The teaching of mathematics, according to Agwagah as cited by Wasanga, Ogle and Wambua, (2011) continues to follow the conventional pattern, which has been described as inadequate and a major factor in students' poor performance in mathematics. Thus, the current paper investigated the effect of mind mapping teaching strategy on mathematics achievement among form two students in secondary schools in Nandi County, Kenya.

2. Literature Review

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 (Kurniasih, & Irpan, 2019). There are numerous approaches for visualizing content, according to Parikh (2015). These include concept maps, mind maps, conceptual diagram, visual metaphor and semantic networks.

Tony Buzan created mind maps in the late 1960s as a way to help students make notes using only key words and pictures, but they can also be used by teachers to illustrate concepts in a creative way (Lin, 2018). Because of their visual nature, mind maps are thought to be faster to create and much easier to recall and review. Because mind maps are non-linear, it is simple to link and cross-reference different aspects of the map (Linlin, Yang & Liu, 2019).). Mind Maps are also easy to study because they allow you to refresh information in your mind with a single glimpse. Mind Maps can also be useful mnemonic devices, and knowing their shape and structure can help you remember the details contained within them. In the process of assimilating and linking information, they use far more of the brain than traditional methods of teaching (Lin, 2018).

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 (Khodabandeh, 2021). The essential element is to develop mind maps that make the most of these things building on an individual's creativity, thinking and cross linking between ideas that exist in their individual minds. According to recent studies, any knowledge presented in the form of graph charts has a strong effect on people's minds. Keeping this in mind, teachers should strive to visualize concepts and demonstrate them to their students (Buran & Filyukov, 2015).

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).

The efficacies of instructional strategies on students learning have steadily raised substantial interest on the thematic field of educational research (Wiens, Calkins, Yoder, & Hightower, 2021). Most of the instructional strategies employed currently embrace the use of modern technology and this has been associated with positive changes in the field of learning. Barakaev, Shamshiyev, O'rinov and Abduraxmonov (2020), further noted that the under achievement witnessed among most of the learners in various subjects is usually associated with the use of various teaching methods which are considered ineffective thus teachers need to be acquainted with instructional strategies that enhance students' achievement.

The main objective of teaching at any level of education is to bring an important change among learners. Barakaev *et al.,* (2020) indicated that the low academic achievement

by most of the learners is primarily associated with inefficiencies in instructional methods which are applied by teachers. These inefficient methods negatively affect learner performance. Additionally, a substantial amount of research shows that the achievement of learners in a specific subject is usually a reflection of instructional strategies applied by the teachers. As such the researchers indicated that as a way of bringing desirable changes in learners, instructional methods applied by teachers need to be best suited for the subject that is being undertaken.

Traditional methods of instruction, such as using a chalk and board or giving a lecture, are among the most effective ways of transmitting information to students, but there is no guarantee that knowledge will be transferred. According to Israel, Zipp, D'Abundo, and Deluca (2020), visual teaching tactics such as the usage of mind maps could help 65 percent of visual learners learn more effectively. Transferring existing knowledge and information to students through standard teaching methods does not guarantee that students will understand what they are learning, especially in classrooms, which offers a challenge to learning (Polzer & Miesenberger, 2015).

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. The quasi–experimental research design was chosen and involved the use of pre-test, post-test, control group design with no randomness on participants instead intact classes of learners. In this study, 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). The intention of this was to find out if there was any difference in students' achievement in mathematics when taught using the mind mapping teaching strategy and the conventional methods of instruction.

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. Face validity was assessed by getting students undertaking PhD in Education in the University of Eldoret to test-run the instrument to see if the questions appear to be relevant, clear and unambiguous as outlined by Mikkonen *et al.,* (2010). The researcher designed questionnaires and interview schedules that adequately addressed the construct or area under investigation. Research experts from the University of Eldoret who had content in the area under investigation were consulted and their comments used to improve the questions in both the questionnaire and the interview schedules.

The researcher administered and re-administered the research instruments to a group of respondents at an interval of two weeks to determine the trustworthiness of the research instruments. The respondents were not part of the main data collection participants but were selected from one school in the nearby Uasin-Gishu County. Thereafter Cronbach Alpha Coefficient was calculated to test on the reliability of the research instruments. Cronbach Alpha is normally used as a degree of internal consistency. Cronbach Alpha Coefficient of 0.82 was obtained on the questionnaires and therefore was considered to be reliable for data collection. For interviews, the researcher ensured data collected information did not have any minor errors and at the same time all the research themes were captured during the instrument preparation, the process of interviews and during the analysis stage.

