THE EFFECT OF ACTIVE-LEARNING STRATEGY ON GRADE 10 LEARNERS' PERFORMANCE IN PHYSICAL SCIENCES

Dina Mamashela & Israel Kibirige
University of Limpopo, South Africa
Email: temp4dina@gmail.com; Israel.Kibirige@ul.ac.za

Abstract
Poor performance in Physical Sciences has led the subject to be considered as a difficult one. As a result, learners have negative attitudes towards the subject. Research elsewhere on the effectiveness of active-learning strategy revealed improved learners' performance in science and led to positive attitudes towards the subject. Therefore, this study examined the effect of active learning strategy on Grade 10 learners' performance in Physical Sciences. A quasi-experimental design was used with two groups, a control and an experimental group. A purposive sample of 80 learners (46 control, 34 experimental) studying Physical Sciences participated in the study. A teacher made-test was used as a pre-test to determine learners' knowledge at the start of the study. The same test was administered after the teaching period to determine learners' achievements. Also, a 5-point Likert questionnaire was used to determine learners' attitudes before and after the teaching period. A Mann Whitney U-test results show that the experimental group had higher scores in post-test when compared to the control group, suggesting that active-learning had a positive effect on learners' performance. Furthermore, learners in the experimental group showed positive attitudes towards science but not in the control group. The researcher, therefore, recommends that Physical Sciences teachers should employ active-learning for learners to enjoy science, which may help them to perform better in the subject.

Key words: Effect, active-learning strategy, performance, attitudes

INTRODUCTION

Learners' performance in science in South Africa has been a cause for concern (Grayson & Kriek, 2009; Makgato & Mji, 2006). Some researchers attribute performance to the pedagogy used in teaching (Adeyemo, 2010; Achor, Ogbeba & Samba, 2010; Armbruster, Johnson, Patel & Weiss, 2009; Makgato & Mji, 2006; Wilke, 2003). Pedagogy may include "teaching strategies, content knowledge, motivation, laboratory use, and non-completion of the syllabus in the year" (Makgato & Mji 2006: 253). Grayson and Kriek (2009) further suggest that teachers' limited content knowledge, ineffective teaching approaches and unprofessional attitudes may lead to learners being inactive in class. Inactiveness of learners in class may have a negative impact on learning.

Akinoğlu and Tandoğan (2006) suggest that learners should be active in class so that they improve their performance. Wilke (2003) performed a study in the United States of America (USA) on the effect of active learning on learners' characteristics in science. It was found that learners acquire more content knowledge and show high performance when active learning is used as a teaching strategy. It was also found that learners demonstrate a positive attitude towards learning when they perform well in science (Armbruster, et al. 2009; Baepler, et al. 2008; Lopatto, 2007; Wilke, 2003). Similarly, a study carried out in Turkey showed that active learning through problem-based learning improved learners' performance and their attitudes were found to be positive (Akinoğlu & Tandoğan, 2006). In Nigeria, active learning encouraged positive attitudes in learners and motivated them to perform better in writing chemical equations, work and energy (Oludipe & Oludipe, 2010). Alexander, Daries, Hlalele and le Roux (2010) report that the majority of South African teachers do not engage learners through Outcomes Based Education (OBE) centred teaching styles but use traditional learning teaching strategies. Similarly, Muwanga-Zake (2006:3) contends that "class observations indicate a dearth of learners' participation and ideas; lessons, even practical ones are often teacher-centred".

STATEMENT OF THE PROBLEM

Instructional strategies used in the teaching of physical sciences have not improved learners' performance in South Africa. A study in the Trends in International Mathematics and Science Study TIMMS 2003 and 2011 in Mathematics and Science show that South African learners scored the least among all countries that participated in those studies (Gonzales et al., 2004, Martin, et al., 2011).This can be attributed to teachers' and learners' failure to use active practical work strategies. Hatting et al. (2007) and Rogan (2004) found that many teachers in Mpumalanga Province did not involve learners in practical activities. These findings concur with Muwanga-Zake (2001) in the Eastern Cape Province where teachers ignored practical work. Maybe this could have contributed to the lack of learners' interest in science. Consequently, enrolment in Physical Sciences has been on a decline since 2009. For instance, in 2009 enrollment was 220882 and in 2011 it was 180585, which is decrease of 18.2% (Department of Basic Education, 2010, 2011, 2012).

