The effects of cooperative learning on the performance of Grade 11 Mathematics learners in the Oshana educational region, Namibia

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Abstract

This study sought to determine the effects of cooperative learning on the performance of the Grade 11 learners doing Mathematics on higher level in the Oshana Education Region. The study used a quasi-experimental design. Two Grade 11 classes (each comprising 31 learners) doing Mathematics on a higher level from one school in the Oshana region were purposefully selected; one as a control group and the other as an experimental group. The instruments used to measure the performance in Mathematics were a pre-test and post test. Prior to collection of the data, a pilot study was carried out in a different school to gather information on the appropriateness of the instruments and other administrative logistics. During the main study, the experimental and control groups were separately taught Differentiation a topic from the higher level Mathematics syllabus. The t-test was used to find out whether significant differences existed in the performance of the control and experimental groups. The results showed that significant differences in performance and in the motivation level of the experimental and control group existed at the 0.01 significant level. The findings suggested that cooperative learning improved learners' performance in Mathematics. The study recommended that Mathematics teachers should place emphasis on learners' understanding of particular concepts, guiding learners in active learning, providing opportunities for discussion and elaboration and encouraging them to work with peers to enhance learners' academic performance.

Introduction

The Namibian Government attaches great significance to the teaching of Mathematics in Namibian schools. "Mathematics is indispensable for the development of science, technology and commerce" (National Institute for Education Development [NIED], 2010a, p.18). Mathematics is an entry requirement at tertiary institutions for courses such as medicine, geology, engineering and information technology and Namibia needs experts in these fields in order to accelerate development and economic growth (Iyambo, 2010). The value attached to Mathematics led to the reform policy that Mathematics was to become a compulsory subject for every child in Namibian schools (NIED, 2010b), at the beginning of 2012.

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Volume 4, Number 1 & 2, 2015 - ISSN 2026-7215

The teaching of Mathematics in Namibia has been a challenge since independence in 1990 as the learners' performance in Mathematics at the Grade 12 level has been unimpressive (NIED, 2009; Iyambo, 2010). The Grade 12 national Mathematics results have been very poor over the past few years. In 2011, 80% of the pupils who wrote Mathematics obtained symbols below C, which is the minimum entry requirement to science related fields at the University of Namibia (UNAM) and the Polytechnic of Namibia (PON).

A higher number of Grade 12 pupils have been taking Mathematics on ordinary level. In 2011, a total of 15809 pupils wrote Mathematics examinations but only 560 pupils, equivalent to 3.54%, wrote Mathematics on higher level (DNEA, 2011). It appears that many schools in Namibia do not offer Mathematics on higher level. Of the 560 pupils that wrote Mathematics on higher level, only 31 pupils were from the Oshana education region, which was 5.53% of the total, all the 31 learners were graded (DNEA, 2011). In 2011, only two schools in the Oshana educational region offered Mathematics on higher level. The purpose of this study was to determine the effects of cooperative learning on learners' performance in higher level Mathematics in the Oshana education region and it addressed the following research question:

1. What are the effects of cooperative learning on the performance of grade 11 learners in higher level Mathematics in Oshana educational region?
2. In this study, a null hypotheses was also tested at $\alpha = 0.01$ significance level.
    1. **$H_{o:}$** there is no significant difference between the performance of the Grade 11 higher level Mathematics learners taught using cooperative learning and those who are not.

Theoretical framework & Literature review

This study draws upon the theory of social constructivism. Vygotsky (1986) as cited in Cobb (2005) argues that a key factor in social constructivism is that the children's development is enhanced by participating in activities that are slightly above their level of competence with mastery occurring as a result of help from others; which is enhanced as students are given opportunities to teach each other and practice in a social context.

