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The Impact of Guided Discovery Learning on the Performance of Grade 11 Learners in Identification of Ions

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Abstract
This study explored the impact of guided discovery learning on the performance of grade 11 learners in the identification of ions. Fifty eight grade 11 learners of Matete Secondary School, a public school in Kitwe district of Zambia were involved in the study. The research design used was a Quasi-Experimental counter balance. Chemistry achievement test (Pre-test and Post-test) and a Likert scale questionnaire were used to collect data. The experimental group was taught using guided discovery method while the control group was taught using the conventional (discussion) method. Results from the chemistry achievement test revealed gain for both groups. In the first cycle the guided discovery group had a pre-test mean of 23 which increased to 59 in $posttest_1$. The conventional group had a pre-test mean of 19 which increased to 45 in $posttest_1$. The group means of the conventional and guided discovery groups were compared using student t-test at $\alpha = 0.05$ and were found to be significantly different. This implied that there was a significant difference between the two teaching methods. Both groups showed an increase in the mean but the discovery group showed a greater improvement than the conventional group. The second cycle involved swapping of the two groups and it was found that the discovery group showed a higher mean performance of 61 than the conventional group which had a mean performance of 49. The p-value was found to be 0.029. Results from $posttest_2$ showed a significant difference between guided discovery learning and conventional (discussion) learning. Attitudes towards guided discovery learning on the identification of ions were obtained through a five point Likert scale questionnaire and generally, learners showed positive attitudes towards the guided discovery teaching method. It was concluded that guided discovery learning improved learner performance on chemistry concepts (identification of ions) and learners showed positive attitudes towards the teaching methods as suggested by the measure of central tendency.
Keywords: Discovery learning, Conventional learning, Performance, Attitud

Introduction

Most learners see an independent existence between what they learn in a science classroom and real life situations. This is usually caused by the mode of teaching a teacher uses to deliver science concepts. In a 21st century classroom, there are a number of processes that a learner should undergo in order to come up with their own conclusions about a particular scientific concept. Some of the processes that a learner should acquire include manipulation of instruments, observations, evaluation and hypothesizing. These will enable learners to come up with their own conclusions since they were actively involved in a particular phenomenon. Processes like manipulation of instruments help learners to extend their intellectual capabilities because it requires learners to marry theory to practice and they will easily apply what they learn at school in real life situations.

Research shows that chemistry is generally a difficult subject to students at all levels (O'dwyer, 2012). In Zambia chemistry has had low mean performances in National Examinations in the recent past. According to Examinations Council of Zambia performance reports, the general performance in sciences has been consistently low. For instance, the year 2014 had a mean percentage pass in science of 17.77% (ECZ,2014), 2015 had a mean performance of 17.65% and 2016 mean 32.83% in science (5124) paper 3(ECZ, 2016).

Examination Council of Zambia performance report (ECZ,2016) highlights that one of the challenging topics in Chemistry is Qualitative Analysis because learners are required to marry theory to practice. This topic involves identifying cations and anions in aqueous solutions. Some of the factors that affect the learners' understanding of this topic include teaching methods and approaches, lack of teaching aids and text books. The chief examiner highlighted that candidates showed poor psychomotor skills in practicals and application of theoretical knowledge to explain observations and results from experiments. Another highlight was that the performance on qualitative analysis was poor because candidates failed to express their results as required by the given notes on the identification of ions, leading to a poor performance on the topic (ECZ, 2016). Poor performance in science has been linked to teaching approaches such as lecture and discussion which do not engage the learners (Mansor et al, 2010).