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. Before undertaking fieldwork, a research permit was sought from relevant authorities including the National Council of Science, Technology and Innovations (NACOSTI) and the County Director of Education. 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 aim of this study was to investigate the effect of mind mapping teaching strategy on mathematics achievement of students in public secondary schools in Nandi County. To achieve this objective, the students who were selected to participate in the study were grouped into two groups; experimental and the control groups. Students in the experimental group were subjected to teaching of measures of central tendency through the use of mind mapping approach for a period of one week while students in the control cohort were taught measures of central tendency using conventional methods of mathematics teaching. Initially, a pre-test was administered to all students before the intervention period. However, results of the pre-test were not released to the students so as to ensure that the outcomes of the pre-test did not compromise the outcomes of the post-test. A post-test was thereafter administered to all the students. Before the treatment given for both groups, pretest was given in order to measure students' prior mathematics skills. Both groups showed similar pretest result which means that the mathematics skills of the students in experimental and control group were homogenous. The means and standard error of these two tests were calculated and the results for pre-test are presented in Table 1.

Table 1: Mean Marks of Students in Pre-Test and Post Test

Groups		Mean	Std. Error	Mean Gain in scores
Experimental (Use of Mind maps)	Pretest	44.5282	.83283	11.4564
	Posttest	55.8602	.87837	
Control (use of Conventional methods of Mathematics Instruction)	Pretest	43.9846	.80272	6.8709
	Posttest	50.8555	.69346	

Table 1 shows that students in the control cohort had a mean score of 43.9846 with a standard error of .80272 while those in the experimental cohort had a mean score of 44.5282 with a standard error of .83283. The results of

the pretest were high and this could be attributed to the fact that high school students had initially been introduced to measures of central tendency in primary education. After the treatment, the mean of the test scores for the experimental group was 55.8602 with a standard error .87837 while that for the control group was 50.8555 with a standard error of .69346. The results show that the mean score for the experimental group increased and was higher than the mean score for the control group which also showed some increment. The difference in the mean scores between pretest and posttest was 11.46 while that for the control group was 6.87 while a mean difference of 5.00 was obtained in posttest results between the experimental and the control group. In this case, the use of mind maps resulted to a difference of a mean score of 5.00 and this could be attributed to the change of attitude and the motivation that are associated with mind maps. The general improvement of students' performance in posttest was attributed to use of mind maps since the characteristics of the schools selected were almost similar thus expecting almost similar results when subjected to the same methods of instructions. The general improvement between the pretest and pos test results in both the experimental and control groups was attributed to the fact that both student groups were taught measures of central tendency and tested immediately leading to an expected improvement. Mind mapping strategy makes learning fun and easier for students to solve mathematical problems. It also leads to improved memory performance allowing learners to generate ideas, and connect complicated ideas with each other. This enhances the cognitive functions of the brain leading to improved students' performance. Mind map use also motivates students to learn and lets them think in a radiant making them to be capable of generating numerous original ideas.

The difference of 11.46% between the experimental and control group is not that big as expected. This could be attributed to the fact that the time period for exposure to use mind maps as a learning strategy was only one week and thus an increase in exposure periods could also lead to a higher difference in scores. Additionally, the use of mind maps in teaching is a new concept with some challenges which could influence its use. Teachers initially had difficulty in using mind maps despite their training on the same and this could have contributed to a low difference between the two groups.

The findings of this study were found to be consistent with the findings of Hariyadi, Corebima, and Ibrahim's (2018) study, which aimed to measure the benefits of summarizing and questioning in the Reading-Questioning-Answering Learning Model integrated with mind mapping on genetic learning outcomes. Their study showed that with integration of mind mapping, there was a significant improvement on students summarizing and questioning skills learning outcomes. Thus, they concluded that mind maps enhanced students' performance.

Furthermore, the findings corroborated those of Akanbi *et al.,* (2021), who discovered that students in the experimental group who were taught using the mind mapping instructional strategy had a higher adjusted mean score than students in the control group who were taught using the conventional method in their study on the effect of mind mapping instructional strategy on students' retention in physics in senior secondary schools. Liu *et al.,* (2018) also discovered that employing mind mapping for teaching and learning has a positive impact on student learning and instructor teaching.