PURPOSE OF STUDY

The study aimed at investigating the effect of active-learning strategy on Grade 10 learners' performance in physical sciences in Maraba Circuit in Limpopo and also, to determine the learners' attitudes towards science.

RESEARCH QUESTIONS

The research attempted to address the following questions:

- What is the effect of active and traditional teaching strategies on learners' performance in physical sciences?
- What are the learners' attitudes towards science before and after active and traditional teaching strategies?

SIGNIFICANCE OF STUDY

The study reports on the effect of active learning on learners' performance in science classrooms. Therefore, the study may create awareness, in Physical Science teachers and curriculum advisors, of the relationship between active-learning and learners' performance.

ETHICAL CONSIDERATIONS

Permission was requested and obtained in writing from the Limpopo Department of Education at Maraba Circuit. The researcher was referred to the school principals (managers) of the schools by the circuit manager. The importance of the research and the research questions were explained to the subject teacher and the learners. Learners involved in the study were given assurance that no individual names would be identified. Anonymity was also ensured through the structuring of questionnaires and content test by excluding personal information of the participants. At the end of the study, the Control Group (CG) was taught using active learning like their counterparts the Experimental Group (EG) in order to give an opportunity to learners in CG to experience active-learning strategy.

LITERATURE REVIEW

Armbruster, et al. (2009) conducted a study that focused on using multiple forms of active-learning and learner-centred pedagogies. These researchers incorporated active and problem-based learning to create a more learner-centred learning environment. This led to significant improvement of learners' engagement in science and increased academic performance. Their findings clearly indicate that active-learning improves learner attitudes toward science. The researchers report that learners' satisfaction scores increased significantly as a result of using active-learning and learner-centred strategies.

In a different study, Wilke (2003) in the USA investigated the effect of active-learning strategies on learners' achievement and motivation in a science course. To assess the effects of the continuum-based active-learning strategies, a comprehensive test, and attitude surveys were administered to learners. Wilke (2003) further indicates that the EG acquired more content knowledge and were more self-efficacious than learners in the CG. Research findings by

Baepler, Cotner, Decker and Walker (2008) also demonstrate that learners perform better, in an active class than traditional class. In addition, other studies indicate that a balance of learner-centred activities and presentation-style instruction may be the best approach. Akinoğlu, et al. (2006) conducted a similar study to determine the effects of problem-based active-learning in science education on learners' academic performance and concept learning. Once more, it was determined that the implementation of problem-based active-learning model positively improved learners' academic performance and their attitudes towards science. It was also found that the application of problem-based active-learning model affects learners' conceptual development positively and minimises misconceptions. Thus, it is evident from these studies that active-learning produces improved learners' performance in science.

Crossgrove and Curran (2008) performed an experimental study on the integration of technology in the teaching of science. Findings revealed that learners' performance on examination questions was higher than without the integration. Differences were reported to be "more dramatic" for the CG which showed low performances. The researchers also compared retention of information between the two groups after the course had ended. It was observed that there was increased retention of material in EG taught using active-learning but not in the CG which used traditional strategy.

A research by Oludipe and Oludipe (2010) on the effect of constructivist-based teaching strategy on academic performance in Nigeria shows that teachers' conventional (lecture) methods of teaching science were major causes of learners' negative attitudes towards science. The researchers recommended that science teachers should incorporate constructivist-based teaching strategy in their methods of teaching. In South Africa, factors contributing to poor performance of learners have been identified (Makgato & Mji 2006; Grayson and Kriek, 2009), but there is a dearth of empirical studies on active-learning in classrooms.

RESEARCH METHODOLOGY

This study used quantitative approach. Non-randomized quasi experimental research design was used. The target population for the study comprised of all secondary schools in the Maraba circuit in Limpopo Province. Purposive sampling was used to select two schools that offered Physical Sciences in the further education and training (FET) band from the target population. Also, these schools were chosen because they had only one whole class for physical sciences in grade 10. Thus, one whole science class (34 learners) in one school was assigned EG where learners were engaged in active-learning strategies and in the other school a whole class (46 learners) was assigned CG where traditional talk-and-chalk teaching strategy was used.

