Assessing the impact of Discovery Learning approach on Grade 11 learner Performance in learning salts: A case of Nkana Secondary School

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Abstract— This study explored the impact of discovery learning on the performance of grade 11 learners in the identification of ions. The research design used was a Quasi-Experimental Control group. Chemistry achievement test (Pre-test and Post-test) and a Likert scale questionnaire were used to collect data. The experimental group was taught using discovery method while the control group was taught using the conventional (discussion) method. In order to engage the learners in the learning process, the 5E learning model developed by Bybee in 1980 was integrated in the guided discovery method. The 5E represents Engagement, Exploration, Explanation, Elaboration, and Evaluation. An independent samples t-test was run to compare the two group means. These results from the achievement test revealed there was a significant difference between guided discovery learning and conventional (discussion) learning. It was concluded that 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.

Key words— Achievement, Assessing, attitudes, discovery learning, performance.

1 Introduction

In my teaching experience as a Science teacher, I have come to discover that chemistry is not one of the liked subjects by learners because most of them consider it to have challenging topics. One of the topics which is considered to be challenging to most leaners is Identification of Ions, a very important topic in Chemistry. This topic involves demonstrating the identity of aqueous cations and anions. There are so many factors that affect the learners' understanding of this topic such as; teaching methods and approaches, lack of teaching aids and text books.

According to Examinations Council of Zambia performance reports, the general performance in sciences has had a low mean performance. The year 2013 had a mean percentage in science of 33.94%, 2014 was 17.7% and 2016 was 32.8%. The chief examiner highlighted that candidates showed poor psychomotor skills in practical's and applying theoretical knowledge to explain observations and results from experiment. Another highlight was that the performance on qualitative analysis was poor because candidates were failing to express their results as required by the given notes on the identification of ions, leading to a poor performance on acids, bases and salts (Performance Review Report). 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 will focus its attention on one of the methods that can enhance learner understanding of science concepts namely, discovery learning. Discovery learning engages a learner in direct purposeful activities and therefore results in improved performance (Bruner, 1961).

In order to achieve engagement of a learner in direct purposeful activities, the 5E learning model which represents Engagement, Exploration, Explanation, Elaboration, and Evaluation developed by Bybee in 1980 as a teaching model was used. The results of Akar, (2005) were that instruction based on the 5E learning model caused a significantly better acquisition of scientific conceptions related to acids-base concepts than traditionally designed instruction. Based on these findings the research shall incorporate the 5E learning model. In this method learners will be exposed to engagement where they will be given chance to actively participate in a question asked by the teacher from what they already know, exploration where they will work in groups without direct instruction from the teacher, explanation where teacher encourages learners to explain concepts in their own understanding, elaboration where they will apply the skill in new but similar situation and lastly evaluation in which the teacher will observe students' knowledge and skill.

Constructivists like Bruner emphasize that discovery learning enhances meaningful learning were a learner is capable of relating new information to the information on the cognitive structure.

The Zambian chemistry syllabus is divided as follows: pure chemistry (5070) and combined science (5124) which comprises of two sections. Section A is physics and the second section B is chemistry. In combined science chemistry comprises of 12 units and under unit 11.5 are Acids, Bases and Salts. It comprises of a component on qualitative analysis that includes identification of ions on unit 11.6.4 (chemistry syllabus).

This section on identification of ions in the syllabus includes three categories that are; knowledge, skills and values. In knowledge the learner identifies cations and anions in aqueous solutions. The cations being aluminum, ammonium, calcium, copper (II), iron (II), iron (III) and zinc, and the anions being carbonate, chloride, iodide, nitrate and sulfate. In skills, the learner shows skills that include the observing and interpreting of the reactions of ions, the communication of information on the chemical composition of salts, and being able to conclude on which ions are present in which aqueous solutions. Lastly in values, the learner is expected to apply safety rules during experiments and be able to work collaboratively (chemistry syllabus).