According to constructivism learning theory, there are learning approaches which engage a learner and research indicates that these approaches can enhance understanding of science concepts, (Yuliana, Tasari & Wijayanti, 2016; Wilke and Straits,2001). Therefore, this research focused its attention on one of the methods

that can enhance learner understanding of science concepts that is guided discovery learning. Guided discovery learning engages a learner in direct purposeful activities and therefore results in improved performance (Bruner, 1961). Constructivists like Bruner emphasize that discovery learning enhances meaningful learning because a learner is able to relate new information to the information on the cognitive structure. Discovery-based environments produce a better understanding of knowledge, improved problem-solving skills and improved student communication skills which in turn lead to a more productive discovery learning process. It should be noted that nowadays employers are interested in employees with good problem solving techniques.

To achieve engagement of a learner in direct purposeful activities and follow a systematic way of guided discovery, the Biological Sciences Curriculum Study (BSCS), 5E learning model developed by Bybee, (2009) was incorporated in the classroom. The model consists of different steps which actively involve learners, these phases comprise of Engagement, Exploration, Explanation, Elaboration, and Evaluation

The purpose of this study is to use guided discovery learning as a way of improving learner academic performance in identifying cations and anions in aqueous salt solutions.

Research Methodology

The study was undertaken at Matete Secondary School in Kitwe District on the Copperbelt Province in Zambia. A total of 58 grade 11 learners in two intact classes consisting of 28 and 30 learners participated in the study. The purposive sampling procedure was used in the study to select the participants and random assignment was used to assign experimental and control group in the first cycle. A Chemistry performance practical test was developed to assess learner understanding on identification of different ions in aqueous solutions. The practical test comprised of two sections, section A covered identification of cations and section B covered identification of anions.

The research employed a pre-test, post-test, control group quasi experimental research design. A pre-test was administered to both groups in order to determine whether the two groups were the same at the beginning of the study. Both groups received an intervention, in the first cycle the experimental group was taught identification of cations using guided discovery learning method and the control group was taught using conventional (discussion) method. After the intervention, post-test one on identification of cations was given to both groups. The groups were then swapped the control group in the first cycle became the experimental group and the experimental group in the first cycle became the control group. This was to expose all learners to the same kind of conditions. In the second cycle, the experimental group was taught identification of anions using guided discovery method and the control group was taught identification of anions using conventional method. Thereafter, post-test two on identification of anions was given. The research design is summarized in Table 1.

Table 1. Summary of the research design

$\mathbf{O_1}$	$\mathbf{X_1}$	$\mathbf{O_2}$	$\mathbf{X_2}$	$\mathbf{O_3}$
$\mathbf{O_1}$	$\mathbf{X_2}$	$\mathbf{O_2}$	$\mathbf{X_1}$	$\mathbf{O_3}$

Where: $\mathbf{O_1}$, $\mathbf{O_2}$ and $\mathbf{O_3}$ refer to pre-test, post-test one and post-test two respectively. $\mathbf{X_1}$ refers to intervention using guided discovery learning and $\mathbf{X_2}$ refers conventional learning (discussion)

A questionnaire adopted from University of Cambridge faculty of education (epiSTEM 2010) was given at the end of the two cycles. This questionnaire measured learner attitudes towards the guided discovery method. The Questionnaire consisted of 10 items in a 5 point Likert scale. Students were required to indicate their choice using the number of choice on the scale; 1 = Strongly agree, 2= Agree, 3= Neutral, 4= Disagree and 5= Strongly disagree. This method has been used by other researchers (Akar, 2005; Bilgin, 2009)

Results.

The means of the scores achieved in the pre-test, post-test one and post-test two are given in Table 2.

Table 2. ***Mean and Standard deviation of the Pre-test, Post-test one and Post-test two for the two classes***

	Grade 11A (N=30)		Grade 11B (N=28)	
	Mean (%)	SD	*Mean (%)*	SD
Pre-test	**19**	**12**	**23**	**11**
Post-test$_1$	**45**	**23**	**59**	**28**
Post-test$_2$	**61**	**24**	**49**	**19**

SD- Standard deviation

One of the important assumptions of a t-test is that data should be normally distributed. Normality of the data was checked by converting skewness and kurtosis to a z-score. All the z- scores calculated were found to be between -1.96 and +1.96 indicating data were normally distributed Field (2009). Therefore t-tests were carried out to compare the two teaching methods on the data obtained.