DATA COLLECTION

Two instruments were used for data collection: a multiple-choice performance test and a 5-point Likert scale questionnaire. Questions from the multiple-choice were selected from ‘Physical and Chemical Change’ strand, which was taught at the beginning of third term for a period of four weeks. Out of 20 questions used, only 4 questions (Q1.3; 1.12; 1.16 and 1.11) are presented here below:

1.3 When water freezes it undergoes

A sublimation

B vaporization

C physical change

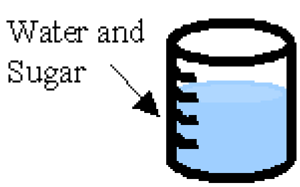
D chemical change (1)

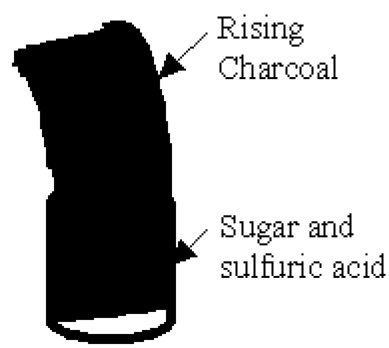
REASON FOR CHOICE: ……………………………………………………………

……………………………………………………………………………………(1)

1.12. Consider the following experiments:

EXPERIMENT A **EXPERIMENT B**





In Experiment A, 40 mL of water were added to beaker ½ full with sugar.
In Experiment B, 40 mL of hydrochloric acid were added to beaker ½ full with sugar.

Two learners, Tumelo and Phenyo, are arguing on whether Experiment B is a physical or a chemical change. Their reasons are as follows:

I Phenyo says Experiment B is a Physical change, his reason is: “Sugar was in solid form and after the experiment, we still get a solid”.

II Tumelo says Experiment B is a Chemical change, his reason is: “From sugar and acid, we get charcoal which is different from sugar and from acid.”

III Phenyo says Experiment A is also a Physical change, his reason is “From sugar and water, we get a homogenous mixture”

Which answer and the reasoning is CORRECT?

A I only
B I and II
C III only
D II and III (1)

REASON FOR CHOICE: …………………………………………………………

……………………………………………………………………………………(1)

……………………………………………………………………………………(1)

1.16. In all chemical reactions the

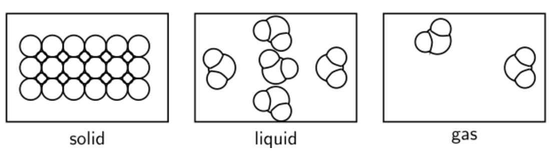
A masses of the combining chemicals must be equal
B volume of the reactants equals the volume of the products
C volumes of the combining reactants must be equal
D mass of the reactants equals the mass of the products (1)

REASON FOR CHOICE: …………………………………………………………

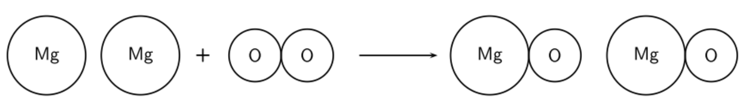
……………………………………………………………………………………(1)

1.11. Which ONE of the following diagram shows a physical change?

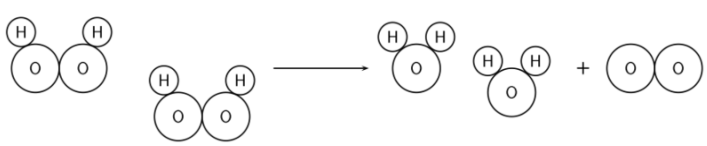
A



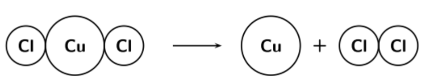
B



C



D



(1)

REASON FOR CHOICE: ……………………………………………………………

…………………………………………………………………………………(1)

A 5-point Likert scale questionnaire was used to establish learners' attitude towards instruction and physical sciences before and after the teaching strategy. The questions for the questionnaire were adapted from Wilke (2003) and only a few changes were made to suite Grade 10 learners' context. Learners were given 45 minutes to answer the multiple-choice questions and 45 minutes for the questionnaire in the pre-test as well as in the post-test.