Impact of use of Mind Maps in Mathematics Instruction

To find out whether there were significant differences in the means as a result of the treatment, the following null hypothesis was tested at significance level of 0.05.
$H0_1$: There is no significant difference in learner's achievement in secondary schools between the experimental and control groups.

The results were subjected to the paired sample t-test where the scores of posttests for the control and experimental group were used. In this case, the experimental group were subjected to use of mind maps during the teaching of measures of central tendencies while the control group were subjected to regular methods of mathematics instructions. First, the results from the pre-tests conducted between the two cohorts were analysed using paired sample t-test. The results of the analysed information are presented in Table 2

Table 2: T-test for students' pre-test scores

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Marks achieved by students in Pre-test (Control Group) - Marks achieved by students in pre-test (Experimental Group)	-.01163	9.36513	1.00987	-2.01952	1.99626	-.012	85	.991

Results from Table 2 show that there was no significant difference in scores of students between the experimental and control group for pre-test scores since the p-values were greater than 0.05 (p=.991). This shows that before treatment, the performance of students in mathematics (measures of central tendency) were similar. Thus, the study findings were found to be similar to those of Mahasneh (2017) which found out that there were no significant differences between the control and experimental groups (t=0.504, P=>0.05) in the achievement test scores in pre-tests when subjected to independent sample t-test. Another study by Yeh *et al.,* (2019) which used ANOVA to test the difference in achievement in a mathematics pre-test showed that there were no significant differences in student's initial mathematics achievement in terms of conceptual understanding, calculating, and word problem-solving (Wilks' $\lambda = 0.943$, $F\ (3110) = 2.210$, $p > 0.05$). In other words, the results in the current study shows that students in both groups had similar mathematics abilities before being subjected to mind mapping teaching strategies. Furthermore, the findings of the study are similar to those of Khodabandeh (2021), who conducted a study comparing the effects of a mind mapping-based flipped learning approach on the speaking skills of introvert and extrovert EFL learners and discovered that the two groups were homogeneous in terms of their performance on a speaking pretest.

Further, the results from the post-tests conducted between the two groups (experimental and control) were analysed using paired sample t-test. The results of the analysed information are presented in Table 3.

Table 3: T-test for post-test scores

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Marks achieved by students in the post Test (Control Group) - Marks achieved by students in the posttest (Experimental Group)	-4.723	13.474	1.215	-7.129	-2.318	-3.89	122	.000

From the Table 3, it was shown that there was a significant difference in scores between the experimental group and the control group since the p-value was less than 0.05 thus the null hypothesis was rejected. The study therefore shows a significant difference in scores between experimental and the control group. This difference is attributed to the treatment that was given to students (using mind maps to teach measures of central tendency). This is in line with the findings of Akanbi *et al.,* (2021), who discovered that the mind mapping instructional technique has a statistically significant effect on senior secondary school students' performance in physics. Al-

Otaibi (2016) also performed research to see if non-hierarchical electronic mind maps could help elementary level female learners in a science class to improve their visual thinking abilities. In the study, there were two groups. The experimental group received instruction utilizing a non-hierarchical electronic mind mapping strategy, while the control group received instruction using the traditional manner. A pre- and post-visual thinking ability test was performed (if same test: The visual skill test was employed as pretest and posttest). The study concluded that statistically significant differences (at the level of 0.01) occurred between students' average grades on the visual thinking skill test in both the experimental and control groups in favor of the experimental group.

According to a review of the literature, intervention programs that integrate teacher-supported education and highlight various elements to enhance the development of mathematics abilities among learners have a good impact on learner accomplishment. Thus, the introduction of mind maps as an intervention program in mathematics education in Nandi County secondary schools improved students' math achievement. The treatment learners got during instruction could explain the considerable difference in achievement between students exposed to mind maps and those subjected to traditional methods. These findings are in line with those of Adesoji and Ibraheem (2009), who found that students exposed to the mind mapping teaching technique performed better in Mathematics than students subjected to the traditional learning strategy. This was confirmed further by Cömek, Akinolu, Elmaci, and Gündodu (2016), who stated that one of the approaches that may be employed and applied by the teacher to increase the learning outcomes of students in any topic is the mind mapping instructional strategy.

