# CONCEPT MAPPING AS A STUDY STRATEGY IN TEACHING AND LEARNING OF MATHEMATICS IN JUNIOR SECONDARY SCHOOLS IN BOTSWANA

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**Abstract**
Numerous efforts have been made towards enhancing mathematics pedagogy in Botswana. However, despite these efforts, performance in the subject has remained abysmal. This study explored teachers' views, ideas, and experiences concerning the use of concept mapping (CM) as a study approach and examined its influence on the teaching and learning of mathematics in Junior Secondary Schools in the Kweneng region of Botswana. The study adopted the constructivist cognitive learning theory and used a quantitative research approach underpinned by positivism. Both experimental and survey designs were used. Data was collected using closed-ended questionnaires and analysed using a two-tailed t-test for the experimental design and descriptive statistics for the survey design. The findings of the experimental design showed no significant difference ($P>0.05$) in the mean pre-test score of the control and experimental groups, while there was a significant difference ($P<0.05$) in the post-test scores, with the treatment group showing higher mean score than the control group. CM was able to improve the performance of the learners in the experimental group. This confirms the applicability of CM in improving performance in mathematics. Findings from the survey designs raised concerns about the use of CM in teaching and learning in Botswana. This has numerous implications for policy and practice and underscores the need to include CM in the various efforts aimed at improving learners' performance in mathematics and other subjects.

**Keywords:** Concept mapping, Botswana, teaching strategy, study approach, mathematics pedagogy.

## 1.0 Introduction

In the field of mathematics, great strides have been made in the development of theories and research-based evidence for effective teaching, learning, and understanding of the subject (Kazemi, 2001). These efforts are appropriate steps since mathematics is regarded as one of the central subjects among the Science, Technology, Engineering, And Mathematics (STEM) combination (Alzahrani et al., 2017). The subject is also important in the understanding of almost every other subject in the curriculum inmost countries. It is therefore not surprising that failure to understand a technical subject like mathematics will have anenormous adverse effect on almost all the sectors of the economy in any nation. Despite the numerous efforts made to improve the understanding of mathematics by students, the subject has remained a nightmare for many. In Botswana for instance, teachers have resorted to the use of several methods such as brainstorming, question and answer, discussion, and lecture methods, among others, in order to improve the performance of students in the subject. However, this notwithstanding, the pass rate was 28.60% and 25.50% in the subject in 2018 and 2019 respectively (Botswana Examination Council, BEC, 2019).

To improve the learning of mathematics which translates to improved performance in the subject, it is essential to adopt teaching and learning strategies with the potential to improve learner participation. The current mathematics teaching practice in Botswana involves the teaching of factual knowledge, assigning what is taught as homework, and memorizing what is taught for tests. This form of teaching is very unlikely to produce better performance and is described by Battino (1992) as rote learning where new knowledge is acquired by memorization and incorporated into the learner's knowledge structure without any form of interaction with what the learner already knows. Meaningful learning occurs only when there are changes within the cognitive structure of the learner, and existing concepts are modified to form new linkages between concepts (Singh, 2015). This form of learning is not supported by rote memorization. This may be why the teaching and learning of mathematics has remained a major challenge despite concerted efforts of all education stakeholders.

Several authors have given credence to the relationship that exists between teaching strategies and performance in mathematics (Alzahrani et al., 2017; Gagic et al., 2019; Toropova et al., 2019; Zimmarro & Cawley, 1998). Although different teaching strategies have different associations with outcomes, cognitive-based teaching approaches appear to greatly enhance mathematics performance among students (Alzahrani et al.). This study was therefore aimed at exploring CM as a teaching strategy that may contribute to improved performance of learners in mathematics. This was done using teachers and students in selected junior secondary schools (JSS) in Kweneng region of Botswana. The study was born out of the researchers' interest in improved teaching and learning in Botswana, especially in the face of the declining quality of education (World Bank, 2014) and the disruptions caused by the Covid-19 pandemic.

**2.0 Background to the study**

The steady decline in the Botswana Junior Certificate Examination (JCE) results has caused a lot of dissatisfaction amongst education stakeholders, particularly in mathematics (BEC, 2017). In fact, failure to make good grades in mathematics is one of the major reasons many students cannot progress to senior secondary school as they have to repeat their grades (Botale, 2018). According to BEC (2019) "candidates demonstrated good knowledge and understanding of mathematical concepts, but they were challenged in the aspect of problem-solving. Most of the candidates had difficulties in recognizing and applying appropriate mathematical procedures for a given situation. Even in syllabuses where candidates showed improvement, mathematical application skills were lacking" (p. 10). This led to a 3.03% decline in performance from the previous year. The BEC (2020) analysis of the results for JCE revealed that the overall pass rate at grade E or better stood at 80.72% in 2020 compared to 84.76% in 2019, which is a significant decline of 4.04%.

The performance of the junior cadre can be likened to the performance of the senior secondary students in Botswana General Certificate of Secondary Education (BGCSE) where more than 20% of the learners obtained grade D in mathematics and failed to progress to tertiary education (Monyatsi, 2001). In 2018, percentage pass was 28.60% while in 2019 it declined to 25.50% (BEC, 2019). This is similar to performance in previous years where 28.7%, 24.5%, 24.4%, and 24.84% obtained at least a credit and above in 2013, 2014, 2015, and 2016 respectively. Similarly, in the Primary School Leaving Examinations the country recorded a mean of 3.8 against the international benchmark of 7.7 (Mullis et al., 2016). A major source for this huge concern is the fact that learners with poor grades in mathematics at the end of the term develop negative attitudes resulting in absenteeism and indiscipline during classes (Monyatsi, 2001).

Poor performance in mathematics and other STEM subjects led education stakeholders in Botswana to put various measures in place to ameliorate this sad situation (Mphale & Mhlauli, 2014). One of the measures was the organization of an in-service Education and Training (INSET) for teachers through a programme known as Strengthening of Mathematics and Science in Secondary Education (SMASSE). INSET is generally one of the approaches employed to up-grade teachers' skills and competencies worldwide. Since improving thequality of education depends on the improvement of the quality of classroom practices (Kibe et al., 2008), SMASSE was aimed at strengthening and enhancing the quality of teaching and learning of and performance in mathematics in secondary schools. This model which was fully implemented in Botswana was originally adopted from Kenya (Mullis et al., 2016). This all-important action taken by the Botswana education stakeholder leads to three poignant questions: is the SMASSE adopted from other countries exactly what Botswana needs? What effect does the in-service training have on the teachers that attended the training and how many teachers actually attended the training? To what extent has the programme led to an improvement in student performance in mathematics? Salani (2019) and Kereeditse (2021) answer some of these questions by arguing that many objectives of SMASSE are far from being achieved in the Botswana education sector.