VALIDITY

To validate the multiple-choice questions, two physical science advisors from Capricorn district and one physical science teacher checked the questions to confirm their suitability for the grade. A content validity form was used as a standard tool for all the experts to use for the purpose of validating each item on the questionnaire. Items were assessed to ensure that they have appropriate content and are comprehensive enough to collect necessary data needed to address the purpose of the study. Items were selected mainly from previous Grade 10 examination question papers with a few additions from textbooks and the internet. The Content Validity Index (CVI) was computed using the formula:

$$CVI = \frac{\text{number of items judged as right}}{\text{number of items on the questionnaire}}$$

Since CVI obtained was 0.87, the instrument was therefore considered to be valid.

RELIABILITY

Prior to the undertaking of the implementation of the actual study, the validated attitude questionnaires were pilot-tested to one Grade 10 class within the population but was not sample to ensure that the questions were clear and easily understood. A few minor changes were made in terms of arranging the questions in themes viz: physical change, chemical change and conservation of mass.

DATA ANALYSIS

Descriptive statistics (mean and standard deviation (SD) were used to analyze the attitude pre-test and post-test for the two groups. A Mann-Whitney U test was used to compare performances on the multiple-choice test between the two groups because the samples were not of equal cases. In both cases SPSS version 18 was used.

RESULTS

Attitudes

Table 1 presents pre-, post-test means and standard deviations of learners' attitudes towards teaching strategies. Tables 2 and 3 are summaries of means per item in the pre-, post-test attitude questions. It is observed that there is a minimal difference of 0.03 between the groups in the pre-test. Mean scores of learners from the EG in the pre-test were mean 3.21±0.96 SD, while mean scores of learners in the CG were 3.24±0.89 SD (Table 2). Thus, both EG and CG had similar responses to questions before the intervention.

Table 1. Overall means and standard deviations of the samples' attitude pre-test and post-test scores.

Test	Strategy	N	Mean	SD
PRE-TEST	Active-learning	34	3.21	0.96
	Traditional	46	3.24	0.89
POST-TEST	Active-learning	34	3.71	0.86
	Traditional	46	3.22	0.91

In Table 1, the means scores for EG in the post-test (mean 3.71± 0.86 SD) and CG (3.22±0.91 SD) indicate that learners in the EG using active-learning had higher post-test mean scores than their counter part the CG. Learners in the CG indicated, that activities done in class were boring and that they would not choose direct teaching over active-learning. Most learners in the CG also reported that physical sciences was too difficult for them, but that activities such as answering questions at the end of chapter in the textbook did help them to learn and understand the content.

Table 2. Summary of means for attitude pre-test

ATTITUDE PRE-TEST QUESTIONS	MEAN		SD	
	E	C	E	C
1. I learn best when I am an active participant in class	3.82	3.89	0.97	0.85
2. I enjoy activities performed in class	3.53	2.8	0.86	0.54
3. I learn more from doing than from listening	3.79	4	1.20	0.79

4.	Reading the textbook will help me understand the material in class	3.56	4.13	0.89	0.88
5.	Doing the exercises given to me for homework and class-work helps me	4.29	4.37	0.87	0.74
6.	Answering the questions at the end of each textbook chapter will help me do well in this class	4.15	3.7	1.02	0.76
7.	Performing the exercises in the student workbook will help me learn the material for this class	3.62	4.09	0.85	0.89
8.	I like participating in group discussions in class	3.53	3.26	1.26	0.88
9.	I prefer lessons where direct teaching is the only means of instruction	2.85	2.09	1.13	0.76
10.	I do not like to answer questions out-loud in class	2.5	2.17	0.99	1.08
11.	I like interacting with others in class	3.56	3.72	0.89	1.03
12.	I learn more when the teacher tells me things than from performing activities	2.03	2.02	0.72	0.75
13.	The experiments we perform in lab will help me reinforce what I learn in class	3.65	4.07	0.73	1.06
14.	I enjoy talking to other people about physical sciences	3.88	2.5	0.91	0.62
15.	I really like physical science	4.24	4.02	0.96	1.18
16.	I think physical science is easy and fun	2.65	2.93	0.54	1.04
17.	Most people can understand physical sciences	2.12	2.78	0.81	0.99
18.	I enjoy learning about physical sciences	4.09	3.41	0.87	0.83
19.	Physical sciences makes me feel uncomfortable	1.68	1.93	0.98	1.94
20.	I feel at ease in physical sciences	3.32	2.35	1.36	0.67
21.	It makes me nervous to even think about doing a physical science experiment	1.91	3.85	0.93	0.73
22.	The subject of physical sciences is interesting to me	3.94	2.39	1.07	0.65
23.	Physical science is difficult and it is not practical	1.56	3.13	0.86	0.83
24.	It scares me to have to study physical sciences once more in the next grade	2.15	3.09	1.23	0.86
25.	I feel confident I can do well in physical sciences	3.76	4.26	1.02	0.93
	OVERALL	**3.21**	**3.24**	**0.96**	**0.89**