Vygotsky (1978) maintains that learning is a social process in which students actively participate and contribute with ideas and arguments. Learners, who solve problems in groups, if structured effectively, gain better understanding and achieve better results than learners who work individually. This technique also allows learners to take responsibility for their own learning. It is claimed that during group work learners achieve far more than they would when working individually (Cooper, 2010). Interactions among students are crucial to cooperative learning and it is the interactions that occur in the groups that help to inspire the learning motivation (Cobb, 2005). Vygotsky (1978) believes that knowledge is constructed using prior-knowledge, through language as well as experiences, beliefs and culture, in this way meaningful learning has to take place. Vygotsky also explains that the learner is capable of constructing new knowledge with the help of others who are more knowledgeable. This means that learners learn best through interacting with their peers, teachers and others. Therefore, constructivism is an approach to teaching and learning which emphasises that learning is both an individual and social process. Cooper (2010) maintained that Vygotsky's theory is possibly the most useful theoretical framework if one wants to study learning in small groups and concluded that Mathematics educators should encourage small group work in their teaching.

An Overview of Performance in Grade 12 Mathematics examinations in Namibia.

A study carried out by MBESC (2002) reports that learners have been under achieving in Mathematics. A few years later, Peters (2006) noted that only 34.9 % of the learners who wrote International General Certificate of Secondary Education [IGCSE] Mathematics scored a D symbol or above. According to Iyambo (2010), the passing rate in Mathematics from 2005 to 2009 was unimpressive and below 40%. Iyambo added that another predicament Namibia faced was that only a small number of learners registered for Mathematics on higher level. The Mathematics national results for 2011 showed 80% of the learners obtained lower than the C – symbol (DNEA, 2012). Despites the INSTANT, BES III and MASTEP interventions, Mathematics education in Namibia has been a challenge and learners have performed poorly in Mathematics over the years.

Research on Namibian Mathematics education

Peters (2006) investigated the teaching strategies of Mathematics teachers in Windhoek schools. Peters suspected that the teaching approaches used by the Mathematics teachers could be among the contributing factors to poor performance in Mathematics. Her findings revealed that the teaching strategies of teachers had an effect on the learners' performance and on the motivation of learners to study the Mathematics. Peters (2006) thus recommends that Mathematics teachers design instructions that involve active learners' participation and the ones were learners can view Mathematics as a subject that gives them power to solve problems in real life. She suggests that learning activities be contextualized to enhance understanding.

Ilukena (2009) sought to determine whether there is a need to implement a complementary course in Mathematics education for teachers in Namibia. He found that many schools had Mathematics teachers who were not qualified to teach Mathematics at a secondary level. Ilukena (2009) also found that some teachers had low content knowledge and recommends for a complementary course to be implemented in order for Mathematics teachers in Namibia to upgrade their content and teaching skills.

Nambira et al. (2009) did a study that sought to determine reasons for poor performance in Mathematics, and found that the low performance in Mathematics lies in the teaching approaches, lack of learning resources and the implementation of the syllabus. Similar results were earlier found by DNEA (2004) cited in NIED (2010a) in a study to determine reasons for poor performance in Mathematics, and the study results includes shortage in learners' motivation to learn, availability of teaching materials and methods of presentation.

In a study conducted by NIED (2010a), learners were asked for suggestions to improve their performance and among others mentioned that teachers should adjust their teaching approaches and take views of learners into consideration. Nambira et al. (2009) and NIED (2009) all seem to highlight a need for a better teaching mechanism that enhances learning. "The main challenges facing the attainment of high performance in Mathematics lie on the teaching and learning of Mathematics, the implementation of the syllabus" (NIED, 2009). These studies, therefore, gives support to a study which sought to determine the effects of a teaching method on performance.

Cooperative learning

Cooperative learning is defined in a variety of ways. According to Johnson, Johnson, and Holubec (2008), cooperative learning is a group of three to five learners who work together as a team to solve a problem, complete a task, or achieve a goal. The main description being working together to accomplish a goal, cooperative learning procedures are designed to engage learners actively in the learning process through inquiry and discussion with their peers in small groups (Johnson et al., 2008).

Vygotsky (1978) claimed that socialization is the foundation of cognitive development. According to Vygotsky, socialization facilitates learning because the process of working with others offers a learner an opportunity to operate within his or her "zone of proximal development". The zone of proximal development has been defined as the distance between the current level of development as indicated by what a learner can do without assistance and the level of potential development as indicated by what a learner can accomplish with assistance from peers (Liao, 2005). Liao adds that the rationale that social interaction with peers enhances learning lies on the fact that cooperation with peers allows learners to work closely within one another's levels of proximal development. When learners work closely within one another's levels of proximal development, they can receive explanations that are presented to them in a simpler and more comprehensible fashion than if they were provided by a person of a different mental age. The process of cooperation thus benefits learners academically.