The pre-test results were subjected to an independent sample t-test analysis. The results of this analysis given in Table 3 and show that the two classes were homogenous at the beginning of the study at α=0.05.

Table 3. ***Independent t-test of pre-test scores of the guided discovery and conventional group***

Scores				T-test		
	N	*Mean (%)*	*SD*	df	t	p
Discovery	**28**	**23**	**11**	**56**	**1.175**	**0.488**
conventional	**30**	**19**	**12**			

N- Number of participants, SD- Standard deviation, df- Degree of freedom, t- Calculated t value, P- Probability level.

Examination of post-test one results shows that though both groups improved after interventions were given the guided discovery group improved more than the conventional group as shown by their means 59% and 45% for the guided discovery and conventional groups respectively. The post-test one results for the groups were subjected to an independent t-test and it was found that the difference between the two teaching methods was significant as shown in Table 4.

Table 4. ***Independent t-test of post-test one scores of the guided discovery and conventional group***

Scores						T-test
	N	*Mean (%)*	*SD*	df	t	P
Discovery	**28**	**59**	**28**	**56**	**2.08**	**0.04**
Conventional	**30**	**45**	**23**			

N- Number of participants, SD- Standard deviation, df- Degree of freedom, t- Calculated t value, P- Probability level.

Effect size which is a measure that shows the magnitude of the difference between the two groups (Pallant, 2005) was calculated using Eta Squared as shown below.

$$\text{Eta squared} = \frac{t^2}{t^2+(N1+N2-2)} = \frac{(2.08)^2}{2.08^2+(28+30-2)} = 0.07$$

Where t is the statistical t-test value, N1 and N2 are the participants in the discovery group and conventional group respectively.

According to Cohen (1988), Eta squared values are interpreted as follows; 0.01 ≤ eta squared <0.06 small effect, 0.06 ≤ eta squared < 0.08 moderate effect and 0.08 ≤ eta squared < 0.16= large effect. For post-test one, it can therefore, be concluded that the difference between the discovery group and the conventional group is moderate.

Post-test two results showed that the guided discovery group had a mean of 61 whilst the conventional group mean was 49. An independent sample t-test to compare the two teaching strategies showed that the difference was statistically significant at α=0.05 (Table 5).

Table 5. ***Independent t-test of post-test two scores of the guided discovery and conventional group***

Score						T-test
	N	*Mean (%)*	*SD*	df	t	p
Discovery	**30**	**61**	**24**	**56**	**-2.24**	**0.029**
Conventional	**28**	**49**	**19**			

N- Number of participants, SD- Standard deviation, df- Degree of freedom, t- Calculated t value, P- Probability level.

The effect size was calculated to measure the magnitude of the difference between the two groups. This was found to be 0.08 indicating a large difference between the two teaching method

Questionnaire Analysis

After post-test two both groups were given a questionnaire to obtain their attitudes towards the guided discovery learning method. A Likert scale was used to obtain attitudes ranging from one extreme of agreeing to the other extreme of disagreeing. Frequencies in form of percentages were computed and central tendency was calculated for each questionnaire item as shown in Table 6 below.