*The ranking is based on a 5-point Likert scale of 1 (Strongly disagree), 2 (Fairly disagree), 3 (Agree), 4 (Fairly agree) to 5 (Strongly agree).

*E stands for EG, and C is for CG. For the pre-test, the scores for EG (mean 3.21± 0.86) and control group (mean 3.24± 0.89) (Table 1) and the post-test scores for EG (mean 3.71 ±0.86 SD) are high when compared to scores from CG (mean 3.22± 0.91) (Table 3).

These results indicated that:

1. Learners in the EG generally liked active-learning, believed that active-learning strategies helped them understand the material better, would choose an active-learning course over a teacher lecture method and direct learning, and were confident that they would do well in physical science.

2. Learners in the CG indicated that, in general, active-learning would be a good strategy in addition to traditional teaching strategy. They also indicated that activities done in class were boring and that they would not choose traditional over an active-learning. Most learners also reported that physical science was too difficult for them, but that activities such as answering questions at the end of the chapter in the textbook did help them to learn and understand the material (Table 3).

Table 3. Summary of means for attitude post-test

ATTITUDE POST-TEST QUESTIONS	MEAN		SD	
	E	C	E	C
1. The activities used in class were fun.	3.5	2.2	0.92	0.77
2. Participating in the activities in class made me feel uncomfortable.	1.79	2.02	0.84	0.77
3. I understood the point of the activities we did in class.	3.62	2.41	0.95	0.68
4. Sometimes, I found myself thinking about the class activities when I studied.	3.85	3.54	0.85	1.19
5. I can learn better through activities than from the teacher	3.97	3.76	0.83	0.89
6. The worksheets helped me learn the material for this class..	3.38	3.78	0.95	0.92
7. I found the use of active-learning helped me understand the material better.	3.85	3.57	0.78	0.98
8. I liked the opportunity to work on open-ended problems in class.	3.71	3.67	0.87	0.92
9. I would choose an active-learning method over a “teacher lecture” method if I had a choice.	3.74	3.85	0.75	0.79
10. I believe I can use the problem solving skills I learned in class in other situations.	3.88	3.91	0.84	0.96
11. I felt comfortable answering questions out-loud in class.	3.82	3.33	0.87	1.17
12. Active-learning would be a good addition to other lessons I’m taking.	3.85	3.74	0.96	1.22
13. I felt comfortable contributing information out-loud in class.	4.12	3.26	0.98	0.88
14. Physical science lessons would have been boring without the activities.	3.88	3.63	0.91	1.14
15. I learned a lot about physical sciences during the lessons.	4.06	2.7	0.89	0.66
16. Physical science is relevant to my everyday life.	4.24	3.85	0.85	1.07
17. I liked the way the lesson was taught.	4.03	2.17	0.79	0.79
18. The student workbook helped me learn the material for this class.	4.71	3.57	0.94	1.19
19. I prefer lessons where the teacher is talking most of the time.	2.03	2.24	0.72	0.77
20. I would prefer direct teaching from the teacher than active involvement in future.	2.79	1.80	0.69	0.65
21. I enjoyed talking to other learners in class about physical science.	3.82	3.89	0.79	0.95
22. I prefer lessons that challenge me to think about the content.	4.21	3.7	0.77	0.99
23. Answering the end of chapter questions in the textbook helped me learn the material for this class.	4.71	4.04	0.97	0.94
24. I learn more from listening than from doing.	2.79	1.67	0.69	0.63
25. I believe it is my own responsibility to learn the material presented in this class	4.5	4.24	0.93	0.87
OVERALL	**3.714**	**3.22**	**0.86**	**0.91**

