The effects of concept mapping on primary school learners' achievement in Natural Science in Windhoek, Khomas Region, Namibia

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Abstract

The study investigated the effects of concept mapping on achievement among the Grade six learners in Natural Science. The study was conducted with 31 learners at Alpha Primary School and 34 learners at Omega Primary School. A quantitative approach in which the quasi-experimental design pre-test and post-test were used in order to find out the difference in learners' understanding of "matter and its properties" when taught through concept mapping and traditional lecture methods. All learners were given the same pre-test on matter and its properties after which the experimental group was taught the content using the concept mapping method and the control group was taught using the traditional lecture method. The same post-test was administered to both groups. Both the pre-test and post-test and interventions were constructed, conducted and presented by the researcher. All learners were given the same pre-test to write on the first day of conducting the research at each school followed by the interventions for two weeks and then the same post-test on the last day of conducting the research. Each test had 22 items. The scores on both tests were analysed using SPSS data analysis.

The findings revealed that learners taught through concept mapping out-performed those who were taught through the traditional lecture method. The concept mapping group mean scores on the pre-test and post-test were 33.97 and 47.32 respectively, while the traditional lecture group had 20.29 and 27.94. This indicated a significant difference in the performance of the experimental group at 0.05 significant level and proved that concept mapping improves learners' achievements in Natural Science. The study recommended that the use of concept mapping should be extended to other subject areas in order to enhance effective teaching and learning. And further research on concept mapping should be carried out on the implementation and application of concept mapping strategy in all science subjects including mathematics.

Keywords: *concept mapping, conceptual understanding, science, science teaching, scientific concepts, traditional lecture*

Introduction

The difficulty of teaching and learning in science is not unique to African countries but manifests itself in Western countries too, such as the United States of America (Ottevanger, van den Akker, & de Feiter, 2007). In Namibia, most teachers seem to focus on using the lecture method of teaching rather than new and innovative methods of teaching (Amoonga & Kasanda, 2011; Kapenda, Kandjeo-Marenga, & Kasanda, 2002). Kasanda (2005) conducted a study on problems that prevent effective development of the teaching of mathematics and science education in Namibia and Zambia in primary and secondary schools. The study found that teachers concentrated on teaching rules more than employing innovative teaching strategies in teaching science content. Amoonga and Kasanda (2011) also found that teachers in Namibian schools prefer to use the lecture method. The lecture method is not only used by Namibian teachers, but globally (Mwakapenda, 2006; Safdar, Hussain, Shah, & Rifat, 2012). Lubben, Kasanda, Gaoseb, Kandjeo-Marenga, Kapenda, and Campbell (2005) also found that the lecture method was preferred by many teachers since many teachers think that the lecture strategy could contribute to rote learning and, thus, high retention of subject content by most learners and consequently high performance in examinations. There is therefore a need to use innovative teaching strategies such as "concept mapping" in teaching and learning science concepts rather than the lecture method in order to nurture learners' scientific skills and understanding.

Notably, concept mapping is regarded as the most constructive teaching and learning method in developed and developing countries such as Finland (Hyvonen, 2011) and South Africa (Titus, 2013). In light of this, it is obvious that concept mapping has many positive effects on learners and teachers, as this method fosters meaningful learning instead of rote learning (Beigzadeh & Haghani, 2015) and has noticeable positive impacts on learners. In addition, concept mapping method provides learners with opportunities to operate at the main domains of learning.

Literature review

What is concept mapping?

Concept mapping is a teaching and learning tool derived from Ausubel's learning theory which is used to help learners explain and generate individual understanding about certain concepts (Novak, 1990; Novak & Canas, 2008). According to Prediger (2008), cross-links or relationships between concepts in different domains of the concept map, for example, events or objects help learners to understand relationships amongst given concepts. The process of teaching and learning by using concept mapping, gives learners a structured space in which to reflect upon a specific theme and topic, that is "matter and its properties" (Elizabeth, 2013) and to scientifically clarify their ideas on that theme and topic. According to Vitale and Romance (1992), mastery of core science concepts could assist learners to improve in understanding and learning science. Elizabeth (2013) notes that concept mapping teaching strategy gives learners a clear understanding on how science concepts are inter-linked when learning through concept mapping rather than given the traditional lecture.