TABLE 6. ***Learner's responses to the questionnaire***

	STATEMENT	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE	MEDIAN	MODE
		PERCENTAGE						
1	Chemistry is a useful subject I learn at School.	70.7	29.3	0	0	0	1	1
2	Identification of ions became an interesting topic after discovering concepts on my own.	53.3	46.6	0	0	0	1	1
3	I was able to discover different ions in the experiment which was important in my learning experience	70.7	29.3	0	0	0	1	1
4	I was able to discover different Ions from the formed precipitates which gave me an opportunity to apply theory to practice.	53.4	44.8	0	0	1.7	2	2
5	I was able to differentiate Ions correctly	44.8	43.1	6.9	5.2	0	2	1
6	Doing the experiment improved my understanding of different Ions.	60.3	34.5	3.4	0	1.7	1	1
7	I am able to contribute my views on issues relating to which Ions are soluble and insoluble in excess NaOH and which ion forms a particular ppt	27.6	55.2	10.3	6.9	0	2	2
8	My experience in discovering how different ions behave will improve my performance on this topic	55.2	43.1	0	1.7	0	2	2
9	I would like to experience this kind of learning with other topics in chemistry	72.4	27.6	0	0	0	1	1
10	The experience made me want to learn more about ions and their behavior in aqueous solutions	70.7	27.6	1.7	0	0	1	1

1=strongly agree, 2=agree, 3 = neither agree nor disagree, 4=disagree, 5=strongly disagree.

The analysis was done using SPSS version 22. For each questionnaire item the median and mode were computed to characterize middleness. The median and mode were used because they are less affected by extreme scores.

Median for each questionnaire item was found to range between 1 and 2 i.e. strongly agree and agree, respectively. This shows that most learners appreciated learning identification of ions using guided discovery and that they would like to learn other chemistry topics using this method. The analysis was triangulated (using another measure to find central tendency) using the mode and it was seen that the mode for each questionnaire item was also between 1and 2. The overall mean and mode were calculated and the results that in both cases were 1 was found which translates to learners having a positive attitude towards the teaching method.

Discussion and Conclusion

In this study, it has been found that using guided discovery learning in the teaching of chemistry 5124 identification of ions concepts has a positive impact on learner performance. Learners who were taught using guided discovery method performed significantly better than learners who were taught using conventional method. The study has also revealed that learner attitudes towards the guided discovery teaching method were positive because learners expressed a desire to learn more chemistry topics using this method. These results are consistent with other studies carried out on guided discovery learning. In the United Arab Emirates Hasan (2012) found that after implementing guided inquiry instruction in the teaching of environmental biology, it had a significant effect in improving students' academic achievement and developing nature of science conceptions. Wilke and others (2001) carried out a study using moderate amount of discovery learning and its effects on students' achievement and attitudes towards instruction in a lower biology course in America. The study revealed that moderate amount of discovery used in combination with the traditional method of instruction was an effective means of promoting students' achievement. In West Africa Bamiro (2015) carried out a study which compared guided discovery, thin-pair share, and lecture me on secondary school achievement in chemistry. The findings of the study were that guided discovery learning and thin-pair share strategies had a great potential for

improving achievement in chemistry and science learning generally.

The implications of these findings are that if guided discovery learning is properly implemented in schools with similar characteristics like that of Matete Secondary School and similar sets of learners taking chemistry 5124, these schools will highly benefit from such a teaching strategy. The benefits of such a teaching strategy will come in form of improved learner performance in the identification of ions concepts as well as other chemistry concepts at large. This will in turn improve the performance of learners in chemistry and science as a whole.

Attitudes of learners have also been explored in some previous studies that incorporated guided discovery learning with other teaching strategies. Such studies include Bilgin (2009) who explored learner attitudes towards guided discovery instruction. He found that learners showed positive attitudes during learning of acid and base concepts using guided discovery instruction.

This study has shown that if guided discovery learning is incorporated in the teaching of chemistry 5124 identification of ions concepts and if it is systematically handled a positive impact on learner performance may result. The study has also shown that learners had positive attitudes towards the teaching method. If this teaching method is used in similar situations it may improve learner performance.

This study recommends that chemistry topics should be taught by giving learners an experience so as to enable learners to actively participate because this will enhance the understanding of these scientific concepts. Learners may also be guided to discover scientific concepts on their own with minimal help from the teacher. This will enable learners to verify scientific concepts by engaging fully with their minds and hands.

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