According to Johnson, Johnson and Holubec (1994) cited in Regnier (2009), cooperative learning is incorporated mainly by splitting learners into groups of three to five to work on assignments until all group members understand it. In these groups, learners are expected to discuss ideas, help each other to reveal links and clarify concepts and then complete the tasks. The group work is carefully organized and structured so as to promote the participation and learning of all group members in a cooperative context (Regnier, 2009).

Johnson et al (1994) as cited by Regnier (2009) listed five components of cooperative learning that needs to be considered for cooperative learning to be effective. The five components are positive interdependence, face-to-face interaction, individual accountability, interpersonal skills and group processing.

Positive interdependence

Johnson et al. (1992) and Kagan (1994) both cited in Regnier (2009) stressed that the positive interdependence is the most important element of cooperative learning. Positive interdependence is the need for learners to perceive that they are linked with their group mates in such a way that they will not succeed unless everyone else succeeds and that they must work together to achieve the goal. The success of the whole group depends on the success of each member and vice versa.

Face-to-face interaction

Cooperative learning greatly emphasises learner interactions (Liao, 2005). It promotes a context where learners argue, elaborate and explain by linking current materials to what is learned before. Learners have to sit in circles and interact face-to-face as this gives them an opportunity to negotiate and discuss their learning together (Zourez, 2010).

Individual accountability

According to Chen (2005), individual accountability occurs when every team member feels in charge of his/her own learning and those of other group members and hence makes active contributions to the group. Individual accountability is stressed when the performance of each member can be seen by the rest of the group members so that the group knows who needs more help in completing the task. The group then, in turn, helps that member at the benefit of everyone. Randomly selecting one learner' scores to represent the entire group or averaging the scores of the group members are common ways of promoting individual accountability.

Interpersonal skills

This refers to the way learners interact with teammates when mediating disagreements, encouraging others, giving complements, explaining problems, and defending their solutions (Chen, 2005). If learners do not have collaborative skills, groups cannot function effectively. Learners should therefore be taught good social skills to enhance collaboration in solving problems.

Group processing

According to Liao (2005), group processing entails reflecting on group sessions to describe what actions of the members were helpful and unhelpful and then decide which actions should be changed. The group processing serves to shed light on and improve the effectiveness of the members in contributing to the collective efforts towards attaining the group goals. Such processing enables the learning group to focus on group upholding, ensures that members receive feedback on their participation, facilitates the learning of interpersonal skills and encourages the use of these interpersonal skills. Interpersonal skills are instilled by the teachers through reminding learners to collaborate politely and humanely respect each other and their opinions.

Regnier (2009) suggests that teachers should first understand what cooperative learning is, be confident in the effectiveness of the cooperative learning approach, and use and know various ways of using cooperative learning approach. The teacher's role should include initiating group work, giving guidelines, preparing and introducing new materials, interacting with the groups, tying ideas together and evaluating the learners' performance (Regnier, 2009).

Cooperative learning and academic achievement

Performance refers to the academic accomplishment of a given task measured against preset known standards of accuracy, completeness and speed (Cobb, 2005). In this study the word performance referred to the scores/marks of learners in Mathematics tests/examinations.

A number of studies that have investigated the effects of the cooperative learning method on the learners' achievement have been carried out (Malin, 2007). The results of these studies indicated that cooperative learning instructions had an improvement effect on academic achievement in Mathematics. Learners who participated in cooperative learning activities had higher levels of academic performance than peers in the control groups (Chen, 2005). Malin (2007) and Chen (2005) highly reinforced the incorporation of the basic elements of cooperative learning whenever cooperative learning approach was to be used to ensure effectiveness.

