

**The impact of enrichment programs on the performance of gifted Science learners.**

**By**

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**DECLARATION**

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I declare that **The impact of enrichment programs on the performance of gifted Science learners** is my work and all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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27th September 2013.

## **Abstract**

In the majority of schools gifted learners are given the same quantity and quality of academic work as their non-gifted classmates. In some cases gifted learners are left to look after themselves when they are done with class work or worse still, asked to teach their non-gifted classmates.

Some educationists advocate for a differentiated curriculum between gifted and non-gifted learners. This study sought to establish the impact of enrichment programs to gifted Science learners. Forty gifted learners were identified and drawn equally into one of the two groups — experimental or control.

These learners wrote a pre-test after which the twenty learners in the experimental group received enrichment. The forty learners then wrote the same post-test to assess their understanding of the concepts learnt.

The cycle was repeated but with a different topic. Learners' marks were compared and it emerged all twenty learners in the experimental group performed better than those in the control group. Gifted learners should therefore be given enrichment as it deepens, broadens, and sharpens their understanding of concepts.

## **Key terms:**

Giftedness, Enrichment, Enrichment programs, Gifted Science learner, Science education, Academic performance, Pre-test, Differentiated curriculum, Post-test, Experimental group

## **List of abbreviations:**

ADHD.....Attention Deficit Hyperactivity Disorder

CAPS.....Curriculum Assessment Policy Statement

DoE.....Department of Education

DVDs.....Digital Video Devices

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<b>TABLE OF CONTENTS</b>	<b>PAGE</b>
<b>DECLARATION.....</b>	<b>ii</b>
<b>ABSTRACT.....</b>	<b>iii</b>
<b>KEY TERMS.....</b>	<b>iii</b>
<b>LIST OF ABBREVIATIONS.....</b>	<b>iii</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>v</b>
<b>CHAPTER 1</b>	
<b>1.1 INTRODUCTION/BACKGROUND.....</b>	<b>1</b>
<b>1.2 MOTIVATION FOR THE RESEARCH.....</b>	<b>4</b>
<b>1.3 PROBLEM STATEMENT.....</b>	<b>6</b>
<b>1.4 RESEARCH QUESTION.....</b>	<b>6</b>
<b>1.5 AIM OF THE RESEARCH.....</b>	<b>6</b>
<b>1.6 DEFINITION OF CONCEPTS.....</b>	<b>6</b>
<b>1.7 LIMITATIONS OF STUDY.....</b>	<b>7</b>
<b>1.8 CHAPTER OUTLINE.....</b>	<b>8</b>
<b>CHAPTER 2</b>	
<b>LITERATURE REVIEW.....</b>	<b>9</b>
<b>2.1 INTRODUCTION.....</b>	<b>9</b>
<b>2.2 DEFINITIONS OF GIFTED STUDENTS.....</b>	<b>10</b>
<b>2.3 DEFINITIONS OF ENRICHMENT.....</b>	<b>19</b>
<b>2.4 TYPES OF ENRICHMENT PROGRAMS.....</b>	<b>22</b>
<b>2.5 BENEFITS DERIVED FROM ENRICHMENT PROGRAMS.....</b>	<b>39</b>
<b>2.6 CONCLUSION.....</b>	<b>42</b>

## **CHAPTER 3**

<b>3.1 INTRODUCTION.....</b>	<b>43</b>
<b>3.2 RESEARCH METHODS AND DESIGN.....</b>	<b>43</b>
<b>3.3 SAMPLING.....</b>	<b>48</b>
<b>3.4 DATA COLLECTION AND ANALYSIS.....</b>	<b>50</b>
<b>3.5 VALIDITY AND RELIABILITY.....</b>	<b>54</b>
<b>3.6 STATEMENT ON RESEARCH ETHICS.....</b>	<b>60</b>
<b>3.6.1 INFORMED CONSENT.....</b>	<b>61</b>
<b>3.6.2 CONFIDENTIALITY AND ANONYMITY.....</b>	<b>61</b>
<b>3.6.3 VOLUNTARY PARTICIPATION.....</b>	<b>62</b>
<b>3.6.4 FULL DISCLOSURE OR DECEPTION.....</b>	<b>63</b>
<b>3.7 CONCLUSION.....</b>	<b>63</b>

## **CHAPTER 4**

<b>4.1 INTRODUCTION.....</b>	<b>65</b>
<b>4.2 DATA PRESENTATION AND ANALYSIS.....</b>	<b>66</b>
<b>4.3 SUMMARY.....</b>	<b>107</b>
<b>4.4 DISCUSSION OF RESULTS OF THE RESEARCH.....</b>	<b>111</b>
<b>4.5 CONCLUSION.....</b>	<b>115</b>