The Zambian chemistry syllabus emphasizes on the learner acquiring knowledge through manipulating, communicating, interpreting, observing and collaborating.

2 Research Design and Methodology

According to Philliber et al (1980), research design is a "blueprint" for research, dealing with at least four problems: which questions to study, which data are relevant, what data to collect and how to analyze the results. The research targeted grade 11 learners and it employed a pre-test post-test control group quasi experimental research design. Pre-test was administered to the experimental group and control group to determine whether students had any pre-existing knowledge on the topic of salts. An intervention to the experimental group in form of discovering concepts on identification of ions and the control group through discussion method was administered, thereafter, a post was given to both groups. Random assignment was used to assign experimental and control group through a coin (heads and tails).

2.1.1. Pre-Intervention

This stage involved a practical test being given to both groups that helped in finding out about what an ion is and identification of ions from aqueous salts. The reason for this stage was to gauge the homogeneity of the two groups, the questions required them to use the prior knowledge of symbols, valences, chemical formulae and salts. It also helped the researcher to understand the baseline information the learners have on ions.

2.1.2. Intervention

This is the stage that involved teaching of identification of ions through discovery method to the experimental group and conventional method (discussion and lecture) to the control group. During the intervention the experimental group adopted the 5E learning model. This design was modified according to the research questions and objectives. The 5E learning model was used because it consists of very important stages that allow the learner to be actively involved in the exploration of scientific concepts, table 1.2 describes how the cycle was used.

Table 1.2.Steps in the 5E learning cycle model.

Step	Teacher Activity	Learner Activity	Conclusion
One	**Engagement** Teacher generated curiosity in the learners by starting with sodium chloride (salt) which is what they use at home and what they understand by the term salt. Thereafter, asking the learners what an ion is and the difference between soluble and insoluble salts	Carefully examine the given substance and relate it to the question by giving definitions and relations that exist between a salt and an ion	Learners will be able to critically think and see relationships between what they use in day to day lives and what they learn in class. Learners to recall different types of ions
Two	**Exploration** Teacher gave an opportunity to learners to work in groups of two in order for them to observe what is happening in the given solutions by following the instructions on the worksheet	Observing what is happening by manipulating the given materials	Record the observed results and make conclusions on which ion is present and why that particular ion.
three	**Explanation**		

	Asked the learners to use the observed results to give a clarification of their explanation by posing questions in relation to each ion identified	By integrating the observed results, they give evidence of what they have observed through presentations	Learners will be able to effectively communicate what they have discovered with confidence
four	**Elaboration** Teacher allowed learners to apply concepts and skills in new but similar situation	Need to consider existing data and evidence as they explore new situations to make decisions	Learners will be able to acquire critical thinking skills and apply them beyond classroom setup
Five	**Evaluation** This stage took place throughout but learners will be given a performance test at the end of the topic	Learners will be given an opportunity to manipulate materials as an individual and answer questions	Problem solving will be an important skill learners will acquire at this stage

All the above processes were given to the experimental group in identification of ions, and the teacher in this case will be a facilitator or a co-explorer. The experimental group was exposed to identification of cations whereas the control group will be taught identification of cations using conventional method (lecture).

2.1.3 Post intervention

This stage of the research design was carried out in one stage. The stage involved administering a practical test to both groups on cations and anions which were identified in aqueous solutions. A questionnaire to determine learner attitudes towards the teaching method was administered to the learners at the end in order.

2.2 Study Population

The grade eleven's of Nkana Secondary School were used in this research. The school comprised of four classes. There are one hundred and twenty (120) grade eleven learners and the researcher only used 40 learners from two classes. One was the experimental group and the other class was used as control group this was because at the time of data collection, classes were alternating and management only gave the researcher to work on specific times.

2.3 Research Instruments

The researcher used two research instruments to capture data namely, a performance test to collect scores and a questionnaire to collect attitudes of learners. The questionnaire was in form of a Likert scale adopted from the faculty of education at University of Cambridge. Validity of the performance test was done with the help of an expert who is my supervisor and also the questionnaire was piloted with just one class before administering it to a larger sample.