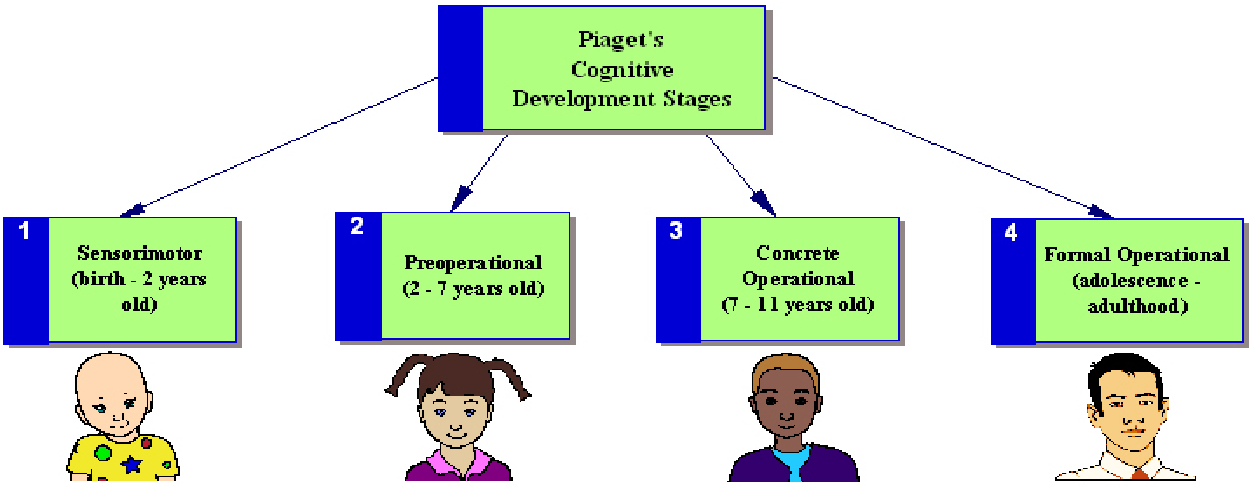
Although the poor performance of students in mathematics can be attributed to various factors, Tabulawa (2009) noted that the teaching strategies have the most notable impact in Botswana. According to Kgosikebatho (2013), few classrooms are concerned with knowledge construction, and educators have failed to implement a constructivist instructional view that focuses on student-centred learning because of various challenges such as motivation factors, student factors, and structural facilities. Lee et al. (2013) opine that students without enough knowledge and application of appropriate mathematics models usually find it difficult to cope with the high cognitive demands of the subject. This is even as Kimani et al. (2013) posit that in developing countries there is limited teacher-student and student-student interaction during teaching and learning. Majority of the learners are always passive and this may culminate in a poor absorption rate of important mathematics concepts (Kgosikebatho, 2013). In addition, teachers in Botswana are mainly making use of teacher-centred methods (Makwinja, 2017) with very little effort placed on elaboration and meta-cognitive strategies that facilitate learning, and more concerted effort made towards 'completing' the curriculum. This is against the desired learning strategies for mathematics where the lessons should be dominated by students being engaged in individual or group activities (Panthi & Belbase, 2017).

For Botswana to be at par with global economies, it is very necessary to produce graduates with 21stcentury skills such as collaboration, communication, information and communication technology literacy, social and cultural competencies, creativity, critical thinking, and problem-solving (Joynes et al., 2019). Instilling these skills in students is only possible if education standards are aligned with these skills (Boikhutso & Molosiwa, 2019). Although numerous policies have been put in place to foster the transmission of these skills, a gap remains in their implementation as teachers have continued to use outdated methods of teaching and learning. It was, therefore, necessary to explore other methods of teaching and learning such as CM that may act as an antidote for the poor performance of students not just in mathematics but in other subjects. This will be a major step towards imparting the 21st century skills in modern-day Botswana.

## 3.0 Theoretical framework

This study was underpinned by the cognitive learning theory proposed by Piaget which emphasizes "making knowledge meaningful and helping learners organize and relate new information to existing knowledge" (Zhou & Brown, 2017, p. 54). Piaget highlighted four major stages in the cognitive development of a child as shown in Figure 1.These stages include sensorimotor, preoperational, concrete operational, and formal operational (Woolfolk, 2001). Children are expected to pass through these phases before advancing to the next level of cognitive development, and skipping any stage may prove disastrous to the development of a child (Ertmer & Newby, 2013).

**Figure 1: Stages of cognitive development**




Source: Wood et al. (2001)

This study was hinged on the constructivist theory of learning. Although this theory is considered a branch of cognitivism because they both conceive learning as a mental task, constructivists believe that the "mind filters input from the world and uses such input to produce a unique reality" (Ertmer & Newby, 2013, p. 55). The constructivist theory is based on observation and scientific study about how students gain knowledge (Williams, 2015), and is premised on the fact that learners should be positioned to construct their own understanding and knowledge of the world by experiencing things and reflecting on what they have experienced (Zahi, 2019). When a learner encounters something new, he/she should be able to reconcile it with previous ideas and experience, which may lead to changing what the learner believes, or discarding the new information as irrelevant. In any of the two cases, the learner is the active creator of his/her own knowledge. Learners are expected to ask questions, explore, and assess what they know individually (Tanriseven, 2014).

One such strategy that allows learnerstotap into their previous knowledge to come up with related concepts and their relationshipsis CM. In this teaching strategy, the teacher should be in a position to understand the students' pre-existing conceptions and guide them based on their conceptions (Zahi, 2019). The success of constructivism as a pedagogical technique and psychological theory provides converging evidence of its utility. As proposed by Qian (2011), students must be engaged in the learning process to facilitate retention. This active learning is a hallmark of constructivism and transformation in mathematics education must be based on cognitive constructivism which allows the construction of knowledge by interacting with previous knowledge, beliefs, and intuitions.

In addition to the above, Constructivism was selected for this study for several reasons. First is it may be particularly valuable where the teaching of complex skills such as problem-solving or critical thinking skills are concerned (Liu et al.,2014). The theory also allows for the active participation of learners (Tam, 2000) which is typical of CM. Secondly, the theory lays emphasis on thinking and understanding rather than rote memorization (Guliz & Ali, 2009). It was applicable in the study because it gives learners ownership of what they learn in mathematics. Learning is based on learners' questions and explorations, and often the students have a hand in designing the assessments as well (Rockstroh, 2013). Thirdly, CM aspect of constructivism allows students to pose questions about various relationships and their mastery of certain concepts. Engaging creative instincts helps develop students' cognitive abilities on how to express knowledge using a variety of ways. Finally, the constructivist theory is able to ground learning activities in an authentic and real-world context. This largely helps to stimulate and engage students in CM during the real context of teaching and learning mathematics. Learners therefore learn to question things and apply their natural curiosity to the world (Lamy & Steve, 2016). The overall result will be the development of holistic learners who are likely to retain and transfer new knowledge to real life situations.

**4.0 Research Questions**

The study seeks to answer the following questions.

a) Does CM as a teaching and learning strategy have any effect on students' performance in mathematics?
   $H_o1$: CM as a study strategy for teaching and learning Mathematics at junior secondary level has no effect on students' performance in the subject.

$H_a1$: CM as a study strategy for teaching and learning Mathematics at junior secondary level has an effect on students' performance in the subject.

b) What are teachers' views on utilizing CM as a teaching and learning strategy towards improving students' mathematics performance?

## 5.0 Literature Review

### 5.1 Impact of CM on teaching and learning

CM is a valuable tool for adequately demonstrating the changes that occur in a learner's knowledge structure and the increasing complexity of knowledge structure that develops as learners integrate new knowledge with existing knowledge (Ellis et al., 2004; Vanides et al., 2005). International and regional literature show that CM has tremendous positive impacts on the performance of learners. A study by Erdem et al. (2009) limited to only 30 students enrolled in basic Chemistry at the faculty of education, university of Hacettepe, Turkey, shows that CM contributes to meaningful learning. Using a survey research design and 124 first-year learners at the School of Management, National Changhua University of Education in Taiwan, Chiou (2008) revealed that concept maps are effective in improving learners' performance in advanced accounting. The participants further recommended the application of CM in other curricula. This study presents a backbone for other studies since it offered the views of the learners regarding concept mapping. It also corroborates previous studies (Erdem et al., 2009) which took into consideration the performance of learners through tests only. The study is however limited to university students in Taiwan, and may not be applicable to learners in Botswana JSS.