## **CHAPTER 5**

<b>5.1 INTRODUCTION.....</b>	<b>116</b>
<b>5.2 SUMMARY OF THE RESEARCH.....</b>	<b>116</b>
<b>5.3 CONCLUSION OF THE RESEARCH.....</b>	<b>120</b>
<b>5.4 RECOMMENDATIONS.....</b>	<b>123</b>

<b>5.5 REFERENCES.....</b>	<b>125</b>
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## **LIST OF TABLES**

<b>TABLE 1 Example of distribution frequency table.....</b>	<b>53</b>
<b>TABLE 2 Pre-test 1 scores for all learners.....</b>	<b>67</b>
<b>TABLE 3 Learners who obtained 62 % in Pre-test .....</b>	<b>70</b>
<b>TABLE 4 Learners who obtained 68 % in Pre-test 1.....</b>	<b>70</b>
<b>TABLE 5 Learners who obtained 70 % in Pre-test 1.....</b>	<b>71</b>
<b>TABLE 6 Learners who obtained 72 % in Pre-test 1.....</b>	<b>72</b>
<b>TABLE 7 Learners who obtained 74 % in Pre-test 1.....</b>	<b>72</b>
<b>TABLE 8 Learners who obtained 76 % in Pre-test 1.....</b>	<b>73</b>
<b>TABLE 9 Post-test 1 scores: Control group .....</b>	<b>77</b>
<b>TABLE 10 Frequency distribution: Post-test 1 scores: Control group. ....</b>	<b>80</b>
<b>TABLE 11 Post-test 1 scores: Experimental group.....</b>	<b>80</b>
<b>TABLE 12 Frequency distribution: Post-test 1 scores: Experimental group.....</b>	<b>83</b>
<b>TABLE 13 Pre-test 2 scores: Control group.....</b>	<b>85</b>
<b>TABLE 14 Frequency distribution: Pre-test 2 scores: Control group.....</b>	<b>87</b>
<b>TABLE 15 Pre-test 2 scores: Experimental group .....</b>	<b>88</b>
<b>TABLE 16 Frequency distribution: Pre-test 2 scores: Experimental group.....</b>	<b>90</b>
<b>TABLE 17 Post-test 2 scores: Control group.....</b>	<b>93</b>
<b>TABLE18 Frequency distribution: Post-test 2 scores: Control group .....</b>	<b>95</b>
<b>TABLE 19 Post-test 2 scores: Experimental group.....</b>	<b>96</b>
<b>TABLE 20 Frequency distribution: Post-test 2 scores: Experimental group.....</b>	<b>99</b>
<b>TABLE 21 Comparison of the different means for the two groups.....</b>	<b>107</b>



## **LIST OF FIGURES**

<b>FIGURE 1 Summary of data collection process.....</b>	<b>59</b>
<b>FIGURE 2 Pre-test 1 scores: Control group.....</b>	<b>74</b>
<b>FIGURE 3 Pre-test 1 scores: Experimental group.....</b>	<b>75</b>
<b>FIGURE 4 Post-test 1 scores: Control group.....</b>	<b>79</b>
<b>FIGURE 5 Post-test 1 scores: Experimental group.....</b>	<b>84</b>
<b>FIGURE 6 Pre-test 2 scores: Control group.....</b>	<b>88</b>
<b>FIGURE 7 Pre-test 2 scores: Experimental group.....</b>	<b>91</b>
<b>FIGURE 8 Post-test 2 scores: Control group .....</b>	<b>96</b>
<b>FIGURE 9 Post-test 2 scores: Experimental group.....</b>	<b>99</b>

## **LIST OF APPENDICES**

<b>APPENDIX A STUDENT ASSENT FORM.....</b>	<b>133</b>
<b>APPENDIX B PRETEST 1 QUESTIONS.....</b>	<b>135</b>
<b>APPENDIX C PRETEST 1 MEMORANDUM.....</b>	<b>138</b>
<b>APPENDIX D POSTTEST 1 QUESTIONS.....</b>	<b>139</b>
<b>APPENDIX E POSTTEST 1 MEMORANDUM.....</b>	<b>145</b>
<b>APPENDIX F PRETEST 2 QUESTIONS.....</b>	<b>148</b>
<b>APPENDIX G PRETEST 2 MEMORANDUM.....</b>	<b>152</b>
<b>APPENDIX H POSTTEST 2 QUESTIONS.....</b>	<b>154</b>
<b>APPENDIX I POSTTEST 2 MEMORANDUM.....</b>	<b>158</b>
<b>APPENDIX J RUBRIC FOR RESEARCH QUESTIONS.....</b>	<b>161</b>
<b>APPENDIX K RESEARCH PROJECT.....</b>	<b>163</b>