The findings were also similar to those of Adodo (2013), Jibril, *et al.,* (2012), and Oluwatosin and Bello (2015), who discovered that the mind-mapping approach helped to increase students' performance in sciences. A similar result was reached in a study conducted in Turkey by Comek, *et al.*, (2016), who discovered that using mind mapping increases students' academic achievement in science class. Furthermore, researchers in Korea discovered that using mind mapping in science instruction boosted the creative thinking skills of junior high school pupils (Yoon & Kang, 2015). Researchers in the Republic of Serbia (Gagi, *et al.,* 2019) have also demonstrated beyond doubt the educational efficiency of teaching with the use of mind mapping, which was determined to be higher or more than the efficiency of conventional teaching approaches.

5. Conclusion and Recommendations

The paper concluded that there was general improvement of students' performance in posttest which was attributed to use of mind maps since the characteristics of the schools selected were almost similar thus expecting almost similar results when subjected to the same methods of instructions. However, there was no significant difference in scores of students between the experimental and control group for pre-test scores. This shows that intervention strategies in mathematics instruction through use of mind maps leads to overall student improvement in mathematics performance. The study 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 students' academic achievement.

References

Adesoji, F. A., & Ibraheem, T. L. (2009). Effects of students' teams-performance divisions strategy and mathematics knowledge on learning outcome in chemical kinematics. *Journal of International Social Research*, *2*(6),15-25.

Adodo, S. O. (2013). Effect of mind-mapping as a self-regulated learning strategy on students' achievement in basic science and technology. *Mediterranean Journal of Social Sciences*, 4(6), 163- 172.

Akanbi, O. A., Olayinka, W. Y., Omosewo, E. O. & Mohammed, E. R (2021). Effect of Mind Mapping Instructional Strategy on Students' Retention in Physics in Senior Secondary Schools. *Anatolian Journal of Education*, 1(6), 145-156.

Alordiah, C.O.; Akpadaka, G. & Oviogboda, C. O. (2015). The influence of gender, school location and socio-economic status on students' academic achievement in mathematics. *Journal of Education and Practice*, *16* (17): 130-136.

Awajan, W. (2013). Design and Examine Effectiveness of a Learning Program Using Mind Maps in Developing Students' Cognitive Performance Skills in Child Education in Islam at Princess Alia College. *International Educational Specialized Journal*, *2*(6), 544-560.

Barakaev, M., Shamshiyev, A., O'rinov, X., & Abduraxmonov, D. (2020). Problems of Teaching Mathematics in Modernization. *International Journal of Progressive Sciences and Technologies*, *19*(2), 201-203.

Blaschke, L. M. (2018). Self-determined learning (heutagogy) and digital media creating integrated educational environments for developing lifelong learning skills. In *The digital turn in higher education* (pp. 129-140). Springer VS, Wiesbaden.

Buran, A., & Filyukov, A. (2015). Mind mapping technique in language learning. *Procedia-Social and Behavioral Sciences*, *206*, 215-218.

Buzan, T. (2002). *How to Mind Map*. London: Thorons.

Buzan, T. (2007). *Mind Map*. Jakarta: PT GramediaPustakautama. Buku Pintar.

Chen, Y., Xiao, H & Lin, X (2018). Developing a mind map-based life review program to improve psychological wellbeing of cancer patients: a feasibility study. *Psycho - oncology*;27(1):339-42.

Çömek, A., Akinoğlu, O., Elmaci, E., & Gündoğdu, T. (2016). The effect of concept mapping on students' academic achievement and attitude in science education. Journal of Human Sciences, 13(1), 348-363.

Dhindsa, H. S., & Anderson, O. R. (2011). Constructivist-visual mind map teaching approach and the quality of students' cognitive structures. *Journal of Science Education and Technology*, *20*(2), 186-200.

Gagić, Z. Z., Skuban, S. J., Radulović, B. N., Stojanović, M. M., & Gajić, O. (2019). The implementation of mind maps in teaching physics: educational efficiency and students' involvement. *Journal of Baltic Science Education*, 18(1), 117-131.

Ghanbari, A., Javadnia, F. & Abdolahi, M. (2010). Teaching of gross anatomy for students of medicine by mind map-based power point slides. *Medical teacher*; 32(3):272.

Hariyadi, S, Corebima, A & Ibrohim, S.Z. (2018). Contribution of mind mapping, summarizing, and questioning in the RQA learning model to genetic learning outcomes. *Journal of Turkish Science Education*, *15*(1), 80-88.