3.0 DATA ANALYSIS

According to Sekeram (2003), data analysis comprises of three objectives such as, getting a feel of the data, testing the goodness of the data and answering the research questions this author also noted that establishing the goodness of data leads to credibility. Subsequent analysis and findings measure the reliability and the validity of the measures used in the study. Data scores of the pre-test and post-test were calculated out of 100 and are given in Appendices H, I and J respectively. A likert scale was used to measure attitudes of learners towards discovery learning. Statistical Package for Social Sciences version 22 (SPSS) was then used to analyze the different data sets. Figures 4.1 and 4.2 show distributions of the pre-test and post-test respectively. Means of the pre-test, post- test one and post-two and their standard deviations are given in Table 4.1. Grade 11A was taught using the conventional method and 11K was taught using guided discovery learning.

Figures 2,3,4 and 4 show distributions of the pre-test and post-test respectively

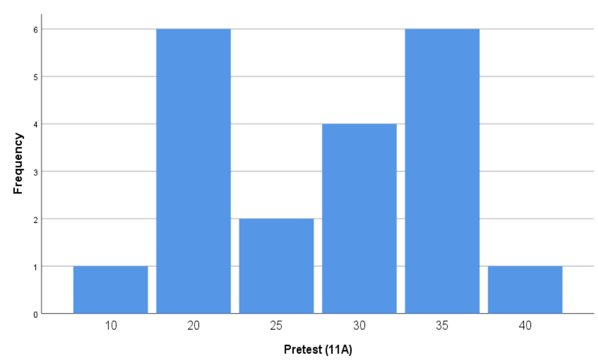

Figure 1: Pre-test distribution of 11 A (Control Group)

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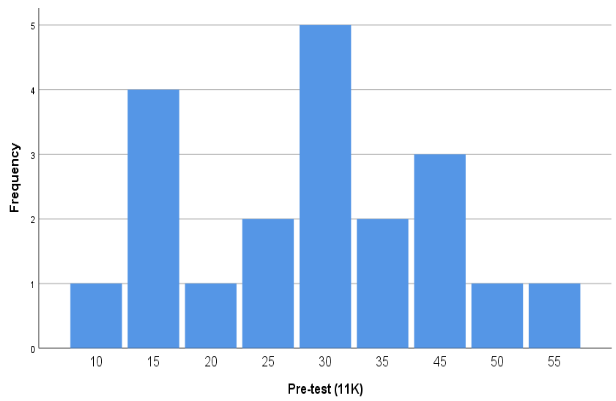

Figure 2:Pre-test distribution of 11 K (Experimental Group)

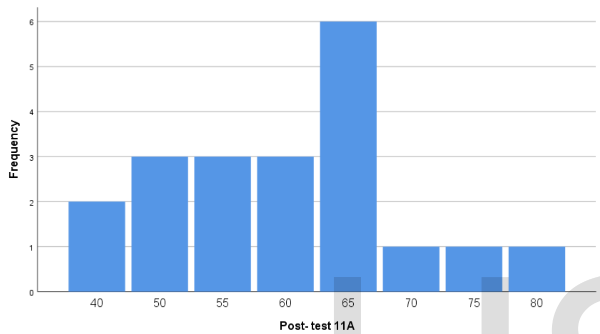

Figure 3: Post-test distribution of 11 A (Control Group

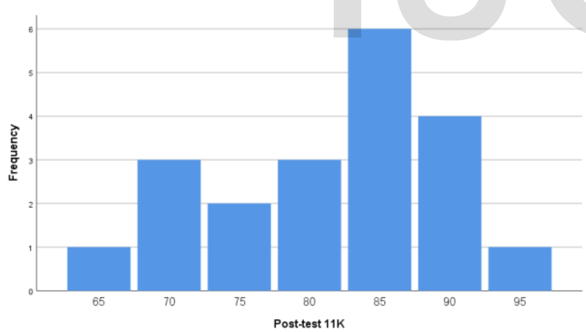

Figure 4: Post-test distribution of 11 A (Experimental Group)