<b>APPENDIX L INTERVIEW QUESTIONS.....</b>	<b>164</b>
<b>APPENDIX M TRANSCRIPTS OF INTERVIEWS.....</b>	<b>165</b>
<b>APPENDIX N UNSIGNED LETTER OF PERMISSION FROM THE PRINCIPAL.....</b>	<b>181</b>
<b>APPENDIX O SAMPLE OF LEARNERS' WORK .....</b>	<b>182</b>
<b>APPENDIX P SIGNED LETTERS OF PERMISSION FROM PRINCIPALS AND DISTRICT OFFICE.....</b>	<b>194</b>
<b>APPENDIX Q LANGUAGE CLEARANCE CERTIFICATE.....</b>	<b>198</b>

## **CHAPTER ONE**

### **1.1 INTRODUCTION/ BACKGROUND**

There can be few teachers who have not encountered the concepts of ‘giftedness’, ‘the talented’, or creative thinking, or failed to detect the upsurge of interest in recent years. This has prompted some governments to sponsor research dedicated to the task of identifying, measuring, cultivating, and exploiting the potential of exceptional learners in their countries (Child 2004: 253). Unfortunately most government-funded programs are focused on meeting the needs of ‘at-risk’ learners and not for providing assistance to the gifted learners (Clark 2008: 6). This tendency, therefore, leaves the gifted learner stranded alone in the ‘academic desert’ with an unquenched thirst for knowledge. This has resulted in several scholars carrying out research on how best to assist the gifted learners.

In an unpublished thesis titled “Teachers’ attitudes towards the gifted” by McCoach and Siegle (2007) the researchers suggest that the majority of schools and governments tend to turn a blind eye to the gifted learners and hope they will look after themselves, or worse still use the gifted learners as tutors for their non-gifted classmates. This view is also noted by Child (2004: 270) suggesting that “some teachers believe that the bright can look after themselves’, and thus they concentrate on the mentally challenged learners.

For those that concern themselves with gifted learners, several methods of helping the gifted have been tried in some countries with varying degrees of success. Child (2004: 268) observes that the commonest of these methods, often in combination are acceleration, segregation, and enrichment. In implementing any of the three methods, the teacher differentiates the curriculum for the gifted learners from the mainstream curriculum.

The provision of educational services to gifted learners has a long and sporadic history. The first special education services aimed at accommodating gifted learners were initiated in St. Louis in 1868 and involved a plan for flexible promotion (Heward 2014:

488). Around 1900, rapid advancement classes were established, in which learners could complete two years' worth of academic work in one year, or three years worth of academic work in two years. The Progressive education movement in the 1920s advocated "enrichment", which involved more in-depth instruction and ability grouping for gifted learners (Heward 2014: 488). The provision of extra and in-depth instruction for the gifted learners continued over the years in different countries and continents (Smith, Polloway, Patton and Dowoy 2008: 388). Whichever of the three methods (acceleration, segregation, or enrichment) the educationists chose, the curriculum had to be differentiated.

In South Africa, Skuy, Mentin, Nkwe-Artnott and Hickson (1990) in Engelbrecht and Green (2003: 197) found in the Soweto Gifted Child Program that disadvantaged gifted learners in a program designed to develop thinking (Instrumental Enrichment) combined with attention to socio- emotional development and creativity gained more than the control group subjected to Instrumental Enrichment or the regular curriculum only. In this research, the researcher sought to establish the impact of enrichment programs to gifted grade eleven science learners from average-income families who attend urban schools.

Hall, Strangman, and Meyer (2003: 3) suggest the intent of differentiating instruction is to maximize each learner's growth and success by meeting each learner where s/he is and assisting in the learning process. In a postgraduate thesis for MEd titled 'Perceptions of teachers and students on gifted children and their education: a Hong Kong secondary school case study' by Tam Cheung-on (1995) as well as another one titled 'The Educational needs of gifted children', PhD thesis by Phillips Eunice (2001) both researchers hold the opinion that acceleration is the best method to use for the gifted learners.