Regnier (2009), Bawn (2007), and Liang (2002) found that cooperative learning enhances learners' performance. In their studies, students were placed in either the cooperative learning class or in the individual learning traditional class. These studies used pre-test and post-test designs to compare the achievement of the control and experimental groups. They found a statistically significant mean improvement from pre-test to post-test for the students in the cooperative learning classes than the students who studied the same Mathematics activities individually.

Effandi & Zalton (2006) found that cooperative group instruction showed significantly better results in Mathematics achievement and problem solving skills. Effandi & Zalton recommended the use of cooperative learning instructional approaches in Mathematics classrooms.

Methodology

This study was situated in the quasi - experimental paradigm and used a non-equivalent control group design by studying the intact classrooms (Gay et al., 2009) because the class groups already existed in the school and the researchers could not split up the classes. There were two schools offering Mathematics on higher level in the Oshana Education region in 2012. One of the two schools offering Mathematics on higher level in the Oshana education region was purposefully selected to take part in the study. Hence, the sample consisted of two Grade 11 higher level Mathematics classes; one class was the control group and the other an experimental group and each class had 31 learners which gave a total of 62 learners.

The researchers used a pre-test, post-test to collect the data. The Mathematics pre-test was administered and the results of the individual participants were recorded. After the pretest the experimental and control groups were taught the same content on derivatives separately using the traditional teacher centred and the comparative method respectively by one of the researchers for five weeks. The Mathematics post-test was then administered immediately after the treatment.

A *t*-test was used to test for a significant difference in both pre-tests and post-tests results for the Mathematics performance tests prior to and after the intervention.

Presentation of findings

The Mathematics pre-test was administered in order to determine whether the participating groups were at the same level of understanding of Mathematics so that the degree of change occurring in the post-test results of the treatment group could be attributed to the treatment (Gay et al., 2009). The Mathematics pre-test results yielded the mean scores of 35 for the control group and 33 for the experimental group. Table 1 presents the results of the Mathematics pre-test for the control and experimental groups.

Table 1: Results of the pre-test for the control and experimental groups

	Mean	Number	Standard Deviation	$t_{calculated}$
Control	35	23	14.8	0.4759
Experimental	33	27	9.97	

The t-test for the Mathematics pre-test results with degrees of freedom, *df* = 48, at the significance level, $\alpha = 0.01$ yielded $t_{calculated} = 0.4759$.

The obtained $t_{calculated} = 0.4759$ is less than $t_{critical} = 2.000$. This result shows that there was no significant difference in the performance of the control and experimental groups at the beginning of the study. Therefore, the control group and experimental group could be said to have been equivalent at the beginning of the intervention.

Control group

After the Mathematics pre-test, the control group was taught Differentiation, a topic on rates and derivatives in the higher level Mathematics syllabus, using the following instructional approaches: explanatory, demonstrations and question and answer method. The class desks were arranged in columns and rows to minimise discourses amongst the learners. The learners were encouraged to work on problems individually. The Mathematics post-test was administered at the end of the five week teaching period. A t-test was carried out to compare the Mathematics pre-test and post-test results of the control group (See Table 2).

Table 2: Control group pre-test and post-test results

Table 2. Control group pre-test and post-test results.

	Mean	Number	Standard Deviation	$t_{calculated}$
Pre-test	35	23	14.8	1.3767
Post-test	30	23	7.99	

Table 2 shows that at α = 0.01 and *df* = 22, the $t_{calculated}$ = 1.3767 and is less than $t_{calculated}$ = 2.819. This result shows that there was no statistical significant difference between control groups' pre-test and post-test scores.

Experimental group

After the Mathematics pre-test, the experimental group was taught the same content as the control group using the cooperative learning approach. The Mathematics post-test was administered at the end of five weeks of instruction. The scores for the experimental group from the pre-test and post-test are given in Table 3.

Table 3: Experimental group's pre-test and post-test results

	Mean	Number	Standard Deviation	$t_{calculated}$
Pre-test	33.4	27	9.97	2.8595
Post-test	42.1	27	15.9	

Table 3 shows the t-test for non-independent scores at α = 0.01 and *df* = 26, yielded $t_{calculated}$ = 2.8595 and the $t_{critical}$ = 2.779. This result shows that there was a significant difference in the Mathematics post-test scores and pre-test scores of the experimental group.