Table 4.1. Mean and Standard deviation of the Pre-test and Post-test for the two classes (11A and 11K)

	Grade 11A (20)		Grade 11K (20)	
	Mean	SD	*Mean*	SD
Pre-test	28	8	30	12
Post-test	60	10	81	8

SD- Standard deviation

One important assumption of a t-test is that data is normally distributed. Field (2009) states that normality of a data set can be checked by converting skewness (asymmetry) and kurtosis (how flat or peaked the distribution is) to a z-score. If the z- score falls between -1.96 and +1.96 then the data is assumed to be normally distributed, therefore before a t-test was carried out a normality test was carried out and the following values were obtained as shown in Table 4.2

	Skewness	SE	Z-Score	kurtosis
Pre-Test	0.34	0.31	1.58	0.37
Post-Test	0.02	0.31	0.34	-1.21

SE-Standard Error (standard deviation of a sampling distribution)

From the data above it can be seen that the z-scores were within acceptable values meaning that the data was normally distributed. An independent sample t-test was used to determine the homogeneity of the groups and results are shown in table 4.3

Table 4.3.Comparison of the Pre-test scores for Discovery group (11_K) and Conventional group (11_A)

Scores					T-test	
	N	*Mean*	*SD*	df	t	p
Discovery	20	30	12	18	0.734	0.106
Conventional	20	28	8			

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

11A was taught identification of ions using conventional method and 11K was taught using guided discovery method. Scores of the pre -test and post-test of both groups were compared within themselves through a paired sample t test to see the effect of the treatment. The results show that both groups improved after instruction but the guided discovery group (11_K, Table 4.4) improved more than the conventional group (11_A, Table 4.5). A significant difference between the pre-test score and the post score within each group was observed as $p < 0.05$ *in both cases.*

Table 4.4. Paired Sample t-test for Guided Discovery group (11_K)

Scores	N	*Mean*	*SD*	df	t	Test p
Pre-test	20	30	12	18	-13.6	0.00
Post-test	20	81	8			

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

Table 4.5. The paired sample t-test for Conventional group 11A.

Scores	N	*Mean*	*SD*	df	t	T-test P
Pre-test	20	28	7	18	-15.3	0.00
Post-test	20	60	10			

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

To examine the difference between the guided discovery and conventional teaching methods, post-test scores of the two groups were subjected to an independent sample t test. The post-test scores of the experimental (guided discovery) group (11K) showed a greater improvement than that of the control group (11A). The independent t test showed that there was a significant difference between the two teaching methods as shown in Table 4.6.

Table 4.6.Comparison of Post-test one scores for Guided Discovery (11K) and Conventional group (11A)

Scores	N	*Mean*	*SD*	df	t	T-test P
Discovery	20	81	8	38	2.72	0.04
Conventional	20	60	10			

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

Effect size is the magnitude of the difference between control group and experimental group was calculated, it also shows whether the difference occurred by chance or not (Pallant, 2005).

Effect size can be calculated using Eta Squared. 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, it can therefore, be concluded that the difference between the discovery group and the conventional group shows a large effect size.

4.2 Questionnaire Analysis

At the end of the post-test, learner attitudes towards the teaching methods were determined using a Likert scale questionnaire. According to Survey Monkey (2014), a Likert scale is defined as one that measures attitudes and behaviors using choices ranging from one extreme of agreeing to the other extreme of disagreeing

A 10-item questionnaire designed in a 5-point Likert scale ranging from '1' representing strongly agree to '5' representing strongly disagree (Appendix-G) was administered to the learners who participated in this study at the end of post-test two to examine their attitude on guided discovery learning instruction. This helped to determine the degree of agreement with a statement about the use of discovery learning. Twenty (20) participants from the guided discovery group answered the questionnaire. The data was entered into SPSS and the frequencies and percentages were determined. Table 4.7 gives learners' responses to the questionnaire.