Abbas et al. (2018) assessed the educational efficiency of concept mapping on learners' performance in physics. The sample for the study consisted of 113 learners drawn from seventh graders. An experimental design was carried out where pre-tests were given to both the control and experimental groups. The groups were taught differently, with the experimental group taught through CM while the control group was not taught using CM. Using the ANOVA, t-test, and Chi-Square as statistical tools, the results showed that there was astatistically significant difference in learners' performance between the control group and the experimental group with higher achievement recorded in the experimental group. The researchers concluded that CM could act as a tool for improving efficiency in education. Although the study design and the exclusion of other variables besides CM during testing are quite commendable, the study was carried out within a limited period of time. The results may fail to be applicable to learners in the long run. It is therefore possible that the results of the experimental group were relevant only in the short run while the continued application may have produced different results. Again, the study focused on physics and may not as well be applicable to the teaching and learning of mathematics in Botswana.

There is existing evidence that CM significantly improves the mathematics performance of learners because it encourages learners to brainstorm ideas and solve problems. In Jakarta, Indonesia, a study by Hafiz et al. (2017) which comprised of 72 students took cognizance of the fact that fewer researchers have scrutinized the roles of CM in mathematical connection ability, hence the need for the current study. The quasi-experimental study however revealed that CM enhances mathematical connection ability majorly in trigonometry. The findings of this study may not be applicable to other areas of mathematics and to JSS students in Botswana. Similarly, Baroody and Bartels (2000) suggest the use of CM as a teaching and learning tool for middle school mathematics since it can promote inquiry-based and meaningful learning in various ways, provide a means for the introduction of new concepts, and connect new concepts to one another and to previously known concepts. This in turn provides a perfect opportunity to engage in logical reasoning which fosters metacognition and autonomy, thereby motivating learners.

In the African context, Woldeamanuel et al. (2020), using pupils from EwketFana Primary School in Bahir Dar, Ethiopia, showed that CM can help in better understanding of important concepts such as photosynthesis. The authors argued that science teachers should apply this method in the systematic teaching of science concepts. Their study however failed to show if CM can enhance the learning of basic concepts in mathematics in junior secondary education specifically. In Nigeria, Okoye and Okechukwu (2006) confirmed the positive impact of CM and problem-solving strategies in the teaching and learning of genetics among secondary school students. This study used the same research method by Awofala (2011) who investigated the effect of CM strategy in the performanceof junior secondary year three students in mathematics in Nigeria. The study also shows that CM is capable of improving higher-order cognition in mathematics. However, the findings are limited to 88 students that were selected purposively from two schools in Nigeria. The study is therefore marred by the lack of randomization of the sample to prevent bias and the very short period of time that was used to conduct it. Again, the findings of the study may not be applicable to the Botswana context.

In the South African (SA) region, there is no published literature that gives clear empirical evidence on the impact of CM in teaching and learning of mathematics. However, a study by Fourrie and Machaba (2019) which explored the understanding of coordinates and transformation geometry through CM is worthy of mention in this regard. The study which involved investigative tasks, observation, and reflective interviews using 34 grade 12 mathematics students in SA, posits that learners' understanding of coordinate and transformation geometry can be greatly improved using CM. However, the study is marred by the fact that CM was not used to test the participants empirically. Instead, an interview was used to gather information from the participants who were not experts in mathematics. This calls for the need to conduct a study in the SA region that empirically tests the impact of CM in the teaching and learning of mathematics. Despite the numerous encomiums poured on CM as a potent tool for effective teaching and learning, Trehan (2015) shows that students have mixed experiences with the use of CM. Although it enhances their ability to integrate statistical concepts, it has no effect on their ability to apply concepts in solving problems. This shows that CM may not be completely devoid of shortcomings.

### 5.2 Concept Mapping and teacher practices

The use of CM in teaching and learning does not just make the learning process easier for the learners but also for the teachers. CM can be used as a means of assessing learners' prior knowledge of the topic and monitoring the progress of the learners. In fact, there is growing evidence of the use of CM as an assessment and evaluation tool by teachers. This is confirmed in a recent study by Hammad et al. (2021) which shows that CM can effectively act as a tool to monitor, assess, and improve the understanding of mathematical concepts especially "when used systematically and when their use is followed up by discussions that encourage students to talk about their maps and the links they have made" (p. 1). A similar study which involved a relatively small sample by Barolos (2002) also confirms that in addition to clarifying several misconceptions in mathematics, CM could serve as a possible supplementary tool for the evaluation of students in mathematics. A study by Mutodi (2016) further confirms the applicability of CM in providing feedback on the understanding of a new concept suggests further that teachers should use CM in the formative assessment process. For Katagall et al. (2015), CM can act as a strategy for improving teaching and learning, for instruction, for planning curriculum, for planned learning, and is, above all, a means of assessing the understanding of science concepts. This is in line with the assertion by Devcic et al. (2011) that CM can be applied in the teaching, learning, and assessment of knowledge in the field of mathematics. This is why the analysis of teachers' perspectives on the use of CM as an assessment tool in secondary school mathematics by Mutodi shows that teachers in Limpopo, South Africa, perceive CM as a useful, effective, and practical tool for teaching mathematics, organizing knowledge, enhancing retention and recall of concepts. The study which involved a close-ended questionnaire administered to 50 mathematics teachers from Sekhukhune District buttresses that of Liu and Wang (2010) that teachers should incorporate CM in the formative assessment. It remains to be seen how teachers in Botswana view CM and their willingness to apply this strategy in teaching and learning.

Schmittau (2004), using two pre-service teachers, showed the potential of CM in the teacher-educator sector. The study further asserts that the pedagogical potential offered by CM could be beneficial in the teaching and learning of mathematics. This is also seen in a study by Tanriseven (2014) which analysed the effect of CM on the attitude of mathematics and science teachers in secondary school. The study which adopted a quasi-experimental design divided the sixty (60) pre-service teachers selected for the study into the pre-test and post-test control and experimental groups. Teachers in the experimental group used CM to plan their tasks and both groups completed the motivated strategies for learning questionnaire. The experimental group further attempted an open-ended questionnaire. The results showed that teachers who used CM had a positive attitude toward lesson planning. Although this study was carried out in a short period of time, it shows the need for pre-service teachers to plan classroom activities using CM, and implement the planned concepts in real classroom environments.

Blackwell and Pepper (2008) aimed at determining the effect of using CM to promote reflective instructional decision-making among pre-service teachers when planning lessons for secondary students is quite revealing. The researchers were concerned with unearthing the connection between the uses of CM to help pre-service teachers improve their instructional decisions when planning lessons, and their reflective practices when striving to improve the quality of their lessons. Using a quasi-experimental non-equivalent research design, 85 participants were chosen with the intervention group consisting of 41 pre-service teachers and the control group consisting of 44 pre-service teachers. The independent variable was the intervention method, which is concept mapping, and traditional instruction only. The intervention (CM) was given to the treatment group while the traditional method was used on the control. The findings show that the construction of a concept map during the lesson planning process helped pre-service teachers become more reflective in their instructional decision-making. This shows the potential impact of CM on the training of pre-service teachers in the learning and teaching of mathematics.