*The ranking is based on a 5-point Likert scale of 1 (Strongly disagree), 2 (Fairly disagree), 3 (Agree), 4 (Fairly agree) to 5 (Strongly agree);
*E stands for experimental group, and C is for control group

Multiple-Choice Test

The multiple-choice test results for the pre-test are shown in Table 4 and these results, in percentages (%), are also graphically illustrated in Figure 1 to show the comparison of the distribution of the scores for the EG and the CG pre-test. These two sets of results are not significantly different when a Mann Whitney U Test was used (U = 703.00, p >0.05) (Table 4), suggesting that the two groups had similar science concept understanding.

Table 4. U test results of the multiple choice pre-test scores for EG and CG.

Strategy	N	Mean Rank	U	Z	2-Tailed P
Active-learning	34	38.18			
			703.00	-0.78	0.44
Traditional	46	42.22			

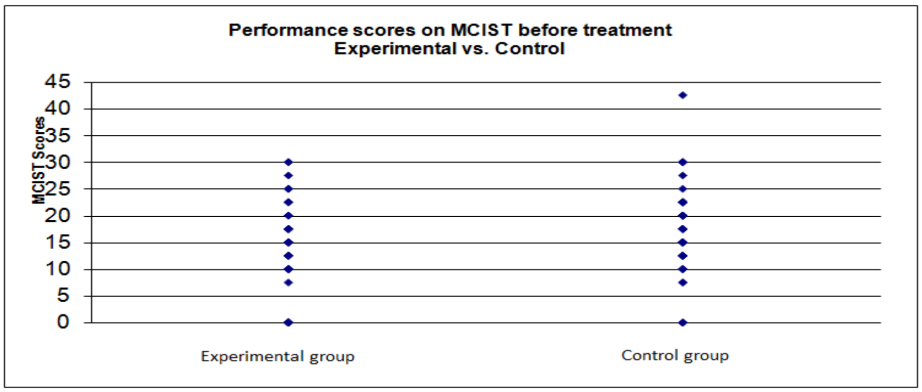


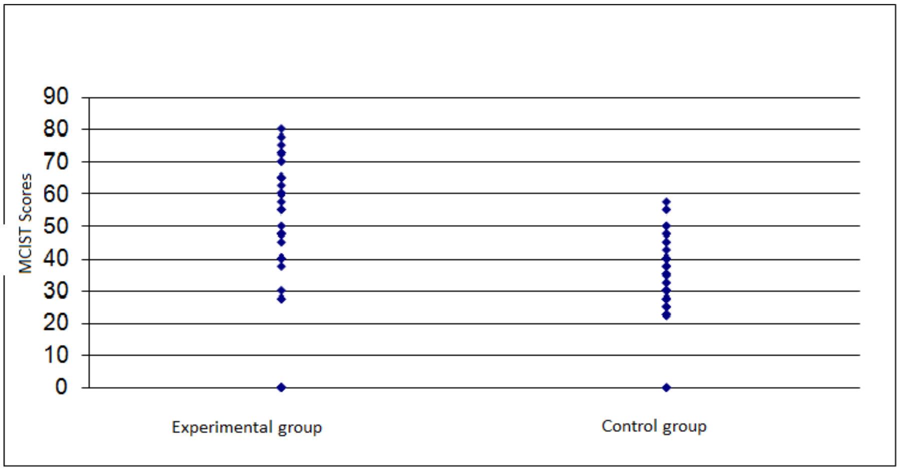
Figure 1. Graph of performance % scores of the EG and CG before treatment.

The multiple-choice test results for the post-test are shown in Table 5. These results are also graphically illustrated in Figure 2 to show the comparison of the distribution of the scores in percentages (%) for EG and CG. Pre-test results (Table 1) the scores for EG (mean 6.85±2.4 SD) and CG (mea 7.39± 2.8 SD) do not differ greatly. Conversely, in the post-test (Table 3) scores for EG (mean 22.38 ±5.6 SD) are high when compared to scores from CG (mean 14.13± 3.8 SD). Also, the comparison of the two groups performance in the post-test differed greatly when using a Mann Whitney U Test (U = 200.00, $p < 0.05$) (Table 5). The calculated effect size was 0.87 and the Cohen d was 0.4.