Table 4.7. Learner's responses to the questionnaire

The participants in groups (n=20)					
Frequency Times (n=20) and percentages					
Question items	1	2	3	4	5
1.Chemistry is a useful subject I learn at school	(6) 30%	(11) 55%	(1) 5.0%	(1) 5.0%	(1) 5.0%
2.Identification of ions became an interesting topic after discovering concepts on my own	(2) 10%	(11) 55%	(5) 25%	(2) 10%	-------
3 I was able to discover different ions in the experiment which was important in my learning experience	(5) 25%	(11) 55%	(3) 15%	-------	(1) 5%
4. I was able to discover different Ions from the formed precipitates which gave me an opportunity to apply theory to practice.	(5) 10%	(17) 85%	(2) 10%	-------	------
5. I was able to differentiate Ions correctly.	(10) 50%	(9) 45%	(1) 5%	-------	-------
6.Doing the experiment improved my understanding of different Ions	(7) 35%	(6) 30%	(4) 20%	……	(3) 15%
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 precipitate	(8) 40%	(9) 45%	(2) 10%	(1) 5%	-------
8.My experience in discovering how different ions behave will improve my performance on this	(7) 35%	(6) 30%	-------	(7) 35%	-------

topic					
9. I would like to experience this kind of learning with other topics in chemistry.	(12) 60%	(8) 40%	-------	-------	------
10. The experience made me want to learn more about ions and their behavior in aqueous solutions.	(15) 75%	(4) 20%	(1) 5%	-------	------

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

All Likert scale items in this study were designed with a view to exposing learner attitudes towards minimally guided discovery learning, for example, the interest towards this mode of instruction was investigated by using the Likert scale item that asked students' opinion whether they would like to experience learning of this kind with other chemistry topics. The result of this investigation was that most learners strongly agreed giving the highest percentage of approximately 60% and 40% merely greed to the statement. Another Likert scale item asked for the learners' opinion if this kind of learning would improve their performance on this particular topic, the results of this investigation was that slightly above half of the learners strongly agreed giving a percentage of 35%, about 30% merely agreed to the statement and only approximately 35% disagreed.

After exposure to guided discovery learning, learners' developed courage to contribute their views on issues relating to which cation is soluble and which one is insoluble in sodium hydroxide. Learners were also capable of contributing their views on which anion produced a particular precipitate when added to a particular substance. The results of this investigation were that 40% of the learners strongly agreed, 45% agreed, 10% neither agreed nor disagreed and 5% disagreed.

The Likert scale was also formulated to investigate if students would like to learn more about cation and anion behavior in aqueous solutions. The outcome of this result showed that approximately 75% strongly agreed that they would want to learn more, 20% merely agreed and 5% neither agreed nor disagreed. The general picture of how 11K experimental group students answered the questionnaire is shown in figure 4.3.

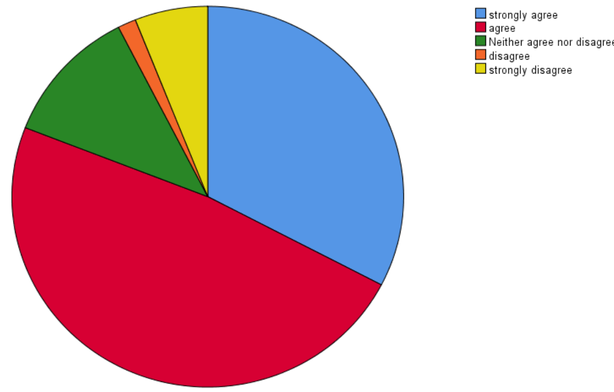

Figure 5: General picture of questionnaire answers from 11K

The central tendency which is a representative number that characterizes middleness of a data set was calculated (Jackson 2009). Median (middle number) and Mode (frequent number) for each statement were used to measure central tendency independently as shown in n in Table 4.8.