Afamasaga-Fuata'i (2009) shows that CM helps pre-service teachers to reflect deeply upon their own mathematics knowledge and assigned topics, and challenges them to strategically organize their conceptual analysis into a meaningful manner that illustrates interconnectedness between key and subsidiary concepts during pedagogical planning. This in turn transmits to abetter teaching plan, good lesson delivery, and good assessment plan. With the place of CM in assisting pre-service teachers when making pedagogical instructional decisions laid bare, findings from Hyerle (1996) support the reference that CM should be perceived as an effective tool to enhance the reflective process. Martin (1994) shows that lessons planned using CM have higher quality with few sequencing errors. However, the study showed mixed findings on the use of CM for lesson plan development in an actual teaching situation. This calls for further studies on the use of CM to categorize, link and organize concepts while planning and delivering lessons (Lim et al., 2003). A summary of the applications of CM in teaching and learning mathematics is presented by Brinkmann (2003) and they include organizing information on a given topic, facilitating meaningful learning by aiding in theunderstanding of a new subject matter, identifying knowledge structures of learners especially alternative conceptions or misconceptions, improving attitudes towards mathematics, designing instructional materials, revision of a topic, training the brain, and as a memory aid for both teachers and learners.

**6.0 Methodology**

The current study adopted a quantitative research approach which tests "objective theories by examining the relationship between variables" (Creswell, 2009, p. 22). It allowed the researchers to employ strategies such as surveys and experiments to collect data on predetermined instruments. This led to the generation of quantifiable and reliable data that can be generalized to a large population (Lelissa, 2018). The researchers selected a sample of the population and used the sample to make a statement about the entire population. Although quantitative research is limited by the lack of an in-depth assessment of CM (Rahman, 2017), it allowed the researchers to carry out a broader study by involving more subjects (teachers and students) and enabled more generalization of results (Rahman, 2017). In this study, the researchers used both experimental and survey research designs in order to effectively answer the research questions posed in this study and to give the two sets of population the required attention. Experimental research design was adopted in order to ascertain the effect of CM on the performance of the students. This involved having a control and treatment group as suggested by Creswell (2009). To examine the teachers' views on the application of CM in improving the performance of students in mathematics, this study adopted a survey research design in line with the second research question posed in this study. Survey strategy was used to study a fair sample of the population as posited by Creswell (2009), and this sample was in turn used to make conclusions about the entire population. Survey was advantageous because of the economy of the design and the rapid generation of a large amount of data (Creswell, 2009).

The population of this study was students and mathematics teachers in JSS in Kweneng region of Botswana. Botswana was chosen because there is no published study on CM as a strategy for learning not just mathematics but other subjects. So this is a novel study in the Botswana education sector. Junior secondary students were chosen because the researcher is a mathematics teacher at that level of education. In addition to the personal experience of the researcher, students at this level have been reported to struggle with mathematics (Mphale & Mhlauli, 2014; Botale, 2018; BEC, 2019; BEC, 2020; Kereeditse, 2021) which later transmits to poor performance at the senior education level. The sample size consisted of one purposively selected school for the experimental design involving students, and nine randomly selected schools for the survey design involving teachers. The reason for the sample size in the experimental group was because of the limited time allotted for this study which did not allow the researcher to carry out the treatment in more than one school in the district. This was also made difficult by the restriction put in place as a result of the Covid-19 pandemic. To effectively administer treatment as required in the experimental design, the researchers used one school where they effectively monitored the effect of the treatment over time. This was done in total compliance with Covid-19 protocol. Again, the researchers were very certain that CM had not been previously used to teach mathematics in the school that was purposively selected. The researchers enrolled 60 respondents (30 from each class) in the purposively selected school in the experimental design. To prevent contamination of the participants who were in one school, the researchers ensured that each of the two classes selected for this study were not aware that the other class was selected as either the control or treatment group.

For the survey design, nine schools out of the 22 JSS in Kweneng (Ministry of Education and Skills Development, 2020) were selected for this study. The researchers believed that the mathematics teachers in these 10 schools can act as representative of the entire population. This was done in line with the assertion by Leedy and Ormrod (2005) that in a quantitative study, the sample size should adequately represent the population to make the findings generalisable. The sample size selected for this study was adequate when compared to the population of JSS in schools in Kweneng district. Five mathematics teachers in each of the ninerandomly selected JSS were randomly selected in this study to give a total of 45 teachers. This form of sampling helped to reduce bias.

Questionnaires were used in the collection of data in the survey and experimental research designs. Questionnaires are aseries of questions that are vital for making statements about aspecific group or entire population when administered properly (Roopa & Rani, 2012). It helps in the generation of responses to specific questions about knowledge, demographics, and other categories of data (Mcnabb, 2004). Close-ended questionnaires were used to obtain quantitative data from the two sets of respondents. The two questionnaires for the pre-test and post-test in the experimental design contained three sections; the first section was used to obtain the biographic data of the students, the second section contained questions with close-ended answers, while the third section allowed the students to solve given questions and write their own answers. The questions in the questionnaire were picked from a topic that is in the curriculum of the chosen class but has not been taught in the school year. This was done to ensure that no set of participants had an undue advantage over the other. During the treatment period, students in the control group were taught using other methods of teaching, while CM was used to teach students in the treatment group. The questionnaire in the survey design was designed using a four-item Likert scale. Items in the questionnaire were generated using extant literature (Abbas et al., 2018; Baroody & Bartels, 2000; Chin & Norhayati, 2010; Chiou, 2008; Erdem et al., 2009; Hafiz et al., 2017; Hammad et al., 2021; Mutodi, 2016; Woldeamanuel et al., 2020) on the perceived problems and prospects of CM. Strongly disagree was graded one point, disagree was graded two points, agree was graded three points while strongly agree was graded four points.

Content validity was chosen to test the validity of the research instruments. This is because it measures the degree to which the collected data represents a specific domain or content of a particular concept (Mugenda & Mugenda, 2003). To ensure content validity, the researchers ensured that the research instrument covered all the possible aspects of the research topic. This is why he included both students and teachers who are instructional leaders as the participants in this study. Again, the researchers ensured content validity of the research instruments by seeking assistance from experts in the Office of Research and Development (ORD) at the University of Botswana, their supervisors, other lecturers in the Department of Mathematics Education, and peer reviewers. The research instruments were given to these groups and their feedback and comments assisted the researchers to readjust and improve the validity of the instruments. A pilot study was carried out to minimize the influence of prior knowledge of the information required from the respondents in the study, and the results helped the researcher to correct and readjust items that depicted inconsistency or indiscretions (Hassan et al., 2006). The result of the pilot study was used to ascertain the level of correlation between the two sets of scores using Cronbach α. According to Cronbach and Glesser (1957), cited in Taherdoost, 2016), the results of a study are reliable if the value of the coefficient alpha is more than 0.60. In the pilot study, the researcher obtained a Cronbach α of 0.70 and 0.80 in the questionnaires for experimental and survey designs respectively. This showed that they were reliable.

During data collection, the researchers followed laid down ethical standards. The ethical issues that were considered by the researchers include informed consent, honesty, respect for the integrity of the participants, anonymity, confidentiality, and protection from harm (Creswell, 2009). Part of the ethical expectations in the study were met by obtaining an ethical clearance letter from the ORD and seeking appropriate permission from the Education Regional Office in Kweneng, and the gatekeepers of the selected schools. The obtained data were analysed using the SAS (Statistical Analysis System) version 9.4 (2020). MS Excel (version 2108) spreadsheet was used for entry of data. Two-tailed t-test was employed to establish whether the two independent groups, control, and treatment, were significantly different for the pre-test and post-test scores. Both tests used $\alpha = 0.05$ level of significance.