Table 5. U test results of the post multiple choice scores for EG and CG.

Strategy	N	Mean Ranks	U	Z	2-Tailed P
Active-learning	34	57.62			
			200.00	-5.68	.02
Traditional	46	27.85			

Figure 2. Graph of Multiple choice % scores for EG and CG after treatment



DISCUSSION

The purpose of this study was to investigate the effect of active-learning strategy on Grade 10 learners' performance in physical sciences. The results show that EG taught using active-learning strategies performed better than the CG taught using traditional strategies. Pre-test results of the content test showed that both the EG and the CG at the beginning of the study had similar understanding of science concepts (Table 2, Figure 1). Akinoğlu and Tandoğan (2006) describe this similar science concepts understanding as the nearness of pre-knowledge level of the two groups. This can also be explained by the fact that both groups had not been exposed to the content before.

Multiple-choice test results from the post-test show clearly that the EG performed better than the CG (Table 5). Results from a Mann-Whitney U-test ($U = 200$, $p < 0.05$) show that the performance of the EG was statistically different from that of the CG. The effect size of 0.87 obtained is greater than (> 0.35) which is a large gain according to Cohen (1988) and it is in favour of the EG. Thus, these results strongly suggest that the use of active-learning improved performance. These results are consistent with previous studies indicating that active and interactive learning activities increase learners' performance (Akinoğlu & Tandoğan, 2006; Armbruster, et al. 2009; Baepler, et al. 2008). For example, the EG multiple-choice questions scored in the 60-80% range but not from the CG (Figure 2). This can be explained by the fact that during treatment, learners in the EG were guided by the teacher on how to discover science facts through active-learning and performing experiments as well as working on questions on the worksheets. Furthermore, learners were encouraged to use science principles in their textbooks that would assist them to explain the discovered science facts.

The results of this study indicate that learners exhibited greater performance on multiple-choice content-based questions learned using active-learning and that questions demanded the use of integrated process skills. These findings are supported by Oludipe and Oludipe (2010) study that learners' active-learning results in improved performance in science content knowledge. Other researchers also reported that when active-learning strategies, namely cooperative learning, discovery learning, constructivist learning, collaboration are used consistently learners' performance become better than those who experience traditional lecture method (Akinoğlu & Tandoğan, 2006; Armbruster, et al. 2009; Baepler, et al. 2008; Lopatto, 2007; Wilke & Straits, 2001). On the other hand, the CG did not have active-learning, were passive and did not perform experiments. Their engagement was mainly through teacher talk-and-chalk and read textbooks in order to pass tests. Learners were not encouraged to use science integrated process skills to explain science facts. This might have generated some misconceptions, which ultimately, might have affected their performance the multiple-choice test.

Another factor that was studied was learners' attitudes towards science before and after the teaching strategies. As it can be seen in Tables 1 and 2, the means of the pre-attitude scores revealed by the EG was (mean 3.21± 0.86) and for CG was (mean 3.21± 0.86), suggesting that there was no significant difference between the pre-test attitude scores of the two groups. Tables 1 and 3 show the means of post-test attitude scores for EG was (mean 3.71 ±0.86 SD) and scores of the CG was (mean 3.22± 0.91). In this respect, there is a significant difference between the post-test attitude scores of the two groups. It seems that learners in EG developed positive attitudes towards science but that was not observed in the CG. This positive attitude increased the number of learners' participation in class activities as evidenced from their group work during class facilitation No one student dominated but many learners worked and suggested solutions in order to solve various solutions (Pers. Com). This concurs with the findings of Jensen and Lawson (2011) that the development of positive attitudes towards inquiry instruction is directly related to learners' active engagement in class. Thus, it can be concluded that active-learning strategies improved learners' attitudes towards learning of science. Active learning breaks the monotony of traditional lecture methods and may assist learners in science in South African school to enjoy science and as a result may perform well science subjects.