Table 4.8. Calculated Median and Mode for each questionnaire item

Statement	N	Median	Mode
1	20	1	2
2	20	2	1
3	20	1	2
4	20	2	2
5	20	2	1
6	20	1	2
7	20	2	2
8	20	2	2
9	20	1	1
10	20	2	1

The overall median was calculated to be 2 which translate to agreeing with most statements. The overall mode was also calculated as a confirmatory statistic and it was found to be 2. These results showed that most learners showed a positive attitude towards the teaching method.

5.0 DISCUSSION OF RESEARCH FINDINGS

5.1 Learner's performance

Discovery learning in this quasi-experimental research design incorporated activities inspired by the 5E learning model which included stages such as engagement, exploration, explanation, elaboration and evaluation. This produced gains in achievement tests based on the identification of aqueous ion concepts used in the study. Progress was seen after the analysis of the post-test scores. Gains in terms of class average which is the mean were seen in both teaching method strategies (discovery and discussion teaching methods) but more gain was observed in the discovery group.

Results from the pre-test showed that there was no statistical significant difference between the two groups (discovery group and discussion group) in relation to the knowledge on identification of ions. This means that at the start of the research the two groups were homogeneous (same) because of the p-value which was found to be greater than the set significance level $(p > \alpha)$ as seen in Table 4.3.

Scores of the discovery group (11ᴋ) increased in post-test one from the pre-test mean of 30 to post-test one mean of 81. This increase was statistically significant. Similarly, there was an statistically significant increase in the mean score for the control (discussion) group from a pre-test man of 28 to post-test one mean of 60. In both cases for the experimental and the control $p < \alpha$ showing that learning had taken place in both cases.

The gain score on the performance of students in relation to identifying aqueous cations from the pre-test to the first post-test after implementation of discovery learning showed no significant difference. In agreement with previous studies (Yuliana and others, 2016; Hasan, 2012). The gain score of the guided discovery teaching did not reach a statistical significance level upon comparison with the conventional method. The group that used discovery teaching approach in collaboration with the 5E learning model gained more chemistry concepts and had a high mean retention than the conventional group in the results. This could have been caused by the experience given to the students where they were able to explore scientific concepts through the manipulation of laboratory apparatus (Dale, 1954).

Students showed enjoyment as they worked through the worksheets. The steps involved

- Engagement of the learners to actively participate in class
- Explorations through manipulation of laboratory equipment and seeing the actual precipitates formed so as to come up with conclusions
- Explanations by teacher came in to consolidate what they discovered on the different aqueous solutions
- Elaboration of the different ions identified by the learners through an exercise to consolidate their conceptual understanding of ions
- Evaluation by the teacher through giving the learners feedback and feedforward on their explanations and elaborations on the identification of ions concepts.

Similar to the current study, the guided discovery group had a significantly higher understanding of scientific concepts than the control group in a research conducted by Yuliana and others (2016). They concluded that guided discovery learning is very effective to achieve meaningful learning. The independent sample t-test between the discovery group and the conventional group showed a significant difference between the two teaching methods as shown Table 4.6.

This research concurs with Lasisi and others (2016) who emphasized that guided discovery teaching is one of those teaching methods that employ exploration, experimentation, and manipulation to find out new ideas and found that guided discovery learning enhances learner understanding of chemistry concepts.

The implications of these findings are that if guided discovery learning is properly implemented in schools with similar characteristics like that of Nkana 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 improving learner performance in the identification of ions concepts and other chemistry concepts at large. This will in turn improve the performance of learners in chemistry as well as science as a whole.