**7.0 Demographic profile of the participants**

The demographic data of the student participants are shown in Table 1. From Table 1 it can be seen that both genders were represented in both the control and treatment groups. In the control group, 43% were males and 57% were female, while in the treatment group 40% were male and 50% were female. This shows that the sample in the experimental design was representative of the female and male gender. The biographic data also shows that majority of the participants were aged between 14-15 years, with 70% of them in the control group and 90% in the treatment group. It was necessary to explore the age of the participants to ensure that a wide difference in age did not give any of the groups an undue advantage over the other. However, all the participants were selected from Form 1 in the same school where they are taught with the same curriculum and by the same set of teachers.

**Table 1:Biographic Data of Student Participants**

| | | Control(n=30) | Treatment(n=30) |
|---|---|---|---|
| Gender | Male | 43% | 40% |
| | Female | 57% | 60% |
| Age | 12-13 | 13% | 10% |
| | 14-15 | 73% | 90% |
| | 16-17 | 13% | 0% |

Teacher participants in the survey design also had the necessary qualifications to provide the data used to answer the research questions. Sample of teachers in this study consisted of 53% male participants and 47% female participants. 78% of the teachers had a diploma while 18% were degree holders. With 89% of the teachers being over 30 years, it shows that the respondents are mature enough to provide the required data for this study. This is because age is an important indicator of one's readiness to play the role of an instructional leader effectively. 84% of the teachers had a teaching experience of at least 6 to 31 years, and this shows that the findings from this study were derived from vastly experienced mathematics teachers. The fact that 89% of the participants were permanently employed shows that the findings of this study aimed at assessing the place of CM in teaching and learning of Mathematics resonate with highly dedicated teachers.

**8.0 Results and Discussion**

**8.1 Effect of Concept Mapping (CM) on student performance in mathematics**

Table 2 shows the control and treatment groups' means for pre-test and post-test scores. For the pre-test scores, thecontrol and treatment groups/scores were not statistically different ($P > 0.05$) whereas for post-test scores the two groups were significantly different ($P < 0.05$). This shows that prior to CM intervention both the control and treatment groups obtained scores that are comparable to each other. However, after teaching the treatment group with CM, it was found that their post-test scores were significantly different, with the treatment group having a higher score than the control group.

**Table 2: Comparison of Control and Treatment group means**

| | Pretest scores (n=30) | | Posttest Scores (n=30) | |
|---|---|---|---|---|
| Group | Mean* | StdErr^ | Mean | Std Err |
| Control | 45.8a | 3.669 | 35.3a | 4.222 |
| Treatment | 43.6a | 2.696 | 48.9b | 2.916 |

* means column with same letter are not significantly different using the t-test (α = 0.05).
^Std Err = Standard error

The findings from the first research question have shown that the use of CM can enhance teaching, learning, and performance of students in mathematics. This is evidenced by the increased mean (48.9) observed in the post-test scores of the treatment group, which is significantly higher than the post-test mean score (35.3) of the control group. This evidence is further strengthened by the fact that there is no significant difference in the mean scores of both the control (45.8) and treatment (43.6) groups in the pre-test scores. These findings agree with Abbas et al. (2018) that there is a statistically significant difference in learners' performance between the control group and the experimental group with higher achievement recorded in the experimental group taught with CM. This shows that CM can act as a tool for improving efficiency in education. It can promote meaningful learning by providing a means for the introduction of new concepts, and for connecting new concepts to previously known concepts (Baroody & Bartels, 2000). Furthermore, CM provides a perfect opportunity for learners to engage in logical reasoning and motivates learners by fostering autonomy. Learners working with concept maps are therefore more successful in developing mathematics skills when compared to learners who did not engage in CM (Polat et al., 2017). As argued by Brinkmann (2003), CM gives learners the opportunity to implement many skills such as counting, establishing cause-effect relationships, detailing, and spatial awareness. In line with the constructivist theory, students must be engaged in the learning process to facilitate retention (Qian, 2011). In this study CM allowed the construction of knowledge by interacting with previous knowledge, beliefs, and intuitions. However, the findings from this study contrast with Trehan (2015) who states that CM had no effect on the ability of learners to solve numeric problems.

Findings of the current study supports the argument raised by Alkilany (2017) that CM, in addition to aiding in the teaching of mathematics, also enhances the creativity of students. During this study the researchers observed that learners were more creative, excited, willing and eager to learn using CM. This could be why majority of the learners in the treatment group completed their post-test assignments faster than learners in the control group. This also shows that concept maps can engender understanding, irradiate how students connect and organize concepts, and identify misconceptions and difficulties in understanding the subject matter (Hasemann & Mansfield, 1995). This study has thus shown that CM does not only influence the ability of teachers to deliver their lessons effectively, but also impacts the performance of students in mathematics. The study also supports the argument raised by several authors (Alzahrani et al., 2017; Gagic et al., 2019; Toropova et al., 2019; Zimmarro & Cawley, 1998) that teaching strategies and performance in mathematics are interconnected. In line with the constructivist theory, CM was able to encourage students to build more knowledge, reflect on the new knowledge, and talk about how their understanding is changing (Tanriseven, 2014).

### 8.2Teachers' Views on the use of CM in teaching and learning

To ascertain the views of teachers on the impact of CM in teaching, learning and student performance, a 10-item questionnaire was given to the teacher participants. The findings are presented in Table 3.

**Table 3:Teachers' Views on the use of Concept Mapping in mathematics instruction**

| S/no | Items | Frequency (%) (n=45) | | | |
|---|---|---|---|---|---|
| | | SA | A | D | SD |
| 1 | I understand concept mapping and what it entails. | 53.3 | 15.6 | 20.0 | 11.1 |
| 2 | Concept mapping is a strategy for teaching. | 46.7 | 26.7 | 20.0 | 6.7 |
| 3 | Concept mapping is a strategy for learning. | 51.1 | 24.4 | 17.8 | 6.7 |
| 4 | I apply/would apply concept mapping in teaching & learning of mathematics. | 33.3 | 17.8 | 33.3 | 15.6 |
| 5 | Concept mapping can improve the performance of students in mathematics. | 46.7 | 22.2 | 20.0 | 11.1 |
| 6 | Concept mapping is suitable for lesson planning. | 26.7 | 22.2 | 40.0 | 11.1 |
| 7 | Concept mapping could be used for students' assessment | 48.9 | 15.6 | 28.9 | 6.7 |
| 8 | Concept mapping could be used to monitor students' progress in the classroom. | 42.2 | 31.1 | 17.8 | 8.9 |
| 9 | Concept mapping should be made a compulsory strategy for teaching and learning of mathematics. | 22.2 | 57.8 | 15.6 | 4.4 |
| 10 | I need training to be able to use concept mapping effectively. | 31.1 | 68.9 | 0.0 | 0.0 |

As can be observed from Table 3, on the first item in the questionnaire, 53% and 15.6% strongly agreed and agreed that they understand CM and what it entails, while 20% and 11.1% disagreed and strongly disagreed respectively. In the case of CM as a strategy for teaching, 46.7% strongly agreed, 26.7% agreed, 20% disagreed and 6.7% strongly disagreed. When asked about concept mapping as a strategy for learning 51.1% strongly agreed, 24.4% agreed, 17.8% disagreed and 6.7% strongly disagreed. In the third item, participants were asked if CM can improve the performance of students in mathematics and 46% strongly agreed, 22.2% agreed, 20% disagreed and 11.1% strongly disagreed.