LIMITATIONS OF THE STUDY

The selected sample constituted few participants (80 learners). The findings of this study were limited to two classes and as such may not be generalised to other schools. Therefore, further study is needed to explore the effect of active-learning and the extent of the use of active-learning in South African schools.

REFERENCES

Achor, E.E., Ogbeba, J.A., & Samba, R.M.O. (2010). Teachers' awareness and utilization of innovative teaching strategies in secondary school science in Benue state, Nigeria. *Educational Research*, 1(2): 32 – 38.

Adeyemo, S.A. (2010). The need for skill development/acquisition in science, technology and mathematics education (STEME) in Nigeria. *Journal of Science and Technology Education Research,* 1(1): 1 – 9.

Akinoğlu, O. & Tandoğan, R.O. (2006). The effect of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education,* 3(1): 71 – 81.

Alexander, G., Daries, G, Hlalele, D. & Le Roux, N. (2010). Do educators in the Free State province of South Africa engage learners via outcomes based teaching styles? *Journal of Social Sciences*, 24(1), 15-22.

Armbruster, P., Johnson, E., Patel, M. & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in introductory Biology. *CBE—Life Sciences Education,* 8: 203–213.

Baepler, P.M., Cotner, S.H., Decker, M.D. & Walker, J.D. (2008). A delicate balance: Integrating active learning into a large lecture course. *CBE – Life Sciences Education,* 7: 361 – 367.

Crossgrove, K., & Curran, K.L. (2008). Using clickers in nonmajors- and majors-level Biology courses: student opinion, learning, and long-term retention of course material. *CBE- Life Sciences Education,* 7: 146 – 154.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). New Jersey: Lawrence Erlbaum Associates.

Department of Basic Education (2010). *National Diagnostic Report on leaner performance 2010. South Africa:*. South Africa: National Department of Basic Education.

Department of basic Education (2011). *National Diagnostic Report on leaner performance 2011.* South Africa: National Department of Basic Education.

Department of basic Education (2012). *National Senior Certificate: School Performance Report, 2012.* South Africa: Department of Basic Education.

Grayson, D. J, & Kriek, J. (2009). A holistic professional development model for South African physical science teachers. *South African Journal of Education,* 29(2): 185 – 203.

Gonzales P, Guzmán JC, Partelow L, Pahlke E, Joselyn L, Kasteburg D & Williams T (2004). *Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES) 2005-05).* US department of Education, National Centre for Educational Statatistics. Washington, DC, US. Government Printing Office.

Martin, M.O., Mullis, I.V.S., Foy, P. and Stanco, G.M. (2012). *TIMSS 2011 International Results in Science.* Chestnut Hill, MA: Boston College, TIMSS and PIRLS International Study Center. http://timssandpirls.bc.edu/timss2011/reports/international-results-science.html (Accessed: December 11, 2012).

Jensen, J.L., & Lawson, A. (2011). Effects of collaborative group composition and inquiry instruction on reasoning gains and achievement in undergraduate Biology. *CBE—Life Sciences Education*, (10): 64–73.

Lopatto, D. (2007). Undergraduate Research Experiences Support Science Career Decisions and Active Learning. *CBE - Life Science Education,* 6(4): 297-306.

Makgato, M. & Mji, A. (2006). Factors associated with high school learners' performance: A spotlight on mathematics and physical science. *Africa Education Review, 4(1), 89 – 103.*

Mohamed, A. (2008). Effects of active learning variants on student performance and learning perceptions. *International Journal for the Scholarship of Teaching and Learning, 2(2).*

Muwanga-Zake, J.W.F. (2006). What kind of science do educators present to learners in South African classes? www.casme.org.za/docs/muwangazake1.pdf. Accessed: October 21, 2010.

Oludipe, B. & Oludipe, I.D. (2010). Effect of constructivist-based teaching strategy on academic performance of students in integrated science at the junior secondary school level. *Educational Research and Reviews,* 5(7): 347 – 353.

Wilke, R.R. & Straits, W.J (2001). The effects of discovery learning in a lower-division Biology course. *Advances in Physiology Education,* 25(2): 62-69.

Wilke, R.R. (2003). The effect of active learning on student characteristics in a human physiology course for nonmajors. *Advances in Physiology Education,* 27(4): 207 – 223.