In addition, a concept map is a "graphical representation of the relationship among terms" (Vanides, Yin, Tomita, & Ruiz-Primo, 2005, p. 27). Canas & Novak (2009) and Vanides et al. (2005) define concept mapping as a graphical tool for organising and representing science concepts. In other words, learners tend to learn and perceive science concepts from concept maps in a visual manner that enables them to organise, remember, represent and recognise scientific concepts reasonably well. This means that specific concepts in concept mapping are connected together by arrows labelled with short phrases that describe the relationship between the two connected concepts. These connected concepts could be read as a sentence to describe the connection and relationship between these concepts. Ebenezer and Conner (cited in Safdar, Hussain, Shah, & Rifat, 2012) state that a concept mapping is a "semantic network showing the relationships among concepts in a hierarchical fashion" (p. 57). When concepts are written in a hierarchical approach, learners tend to remember them easily than when written in text format and that concepts in semantic network help learners and teachers to organise their thoughts and ideas in an orderly way.

Generally, teachers might use the concept mapping strategy in teaching science concepts for different reasons. Some teachers tend to use it in order to determine the nature of learners' existing ideas on what they already know and what they need to be taught (Asan, 2007). Other teachers use concept maps in order to provide learners with opportunities to operate at all six levels of Bloom's educational objectives of the cognitive domain (Safdar et al., 2012). Thus, allowing learners to engage with the subject matter at all levels of the cognitive domain. For example, Vanides, Yin, Tomita, and Ruiz-Primo (2005) conducted a study on using concept maps in the science classroom. They found that the concept mapping strategy provides learners with opportunities to:

- discover the connections between the science concepts;
- organise their thoughts in making sense of the science concepts;
- visualise the relationships between key concepts in a systematic way in learning science concepts;
- reflect on what they have learned in constructing meaning; and
- show their understanding of science concepts by illustrating what they have

learned in visual concept mapping (Vanides et al., p. 28).

It is, for the aforementioned reasons that teachers tend to use the concept mapping strategy in order to allow learners to discover the connections between the science concepts first and in so doing be able to understand the science concepts in a manner which is easy (Mwakapenda & Adler, 2003). For example, it becomes important for learners to connect and link concepts by using new linking words such as "formed by", "can be changed to", "taken up by", "released from" in order to construct new understanding about the science concepts learners are taught (Asan, 2007). Moreover, such an exercise is used to determine the nature of learners' existing knowledge and the acquisition of the taught concepts.

Despite the positive contributions earlier discussed, the use of the concept mapping strategy seems to have challenges too. Learners seem to experience many challenges when they are not properly introduced to how to use and/or present science concepts in a concept map hierarchy. Mwakapenda (2004) stated that learners may experience some challenges even if they were taught specific concepts, for example, some learners may not have understood the content well enough in order to be able to communicate the knowledge gained. In this case, the concept mapping strategy might prevent learners from meaningful learning or give learners an opportunity to understand science concepts as well as to critically and freely reflect on relationships between science concepts or ideas. Chiou (2008) conducted a study on the effect of the concept mapping strategy on the Taiwan University students' learning, achievements and interests and found that nearly half of the students could not quickly adapt to the concept mapping strategy. Furthermore, it was indicated that a lack of familiarity with concept mapping technique could be frustrating and that the training of learners to use the concept mapping learning strategy can be tiresome and time-consuming.

Several studies have been conducted in the Namibian context in the field of science education on characteristics of practical work in science classrooms; post colonialism and globalisation in science education; the role of everyday contexts in learner-centred teaching; and the use of constructivism in teaching mathematics for understanding (Amoonga & Kasanda, 2011; Kapenda et al., 2002; Kasanda, 2005; Lubben, Kasanda, Gaoseb, Kandjeo-Marenga, Kapenda, & Campbell, 2005). Thus far, no study seems to have been conducted in Namibia on the uses of innovative teaching strategies such as the concept mapping strategy in teaching science.

Research problem

Concept mapping is one of the new innovation teaching strategies in teaching science subjects in schools. Although some studies (Amoonga & Kasanda, 2011; Asan, 2007; Lubben et al., 2005; Mwakapenda, 2006) consider the concept mapping teaching strategy to be an effective teaching strategy, not many teachers seem to be equipped in using this strategy during instruction (Crawford, 2007; Grosser, 2007).

In Namibia, the application of concept mapping in teaching is still a new teaching strategy and teachers are not well equipped to use it (Amoonga & Kasanda, 2011; Kapenda et al., 2002; Lubben et al., 2005). Therefore, Namibian science teachers seem to experience some problems, particularly in classrooms. It is also a new teaching strategy and teachers are not familiar with it. It seems to take time for teachers to shift from their usual lecture method to the concept mapping strategy and this shift might frustrate some teachers. If teachers are frustrated, then, they might not motivate learners for deeper and meaningful learning to take place. It is also possible that teachers may also find it difficult to get information on how to use concept mapping as compared to the lecture teaching strategy. Therefore, this study aimed at examining the effects of concept mapping by assessing Grade 6 learners' understanding of the concept of "matter and its properties" taught through the concept mapping method as compared to the traditional lecture method.