On the use of CM for students' assessment as reflected in item seven on Table 3, 48.9% strongly agreed, 15.6% agreed, 28.9% disagreed, and 6.7% strongly disagreed. When asked if CM could be used to monitor students' progress in the classroom, 42.2% of the teachers strongly agreed, 31.1% agreed, 17.8% disagreed and 8.9% strongly disagreed. Exactly 22.2% of the teachers strongly agreed, 57.8% agreed, 15.6% disagreed and 4.4% strongly disagreed that CM should be made a compulsory strategy for teaching and learning mathematics. For item ten, 31.1% strongly agreed while 68.9% agreed that they need training to be able to use

CM effectively in the teaching and learning of mathematics. None of the participants disagreed or strongly disagreed with this item. In item 4, teachers were asked if they apply CM as a strategy for teaching and learning mathematics, 33.3% strongly agreed, 17.8% agreed, 33.3% disagreed and 15.6% strongly disagreed. Similarly in item 6, when asked if CM is suitable for lesson planning 26.7% strongly agreed, 22.2% agreed, 40% disagreed and 11.1% strongly disagreed. These findings are discussed in relation to the extant literature in the following section.

CM is a potent tool for visual presentation of new ideas which is known to help learners build conceptual understanding of learning subject content thereby promoting better understanding of that content (Jbeili, 2013). To use CM effectively, one must be adequately equipped for its use. Findings from this study have shown that majority (68.9%) of the teachers understand CM and what it entails, while a smaller number of the teachers (31.1%) argue for the reverse. Although the majority of the teachers understand CM, the remaining 31.1% cannot be ignored. The concern raised by 31.1% that they lack understanding of CM is exacerbated by the number of teachers (100%) who gave credence to the fact that they need training to be able to use CM effectively in the classroom. This shows that the respondents may not fully understand CM and what it entails. It is therefore necessary to train teachers so that they can apply CM as a teaching tool in the classroom. This is because CM visualizes important concepts, facts, and relationships, contributes to construction of knowledge, helps in communication and negotiation of meaning, and helps in the innovation of ideas (Wang, 2019). CM may not be effective if instructional leaders are not brought up to speed on its use. This argument is in agreement with Brinkmann (2003) who is of the opinion that although CM takes time to construct, one has to be familiar with the tool before making use of it. Training of mathematics teachers could be one of those ways of making them familiar with the tool. In agreement, Novak and Cañas (2006) argue that although concept maps may appear as just a graphic representation of information, understanding the foundations for this tool and its proper use shows that it is a profound and powerful tool for teaching and learning. Adequate mastery of the tool does not just help in the organization of knowledge, but it also helps in promoting learning (Brinkmann, 2003).

Despite supporting the notion that CM can be applied in teaching (73.4%) and learning (75.5%), the respondents are indifferent on whether they apply CM in teaching and learning of mathematics. Whilst 51.1% argued that they apply CM in teaching and learning, 48.9% argued for the reverse. When tested statistically, it was observed that there is no significant difference ($P > 0.05$) in the response of the respondents. The argument raised by 51.1% of the respondents supports the views by Devcic et al. (2011) and Katagall et al. (2015) that CM is a strategy for improving teaching and learning. This argument is however nullified by 48.9% of the respondents, a number that is not significantly different from those that argued that they apply CM in teaching and learning. This is a cause for concern since CM is not just a useful and practical tool for teaching mathematics; it also aides in organizing knowledge, enhancing retention, enhancing recalling of concepts learnt (Mutodi, 2016), and in making learners to be active rather than passive as proposed in the constructivist theory (Nousiainen, 2012). This is also supported by findings from this study which show that when learners are properly taught with CM, there is improvement in their performance in mathematics. It is however encouraging that majority of the teachers argue that CM can improve performance of students in mathematics (68.9%). This could be because CM is capable of improving higher order cognition (Awofala, 2011). It is therefore not surprising that 80% of teachers are of the view that CM should be made a compulsory strategy for teaching and learning mathematics in Botswana. However, the 31.1% that argued that CM does not improve performance of learners also points to the need to train teachers on the use of CM in teaching and learning.

CM can effectively act as a tool for monitoring, assessing, and improving the understanding of mathematical concepts (Hammad et al.,2021). This assertion resonates in this study where 64.5% and 73.3% of the teachers argue that CM can be used for assessment and to monitor students' progress respectively. In agreement with these findings, Barolos (2002) opines that CM could serve as a possible supplementary tool for students' evaluation in mathematics, while Mutodi (2016) confirms the applicability of CM in providing feedback on the understanding of a new concept, and further argues that teachers should use CM in formative assessment process. Teachers aiming to impart knowledge should therefore incorporate CM in the formative assessment of their learners (Liu & Wang, 2010). The tool is especially more effective when its use is followed up by discussions that encourage students to talk about their maps and the links they have made (Hammad et al., 2021).

Lessons planned using CM have higher quality with few sequencing errors (Martin, 1994). This is because it helps teachers to strategically organize their conceptual analysis into a meaningful manner that illustrates interconnectedness between key and subsidiary concepts during pedagogical planning (Afamasaga-Fuata'i, 2009). Despite these obvious applications of CM in lesson planning, findings from this study show that there is no significant difference between teachers that argued that CM should be applied in lesson planning (48.9%) and those that do not (51.1%). In fact, more teachers argued that CM cannot be applied in lesson planning. This further shows that mathematics teachers in Botswana may not be fully equipped with the rudiments of CM and its applicability. Hence the need to train teachers on the use of CM to categorize, link and organize concepts while planning and delivering lessons (Lim et al., 2003).

**9.0 Conclusion**

This study explored the use of CM as a tool for improving the performance of students in mathematics. Based on quantitative research approach underpinned by the positivist paradigm and the constructivist learning theory, the study adopted two research designs: the experimental design which ascertained the impact of CM on students' performance, and the survey design that explored the views of the teachers on the use of CM. The major findings from the experimental design were that CM had the potential to positively impact learning outcomes in mathematics. The findings from the survey designs showed that teachers appreciated the use of CM in various areas of teaching and learning but they require training in order to maximize the full potential of the teaching strategy. This shows the need to organize training programs for teachers on the use of CM and to incorporate the strategy in the curriculum of educational institutions that train pre-service and in-service teachers. This will make the strategy to be embraced by all and sundry in the Botswana education sector.

**References**

Alzahrani, A., Stojanovski, E., & Howley, P. (2017). Assessment of teaching practices on mathematics for students in Qatar. *Proceedings of the Satellite conference of the International Association for Statistical Education (IASE).* iase-web.org/Conference_Proceedings.php

Abbas, S., Eldin, S., & Elsayed, A. (2018). The effect of concept mapping and mind mapping utilization on students' understanding level: An empirical study. *Proceedings of the 8th International Conference on Concept Mapping, Medellín,* Colombia. http://cmc.ihmc.us/cmc2018Papers/cmc2018-p77.pdf

Afamasaga-Fuata'i, K. (2009). Concept mapping a teaching sequence and lesson plan for "derivatives". In K. Afamasaga-Fuata'i (Ed.), *Concept mapping in Mathematics* (pp. 149-169). DOI:10.1007/978-0-387-89194-1_8

Alkilany, A. (2017). The impact of using conceptual maps on the development of creative thinking of students. *Information and Knowledge Management*, *7*(6), 54-60.

Awofala, A. O. A. (2011). Effect of Concept Mapping Strategy on Students' Achievement in Junior Secondary School Mathematics. *International Journal of Mathematics Trends and Technology,2(3),* 11-16.

Baroody, A. J., & Bartels, B. H. (2000). Using concept maps to link mathematical ideas. *Mathematics Teaching in the Middle School, 5*(9), 604-609.