Experimental versus control group comparison

In order to find out the effects of cooperative learning on the learners' performance in higher level Mathematics, the following hypothesis was tested:

H_o: There is no significant difference between the performance of the Grade 11 higher level Mathematics learners taught using cooperative learning and those who are not.

H_1: There is significant difference between the performance of the Grade 11 higher level Mathematics learners taught using cooperative learning and those who are not.

Table 4 shows the means of the experimental and control groups on the post-test after five weeks of instruction.

Table 4: Experimental and control groups' post-test results

	Mean	Number	Standard Deviation	$t_{calculated}$
Control	30.0	23	7.97	3.306
Experimental	42.1	27	15.92	

The calculated t-test value was $t_{calculatedl}$ = 3.306 greater than $t_{critical}$ = 2.660 at α = 0.01 and *df* = 48. The results indicate that there was a significant difference in the Mathematics post-test scores of the experimental and the control groups.

Discussion of findings

The comparison of the Mathematics pre-test of the experimental and the control groups reflected that there was no significant difference between the experimental group and the control group (Table 1). This means the experimental and control groups were almost equivalent with respect to mathematical knowledge at the beginning of the experiment.

The comparison of the Mathematics pre-test and post-test mean scores for the control group (Table 2) showed $t_{calculated} = 1.3767$ less than $t_{critical} = 2.819$. This result indicates that there was no significant difference between the pre-test mean and post-test mean of the control group at the 0.01 level of significance. On the other hand, the Mathematics pre-test and post-test scores (Table 3) showed a significant difference at the 0.01 level of significance. The $t_{calculated} = 2.8595$ greater than $t_{critical} = 2.779$. Indeed the mean score of the experimental group was better in the Mathematics post-test in comparison to the mean score in the Mathematics pre-test. The significant performance of the experimental group supports the views by Malin (2007) who warned that it is important to confirm that the intervention caused a significant change within the experimental group.

The experimental group performed significantly better than the control group on the Mathematics post-test. The $t_{calculated} = 3.306$ greater than $t_{critical} = 2.660$. The post-test mean scores of the experimental and control groups were significantly different at 0.01 level of significance. (Table 4) Thus the null hypothesis that "There is no significant difference between the performance of the Grade 11 Mathematics learners taught using cooperative learning and those who were not" was rejected.

The experimental group mean score of 42.1 was greater than the control group mean score of 30.0. The results of this study seem to indicate that the cooperative learning approach resulted in higher achievement than the non-cooperative learning approach. The significant improvement in the performance of the experimental group supports the findings by Regnier (2009), Bawn (2007), Malin (2007), and Liang (2002) that cooperative learning enhances learners' performance. The possible reasons for the significant difference, found in the performance of the experimental group could be due to the learners' involvement in explaining and receiving explanations from fellow learners in which the concepts could be understood easily, and due to opportunities for students to solve problems collaboratively, create solutions, provide ideas and help each other (Bawn, 2007). The results of this study suggest a positive effect of cooperative learning on the performance of the Grade 11 learners in higher level Mathematics compared to non-cooperative learning. Further, it is our view that cooperative teaching and learning would improve learners' understanding of Mathematics if teachers were encouraged and willing to make use of this method in their classrooms.

Conclusions

It can be concluded that the cooperative learning approach significantly improved the performance of the grade 11 higher level Mathematics learners at one school in the Oshana education region. Perhaps using this approach in schools might improve the results of the learners in Mathematics in the Oshana region in national examinations.

Recommendations

Based on the findings of this study the following commendations are made:

1. Mathematics teachers should be encouraged to use cooperative learning to improve the academic achievement of their learners.
2. Strategies and materials which make the learning of Mathematics active, interactive with peers, investigative and adventurous should be used in the teaching of higher mathematics.

3. Small groups of between 3 to 4 learners appear to enhance interactions and consequently better performance in learning higher mathematics.

Acknowledgments

The researchers would like to acknowledge the Namibian Petroleum Fund (PETROFUND) for financial assistance.

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