Research question

The following is the main research question of the study:

1. What are the effects of concept mapping on understanding the concept of "matter and its properties" among Grade six learners in Khomas Region?

Hypothesis of the study

The following hypothesis was tested.

- **H_0:** There is no significant difference between the achievement scores of the Grade six learners who are taught "matter and its properties" using concept mapping method and those taught using the traditional lecture method.
- **H_1:** There is a significant difference between the achievement scores of the Grade six learners who are exposed to concept mapping on "matter and its properties" and those taught using the traditional lecture method.

Methodology

Research design

A quasi-experimental design was used to collect numerical data in order to find out whether concept mapping could be used to enhance learners' understanding. Learners at Omega Primary School were taught "matter and it's properties" using the concept mapping method while learners at Alpha Primary School were taught the same content using the traditional lecture method. A pre-test was administered to the two groups at the onset of the study, and after the treatment, the same post-test was administered to them. This means that the same pre-test was written by all learners on the first day of conducting the research at each school followed by the interventions for two weeks and then the same post-test on the last day of conducting the research. Both the pre-test and post-test and interventions were constructed, conducted and presented by the researcher.

Population

The targeted population of this study consisted of forty-five (45) public senior primary schools offering Natural Science with one hundred and seventy-one (171) Grade 7 classes and five thousand one hundred and thirty (5130) learners in the Khomas region.

Sampling

A random sampling was used to select the two schools from the population. The two targeted schools were given pseudonym names as Alpha Primary School and Omega Primary School with a class of 31 and 34 learners respectively. At each school, one Grade six Natural Science class was randomly selected to participate in the study.

The researcher used the following criteria to select the schools: (a) the schools were not be adjacent to one another in order to reduce the possibilities of learners communicating to one another about how the teacher was instructing them and, thus, contaminating the data; (b) the schools were to be in the same circuit within the selected educational region; (c) the schools had to have internet connections to enable learners to access information as part of teaching and learning aids; and (d) the schools had to have a resourced library.

Research instruments

The pre-test and post-test were used to collect data from the learners in order to assess their understanding of science concepts on "matter and its properties". The researcher gave these research instruments to his colleagues at work and two Senior Education Officers for Natural Science and Health Education to check the appropriateness and suitability of the items in order to maintain an audit trail for transparency (Newman, Lim, & Pineda, 2013). Learners at Alpha Primary School and Omega Primary School were pre-tested, followed by two weeks of instruction. The experimental class was taught the content using concept mapping method and the control class was taught the same content using the traditional lecture method. The instructions were then followed by a post-test. The pre-test and post-test questions were same and focused on evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy.

These 11 science concepts were used for both tests. The test questions were structured in such a way that they focused on the same concept for both the pre-test and post-test. Two types of lessons were prepared each day in advance, one as a traditional lecture and the other lesson involved the use of concept mapping method. The traditional lectures were offered at Alpha Primary School (control) while the concept mapping lessons were offered at Omega Primary School (experimental). During the treatment, learners were exposed to concept mapping on which they were taught and wrote the summaries using concept mapping.

Data analysis

The paired samples t-test (at significant level of 0.05) was used to measure the groups' performance on the pre-test and post-test separately; and also to compare the two groups' mean scores on the post-test to know whether there was a difference in their mean scores and whether the treatment administered was effective. The *p* and *t* values were determined on the pre- and post-tests in order to compare the means of the experimental and control groups.

Findings

The results presented herein were an attempt to find out whether learners in the experimental group performed better than those in the control group at probability (*p*) level of 0.05. Hence, the following hypothesis was tested.

- **H_0:** There is no significant difference between the achievement scores of the Grade six learners who are taught "matter and its properties" using concept mapping method and those taught using the traditional lecture method.
- **H_1:** There is a significant difference between the achievement scores of the Grade six learners who are exposed to concept mapping on "matter and its properties" and those taught using the traditional lecture method.

A t-test was used to determine whether there was a significant difference (at the alpha level of 0.05) on the administered pre-test and post-test between the mean scores of the control group (31 learners) and the experimental group (34 learners). The *p* and *t* values for the two-tailed test were calculated on the pre-test and post-test scores. Tables 1, 2 and 3 show the paired samples t-test results of the traditional lecture group and concept mapping group.