Barolos, G. (2002). Concept mapping as evaluation tool in mathematics. *Proceedings of the 2nd International Conference on the Teaching of Mathematics, Crete, Greece.* http://www.math.uoc.gr/~ictm2/Proceedings/pap451.pdf

Battino, R. (1992). On the importance of rote learning. *Journal of Chemical Education, 69* (2), 135. DOI: 10.1021/ed069p135.

Blackwell, S., & Pepper, K. (2008). The effect of concept mapping on pre-service teachers' reflective practices when making pedagogical decisions. *The Journal of Effective Teaching, 8* (2), 77-93.

Boikhutso, K., & Molosiwa, A. (2019). Improving quality education in Botswana schools: An "illusion" and "elusive"pursuit. *Mosenodi Journal, 22* (1). https://journals.ub.bw /index.php/mosenodi/article/view/1591

Botale, E. (2018). Financing secondary education under fiscal stress in Botswana. *Africa Education Review*, *2*(4), 647-663.

Botswana Examination Council. (2017). *Summary of result.* Botswana Examination Council. http://www.bec.bw.

Botswana Examinations Council. (2019). *2019 report of provisional results.*Botswana Examination Council. http://www.bec.co.bw/results/results-summary-psle-jce-bgcse/jce-results-summary/2019-jce-report-of-provisional-results

Botswana Examination Council. (2020). *Summary of results.* Botswana Examination Council. http://www.bec.bw.

Brinkmann, A. (2003). Graphical knowledge display – mind mapping and concept mapping as efficient tools in mathematics education. *Mathematics Education Review, 16*, 39-48.

Chin, S. F., & Norhayati, M. (2010). Teacher-centered mind mapping vs student-centered mind mapping in the teaching of accounting at pre-u level – an action research. *Procedia-Social and Behavioral Science, 7*, 240-246. https://doi.org/10.1016/j.sbspro.2010.10.034

Chiou, C. (2008). The effect of concept mapping on students' learning achievements and interests. *Innovations in Education and Teaching International*, *45*(4), 375-387. https://doi.org/10.1080/14703290802377240

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). SAGE Publications, Inc.

Devcic, M. J., Topolovec, V., & Mrkonjić, I., (2011). Concept maps in mathematics teaching, learning and knowledge assessment. *International conference EDUvision 2011, modern approaches to teaching the coming generation, Lugbljana, Slovenia*. https://www.researchgate.net/publication/325386687

Ellis, G. W., Rudnitsky, A., & Silverstein, B. (2004). Using concept maps to enhance understanding in engineering education. *International Journal of Engineering Education*, *20*(6), 1012-1021.

Erdem, E., Yilmaz, A., & Oskay, O. O. (2009). The effect of concept mapping on meaningful learning of Atom and bonding. *Procedia Social and Behavioral Sciences, 1,* 1586-1590. doi:10.1016/j.sbspro.2009.01.279

Ertmer, P.A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: comparing critical features from instructional design perspectives. *Performance improvement quarterly, 26*(2),43-71.

Fourrie, J. M., & Machaba, F. (2019). Exploring mathematics learners' conceptual understanding of coordinates and transformation geometry through concept mapping, *Eurasia Journal of Mathematics, Science and Technology Education, 15*(12), 1-16. DOI:10.29333/ejmste/110784

Gagić, Z., Skuban, F., & Stojanović, O. (2019). The implementation of mind maps in teaching physics: Educational efficiency and students' involvement. *Journal of Baltic Education Science Education, 18*(1),117-131.

Güliz, A., & Ali, G.B. (2009). Technologically-supported mind and concept maps prepared by students on the subjects of the unit "systems in our body". P*rocedia- Social and Behavioral Sciences, 1*(1),2838-2842.http://dx.doi.org/10.1016/j.sbspro.2009.01.505

Hafiz, M., Kadir, Fatra M. (2017). Concept mapping learning strategy to enhance students' mathematical connection ability. *AIP Conference Proceedings1848,* 040006.doi: 10.1063/1.4983944

Hammad, S., Dimitriadis, C. & Graham, T. (2021). Using Concepts Maps in a Foundation Mathematics Course: What Have we Learnt? EURASIA Journal of Mathematics, Science and Technology Education, 17(2), em194. https://doi.org/10.29333 /ejmste/9700

Hasemann, K., & Mansfield, H. (1995). Concept mapping in research on mathematical knowledge development: background, methods, findings and conclusions. *Educational Studies in Mathematics, 29*, 45–72. https://doi.org/10.1007/BF01273900

Hassan, A. Z., Schattner, P., & Mazza, D. (2006). Doing a pilot study. *Malays fam Physician, 1*(1-3), 70-73.

Hyerle, D. (1996). *Visual tools for constructing knowledge.* Association for Supervision and Curriculum Development.

Jbeili, M. (2013). The impact of digital mind maps on science achievement among sixth grade students in Saudi Arabia. *Social and Behavioral Sciences,103*, 1078 – 1087.

Joynes, C., Rossignoli, S, & Amonoo-Kuofi, E. F. (2019). *21st century skills: evidence of issues in definition, demand and delivery for development contexts (k4d helpdesk report).* Institute of Development Studies.

Katagall, R., Dadde, R., Goudar, R. H., & Rao, S. (2015). Concept mapping in education and semantic knowledge representation: An illustrative survey. *Procedia Computer Science, 48,* 638 – 643. doi: 10.1016/j.procs.2015.04.146

Kazemi, E. (2001). Learning to teach mathematics: focus on students thinking. *Theory into Practice, 40*(2),102-109. http://dx.doi.org/10.1207/s15430421tip4002_4

Kereeditse, M. (2021). Evaluation of strengthening of mathematics and science in secondary education (SMASSE) program in Botswana using the CIPP model. *Mosenodi Journal, 24*(1), 21-41.

Kgosikebatho, K. (2013). *Experts pinpoint causes of poor results*. The Patriot. www.thepatriotonsunday.co.bw/experts-pinpoint-causes-of-poor-results.

Kibe,S., Odhiambo, J.,&Ogwel, A. (2008). Impact of SMASSE INSET on students' capacity through improved teaching and learning in the classrooms. *Proceedings of the8th Regional conference for SMASSE WECSA, Nairobi.*

Kimani, G. N., Kara, A. M., & Njagi, L. W. (2013). Teachers’ factors influencing students’ academic achievement in secondary schools in Nyandarua County, Kenya. *International Journal of Education and Research, 1*(3), *1-7.*

Lamy, M., & Steve, M. (2016), Why students are motivated to learn maths. *PISA 2012: Series on Learners, 3*, 10-20.

Lee, W., Chiang, C., Liao, I., Lee, M., Chen, S., & Liang, T. (2013). The longitudinal effect of concept map teaching on critical thinking of nursing students. *Nurse Educ. Today, 33*, 1219–1223.

Leedy, P. D., & Ormrod, J. E. (2005). *Practical research: Planning and design* (8th ed.). Prentice Hall.

Lelissa, T. B. (2018). *Research Methodology* [Doctoral thesis, University of South Africa]. DOI:10.13140/RG.2.2.21467.62242

Lim, S. E., Cheng, P. W. C., Lam, M. S., & Ngan, S. F. (2003). Developing reflective and thinking skills by means of semantic mapping strategies in kindergarten teacher education. *Early Child Development and Care, 173* (1), 55-72.