It is important to note that the success of discovery learning at national level would largely depend on how many schools implement the teaching strategy and how well this teaching method is implemented e.g. not leaving learners to entirely discover concepts on their own which may lead to learners having misconceptions

5.3 Learner attitudes

In order to find out learner attitudes on minimally guided discovery learning instruction a 10 item Likert scale attitude questionnaire was given to participants in both groups at the end of the treatment. The questionnaire assessed attitudes of learners towards this method of learning (discovery learning) and attitudes towards the topic identification of ions as shown in Table 4.7 The learner perception of the teaching approach was modelled around discovery learning on how different ions behave and how this teaching approach will improve their performance and understanding of chemistry concepts. Question 8 showed that 7 learners strongly agreed that discovery learning would improve their performance on this topic bringing the percentage to 35% and 6 merely agreed to the fact, giving a percentage of 30%. In item 9, 60 % of the learners strongly agreed that they would like to experience discovery learning with other chemistry topics.

The attitudes of learners have also been explored in some previous studies that compared guided discovery learning with other teaching strategies in line with the current study, such studies include Akar (2005) who explored learner attitudes towards teaching science using the 5E learning model. He found that learners showed positive attitudes during teaching and concluded that attitudes of learners towards a particular teaching method in used should be considered while teaching chemistry.

From Table 4.8 the overall median and mode were calculated from the responses of the participants. The general results showed that learners agreed to learning chemistry through guided discovery learning in the teaching and learning of chemistry. It can be seen that when discovery learning is in cooperated in a chemistry lesson, learners tend to show positive attitudes towards the learning of chemistry.

The implication of the questionnaire results are that if this kind of learning is used, learners will generally have positive attitudes towards the subject, can easily relate chemistry concepts to each other, and they will be able to adapt to the teaching environment easily because of the experience given to them. Discovery learning can in turn enhance learner conceptual understanding (Brunner, 1964). This is a teaching method that can help to improve the performance of learners in Zambia and the world at large.

According to the present study, the general picture of learner attitudes towards discovery learning is positive. This purely means that the integration of discovery learning in the teaching and learning enhances understanding of chemistry concepts and in turn improve their performance. If this teaching strategy is implemented in similar sets of learners, it can be welcomed. This is an important aspect in any kind of learning because a positive attitude towards learning a particular concept, gives learners positive energy and a drive to learn beyond a classroom setup.

The findings of this study revealed that guided discovery learning is an effective way of teaching the identification of ions concepts and the positive attitudes toward the teaching strategy translates to all kinds of benefits that come with it such as a better understanding of content knowledge, improved problem-solving skills and improved student communication skills.

6.0. CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions and recommendations on the findings of the study.

6.2 Conclusions

The study established that there is a positive impact on the use of discovery learning instruction on the identification of ions concepts.

From the study, it can also be concluded that giving learners chance to discover science concepts on their own in a science classroom fully engages them in a lesson. After undergoing guided discovery learning in collaboration with the 5E learning cycle, learners developed communications skills, collaboration skills, critical thinking skills and they were able to hypothesize, evaluate and draw conclusions based on their experience. Learners were involved in hands on and minds on activities which helped them to participate in scientific investigations to verify science concepts on their own.

It can also be concluded that if learners are given a practical experience, learning will be very effective because learners will not only see science concepts from an abstract point of view without marrying it to any practical work.

Furthermore, the findings revealed that learners viewed discovery learning with positive attitudes as they enjoyed the lesson progression and want to learn other chemistry topics using this mode of instruction.

6.3. Recommendations

1. Chemistry topics should be taught by giving learners practical experience so as to enable learners to actively participate and this will enhance the understanding of these scientific concepts.
2. Learners should 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.
3. Learners should be encouraged to develop personal experiences in the learning process as this may help them retain a great percentage of knowledge learnt hence a better performance. This may be done through practicals.
4. Curriculum developers should emphasize on the use of experiential learning during the teaching of topics like identification of ions as this will enable learners to learn meaningfully according to Brunner 1961.
5. Further research can be conducted by using this mode of instruction with other chemistry topics, by increasing the number of schools and also by carrying out this particular combination of discovery learning and 5E learning cycle in different schools.
6. A study of this nature can be carried out in other sciences such as biology and physics.

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