Table 1: Pre-test and post-test results of the control group

Group	Variable	N	Mean	SD.	df	t	Sig.(2-tailed)
Control group	Pre-test	31	20.29	6.95	30	-2.830	.348
	Post-test	31	27.94	14.60			

p>0.05

The results in Table 1 reveal that the control (traditional lecture) group's mean (*M*) score = 20.29 and Standard Deviation (*SD*) = 6.95 on the pre-test and *M* = 27.94 and *SD* = 14.60 on the post-test. The control group's scores on the pre-test and post-test indicate a *t*(30) = -2.830, p = 0.348, $t_{critical}$ = 2.042. The control group's scores improved after instruction. Further, the results show that there was a significant difference in their control group's performance during the pre-and post-test.

Table 2: Pre- and post-test results of experimental group

Group	Variable	N	Mean	SD.	df	t	Sig.(2-tailed)
Experimental group	Pre-test	34	33.97	14.40	33	-4.574	.000
	Post-test	34	47.32	21.51			

p<0.05

As seen in Table 2, the experimental group's mean (*M*) score = 33.97 and Standard Deviation (*SD*) = 14.40 on the pre-test and *M* = 47.32 and *SD* = 21.51 on the post-test. The t-test for the experimental group's pre-test and post-test scores are *t*(33) = -4.574, p = 0.000, $t_{critical}$ = 2.035. The experiential group's performance after the use of the concept mapping method was higher than that on the pre-test.

Table 3: Post-test results of the control and experimental groups

Variable	Group	N	Mean	SD.	df	t	Sig.(2-tailed)
	Control	31	27.94	14.60	63	-4.190	.000
Post-test							

	Experimental	34	47.32	21.51

$p<0.05$

Table 3 indicates that the experimental group achieved higher scores *M* = 47.32, *SD* = 21.51 as compared to the control group *M* = 27.94, *SD* = 14.60 on the post-test. The t-test value of the post-test scores of the control and experimental groups was a $t(63) = -4.190$, p = .000, $t_{critical} = 1.998$. The experimental group's performance seems to suggest that concept mapping had a positive impact on learners' achievement on the topic of "matter and its properties".

Discussion

The mean scores of the two groups on the pre-test were different. The traditional lecture (control) group's mean was 20.29 as compared to 33.97 of the concept mapping (experimental) group. The results show better performance by the experimental group on both the pre-test and post-test than the control group. This seems to indicate that teaching learners using concept mapping method produced better results than using the traditional lecture method

The findings provide empirical evidence (Safdar et al., 2012; Tolley, Johnson, & Koszalka, 2012; Wambugu & Changeiywo, 2008). Therefore, concept mapping could be considered as an excellent teaching and learning strategy that could allow learners and teachers to engage in extended science discourses, organise and structure subjects' content (Krause, Kelly, Tasooji, Corkins, Baker, & Purzer, 2010).

Overall results seem to show learners who were taught through concept mapping out-performed learners who were taught through the traditional lecture method. It was found that concept mapping had a positive impact on learners' performance. Chiou (2008) argues that concept mapping strategy has the capability to enhance learners' understanding and engaging them in the teaching and learning activities with positive results. In addition, using concept mapping might not be easy because the learners are unfamiliar with the strategy and might carried out to adapt to it especially if the concept is not well explained to them (Mwakapenda, 2004). Learners seem frustrated and lose interest when they spend much of their time struggling with the work that they do not understand well (Chiou, 2008; Elhelou, 1997; Krause et al., 2010).

However, it is important to provide opportunities to learners to participate and discuss science concepts during instruction in order for them to clarify their understanding of the concepts (Stoica, Moraru, & Miron, 2011). For the learners to achieve high academic standards and improve achievement in core subjects including science, the correct reading of instructions should be prioritised (Shaver, Cuevas, Lee, & Avalos, 2007).

Conclusion and recommendations

The curiosity behind the research question of this study was answered in terms of learners' achievements through the intervention (concept mapping). Despite the challenges, concept mapping strategy might prove as effective and useful teaching strategy of science concepts that promote meaningful learning among the learners. The concept mapping strategy can enhance learners' thinking capacity and promote scientific skills. As a result, learners' achievement is improved. However, concept mapping strategy itself would not be successful in teaching and learning without the interest and seriousness of teachers and learners. Therefore, teachers and learners should be encouraged to use concept mapping for effective teaching and learning of science. The study therefore recommends that:

1. The use of concept mapping should be extended to other subject areas in order to enhance effective teaching and learning.
2. Further research on concept mapping should be carried out on the implementation and application of concept mapping strategy in all science subjects including mathematics.

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