Liu, Y., Ma, G., Yuwei, B., & Zhao, G. (2014). The effect of mind mapping on teaching and learning: a meta-analysis. *Standard Journal of Education and Essay, 2*(1), 017–031.

Liu, M., & Wang, J. (2010). Investigating knowledge integration in web-based thematic learning using concept mapping assessment. *Journal of Educational Technology & Society*, *13*(2), 25–39. http://www.jstor.org/stable/jeductechsoci.13.2.25

Makwinja, V. M. (2017). Rethinking education in Botswana: A need to overhaul the Botswana education system. *Journal of International Education Research, 13*(2), 45-48.

Martin, D. J. (1994). Concept mapping as an AID to lesson planning: A Longitudinal Study. *Journal of Elementary Science Education*, *6*(11).https://doi.org/10.1007/BF03173755

McNabb, D. (2004). *Research methods for political science: Quantitative and qualitative methods*. M.E. Sharpe.

Monyatsi, P. P. (2001). *An investigation of the effectiveness of the current teacher appraisal system as practiced in Botswana secondary schools* [UnpublishedDoctoral thesis]. University of South Africa.

Mphale, L. M., & Mhlauli, M. B. (2014). An investigation on students' academic performance for junior secondary schools in Botswana. *European Journal of Educational Research*, *3*(3), 111-127.

Mullis, I.V.S., Martin, M. O., Goh, S., & Cotter, K. (2016). *TIMSS 2015 encyclopedia: Education policy and curriculum in mathematics and science*. Boston College, TIMSS & PIRLS International Study Center. http://timssandpirls.bc.edu /timss2015/encyclopedia/

Mugenda, O. M., & Mugenda, A. G. (2003). *Research methods; quantitative and qualitative approaches.* Africa Center for Technology (ACTS).

Mutodi, P. (2016). Concept map as an assessment tool in secondary school mathematics: An analysis of teachers' perspectives. *Eurasia Journal of Mathematics, Science and Technology Education*. DOI: 10.12973/eurasia.2016.2301a.

Nousiainen, M. (2012). Making concept maps useful for physics teacher education: Analysis of epistemic content of links. *Journal of Baltic Science Education*, *11*(1), 29-42.

Novak, J. D., & Cañas, A. J. (2006). The origins of the concept mapping tool and the continuing evolution of the tool. *Information Visualization Journal*, *5*(3), 175-184.

Okoye, N. S., & Okechukwu, R. N. (2006). The effect of concept mapping and problem-solving teaching strategies on achievement in genetics among Nigerian secondary school students. *African Journal of Educational Studies in Mathematics and Sciences, 4*, 93-98. https://doi.org/10.4314/ajesms.v4i1.38626

Panthi, K. R. & Belbase, S. (2017). *Teaching and learning issues in mathematics in the contextof Nepal*. https://files.eric.ed.gov/fulltext/ED573754.pdf

Polat, O., Yavuz, E. A., & Tunz, A. B. O. (2017). The effect of using mind maps on the development of mathematics & science skills. *Cypriot Journal of Educational Science, 12*(5), 32-45.

Qian, G. (2011). Teaching, learning and retention of statistical ideas in introductory statistics education. *European Journal of Pure and Applied Mathematics, 4*(2), 103-116.

Rahman, S. M. (2017). The advantages and disadvantages of using qualitative and quantitativeapproaches and methods in language "testing and assessment" research: a literature review. *Journal of Education and Learning, 6*(1),102-112. doi:10.5539/jel.v6n1p102

Rockstroh, A. H. (2013). *Teacher characteristics on student achievement: An examination of high schools in Ohio.* MPA/MPPCapstone Projects 49. https://uknowledge.uky.edu/mpampp_etds/49

Roopa, S.,& Rani, M. S. (2012). Questionnaire designing for a survey. *The Journal of Indian Orthodontic Society, 46*(4), 37-41. DOI:10.5005/jp-journals-10021-1104.

Salani, E. (2019). Students' SMASSE approaches beliefs: activity based learning in the mathematics and science classroom. *International Journal of Humanities Social Sciences and Education, 6*(12), 153-164. https://dx.doi.org/10.20431/2349-0381.0612014

Schmittau, J. (2004). Uses of concept mapping in teacher education in mathematics. *Proceedings of the First International Conference on Concept Mapping, Pamplona, Spain.*Citeseerx. https://citeseerx.ist.psu.edu/viewdoc/download ?doi=10.1.1.469 .9887&rep=rep1&type=pdf

Singh, I. S. (2015). The Effect of using concept maps on student achievement in selected topics in chemistry at tertiary level. *Journal of Education and Practice*, *6*(15), 106-116.

Tabulawa, R., J. (2009). Education reform in Botswana: reflections on policy contradictions and paradoxes article. *Comparative Education· Journal of Education and Practice, 45*(1), 87-107. https://doi.org/10.1080/03050060802661410

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *SSRN Electronic Journal*, *5*(2), 18-27. DOI: 10.2139/ssrn.3205035

Tam, M. (2000). Constructivism, instructional design, and technology: implications for transforming distance learning. *Educational Technology & Society, 3*(2), *50-60.*

Tanriseven, I. (2014). A tool that can be effective in the self-regulated learning of pre-service teachers: the mind map. *Australian Journal of Teacher Education*, *39*(1), 65-80. http://dx.doi.org/10.14221/ajte.2014v39n1.1

Trehan, D. M. (2015). *The impact of concept mapping as a learning tool on student perceptions of and experiences with introductory statistics* [Unpublished Doctoral Thesis]. Kent State University College of Education, Health, and Human Services.

Toropova, A., Johansson, S., & Myrberg, E. (2019). The role of teacher characteristics for student achievement in mathematics and student perceptions of instructional quality. E*ducation Inquiry*, *10*(4),275-299. doi: 10.1080/20004508.2019.1591844.

Vanides, J., Yin, Y., Tomita, M., & Ruiz-Primo, M. A. (2005). Concept maps. *Science Scope*, *28*(8), 27-31.

Williams, J. (2015) Essentials of business research: A guide to doing your research project. *SAGE Publications*, *3*(4), 7.

Woldeamanuel, W. Y., Abate, N. T. & Berhane, E. D. (2020). Effectiveness of concept mapping based teaching methods on grade eight students' conceptual understanding of photosynthesis at EwketFana primary school, Bahir Dar, Ethiopia. *EURASIA Journal of Mathematics, Science and Technology Education*, *16*(12),1-16. https://doi.org/10.29333/ejmste/9276

Wood, K. C., Smith, H., & Grossniklaus, D. (2001). Piaget's stages of cognitive development. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*.http://epltt.coe.uga.edu/index.php?title=Piaget%27s_Stages

Woolfolk, A. (2001). *Educational psychology (8th ed.).* Pearson Education Company.

World Bank (2014). *Improving the Quality of basic education and skills development in Botswana*. World Bank. https://www.worldbank.org/en/news/feature/2014 /12/02/improving-the-quality-of-basic-education-and-skills-development-in-botswana#:~:text=Botswana%20is%20currently%20faced%20with,a%20shortage%20of%20skilled%20labor.

Zahi, M. (2019). Effect of reflective teaching practices on the performance of prospective teachers. *The Turkish Online Journal of Educational Technology*, *18*(1), 32-43.

Zhou, M. & Brown, D. (2017). *Educational learning theories.*Galileo. https://oer.galileo.usg .edu/cgi/viewcontent.cgi?article=1000&context=education-textbooks

Zimmaro, D. M., & Cawley, J. M. (1998).Concept map module [Online]. Schreyer Institute for Innovation in Learning. The Pennsylvania State University.