Israel, C., Zipp, G. P., D'Abundo, M., & Deluca, D. (2020). Mind mapping to enhance critical thinking skills in physician assistant education: a randomized controlled study. *Journal of Allied Health*, *49*(2), 135-140.

Jibrin, A. G., Abdullahi, Y., Zayum, S. D., & Abdullahi, Y. A. (2012). Effects of mind mapping instructional strategy on the academic achievement of senior secondary school biology students in ecology. *Journal of Science, Technology & Education*, 1(2), 1-5

Johnson, L. R. (2014). Using mind maps to teach medical students. *Medical education;* 48(11):1124-5.

Keller, J. M. (2012). *Motivational design for learning and performance*: The ARCS model approach. New York: Springer.

Khodabandeh, F. (2021). The Comparison of Mind Mapping-Based Flipped Learning Approach on Introvert and Extrovert EFL Learners' Speaking Skill. *Iranian Journal of English for Academic Purposes*, *10*(1), 35-53.

Khodabandeh, F. (2021). The Comparison of Mind Mapping-Based Flipped Learning Approach on Introvert and Extrovert EFL Learners' Speaking Skill. *Iranian Journal of English for Academic Purposes*, *10*(1), 35-53.

Kurniasih, S., & Irpan, A. M. (2019). Diagram Vee and mind mapping application to develop conceptual understanding of plant reproduction. In *Journal of Physics: Conference Series* (Vol. 1157, No. 2, p. 022079). IOP Publishing.

Lin, Y.J. (2018). The Application of Mind Map in Maths Teaching in Senior Middle School. *Mathematics Learning and Research*, (14):16-17.

Linlin X., Yang, Z & Liu, M (2019). The application of mind map in the teaching of maths problem solving in senior middle school. *International Journal of Multidisciplinary Research and Development*, 6, (3); 219-223.

Liu, Y., Tong, Y., & Yang, Y. (2018). The application of mind mapping into college computer programming teaching. *Procedia Computer Science*, *129*, 66-70.

Mahasneh, A. (2017). the effect of using electronic Mind Mapping on Achievement and Attitudes in an

introduction to educational Psychology Course. T*he new educational review*, *47*(1), 295-304.

Mikkonen, K., Tuomikoski, A. M., Sjögren, T., Koivula, M., Koskimäki, M., Lähteenmäki, M. L., ... & Kääriäinen, M. (2020). Development and testing of an instrument (HeSoEduCo) for health and social care educators' competence in professional education. *Nurse education today*, *84*, 104239.

Njiru, B. K. (2015). *Influence of formative evaluation on learner performance in Mathematics in Secondary Schools in Embu County, Kenya*. Doctoral dissertation, University of Nairobi.

Oluwatosin, O. B., & Bello, T.O. (2015). Comparative effect of mastery learning & mind mapping approaches in improving secondary school students' learning outcomes in Physics. *Science Journal of Education*, 3(4), 78-84.

Parikh, N. D. (2015). Mind map and concept map as complementary tools for teaching. *The International Journal of Indian Psychology*, *2*(4), 147-158.

Polzer S, & Miesenberger K. (2015). 2D Presentation Techniques of Mind-maps for Blind Meeting Participants. *Studies in health technology and informatics*; 217:533-8.

Stirling, A. C., & Moro, C. (2020). The use of virtual, augmented and mixed reality in anatomy education. In *Teaching Anatomy* (pp. 359-366). Springer, Cham.

Vogel, S., & Draper-Rodi, J. (2017). The importance of pilot studies, how to write them and what they mean. *International Journal of Osteopathic Medicine*, *23*, 2-3.

Wasanga, P. M., Ogle, M. A., & Wambua, R. M. (2011). Progress in gender equality in education: Kenya. *SACMEQ (Policy Brief No. 6). Nairobi: Kenya National Examinations Council*.

Wiens, P. D., Calkins, L., Yoder, P. J., & Hightower, A. (2021). Examining the relationship between instructional practice and social studies teacher training: A TALIS study. *The Journal of Social Studies Research*, 7(4), 261-273.

Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 1-19.

Zouhor, Z. A., Bogdanović, I. Z., & Pavkov-Hrvojević, M. V. (2017). The effect of the modified Know-Want-Learn strategy on sixth-grade students' achievement in physics. *Journal of Baltic Science Education*, *16*(6), 946.