Their view is also supported by a 10 year longitudinal study that found no negative effects resulting from acceleration (Swialth and Benbow 1991) in Henson and Eller (1999: 232) but instead found those learners to have been equivalent in achievement to

older, talented but non accelerated learners. In dealing with gifted learners, teachers should continually raise the ceilings of expectations so that these learners compete with their own possibilities rather than with a norm. It is also important to balance rigor with joy in learning and to differentiate the materials, assignments, and products in level of complexity, abstractness, and depth in order to enable these gifted learners to maximize their potential (Rief & Heimburge 2006: 63).

Considering the three options, acceleration and segregation are effective when there is flexible curriculum planning based on individual needs, where several resources are available, and in cases where the gifted have to be counseled by a qualified counselor before and during the process of acceleration ( Hughes & Rollins 2009:32). These, therefore, are some of the weaknesses of acceleration and segregation and make them difficult and expensive to implement especially in developing countries, such as South Africa, with limited resources.

Another common concern, associated with acceleration, is that early admission and grade skipping might lead to social or emotional problems because the learner will be in a classroom with older learners who are more advanced physically and emotionally (Heward 2014: 499).

In developing countries where material and human resources are scarce, South Africa not being an exception, the prevalent conditions do not promote these two methods but instead advocate for a method that allows exploring deeper and broader areas of great ability and intense interest. The gifted learner cannot be disadvantaged but afforded an opportunity to excel through alternative ways, such as provision of enrichment programs. This was the essence of this research, to establish the impact of enrichment on the performance of gifted science learners. Bragett (1994: 79) explains enrichment programs as activities that are designed to broaden and develop learners' experiences.

This research provided an opportunity to explore the impact of enrichment programs on gifted Science learners in three chosen South African high schools thus bridging the gap

where and when acceleration and/ or segregation ( advocated by researchers cited above) isn't (aren't) feasible, as the gifted learners still need to be afforded the opportunity to fully-develop their potential. This is because, according to Jacobs, Vakalisa and Gawe (2011: 2), since 1994 the South African government has worked towards the transformation of its education system. Among the many curriculum changes was the notion that classroom activities had to form a participative engagement of learners in significant learning activities.

This research was also necessitated by the fact that acceleration offers a narrow regular curriculum and poses the danger of pushing learners too fast (Borland 1989: 16). Boothe, Beheruz, Stanley and Colgate (1999: 198) also note that there are cases that document academic and/or social decline following radical acceleration of gifted learners, with some learners ending up being socially maladjusted, being social misfits, and some don't even get married.

This therefore left the need to explore another avenue for helping the gifted learners, in the form of enrichment programs (Lemmer & Van Wyk 2010: 153) because if not properly handled, gifted learners end up being socially isolated, under - challenged in the classroom, be disruptive, skip classes, and lose interest in achieving, notes Freeman 1998 in Child (2004: 253).

## **1.2 MOTIVATION FOR THE RESEARCH**

After having read literature on the gifted learner as well as on research carried out earlier on about this group of highly able learners it dawned on the researcher how special and delicate this group was. These innocent learners, if not handled properly, can end up underachieving despite having exceptional potential. At face value, this group seems impossible to cater for, but looking at the number of successful gifted learners in Science education as well as the many programs they can be subjected to in order to fulfill their potential, the researcher decided to carry out this research on the impact of enrichment programs to gifted Science learners.

This is because over the years, the exceptional learners who often have been neglected are those with exceptional gifts- learners who, if appropriately challenged, have the potential to excel at extraordinary levels in particular areas, such as Science (Child 2004: 253). This research focused mainly on the impact of enrichment programs such as research projects, independent study, Saturday classes, extra work, and field trips on twenty gifted Science learners. This was so as the learners' performance could be easily monitored by the researcher, unlike the other two forms (acceleration and segregation).

In this research, each of the identified forty grade 11 gifted science learners was allocated into one of the two groups (either control or experimental) using simple random sampling. The gifted learners were taught a particular topic by the researcher, after which those who were in the experimental group received enrichment in the form of a field trip, extra classes, and carrying out a research project on their own. The whole group then wrote the same post-test under the same conditions, and their performance was compared by the researcher.

The gifted learners were then taught another topic, and like before, those in the experimental group received enrichment (DVDs, extra classes, and extra literature) on the same topic. They again wrote the same post-test and their performance was compared. Those in the experimental group were then given an interview in which the researcher sought to establish their experiences and evaluation of the enrichment programs they received.

Based on some previous research which concluded that enrichment programs help the gifted learners reach their maximum potential academically, the researcher decided to establish the applicability of this conclusion to Science education in three South African high schools. As a Science educator this research gave the researcher the rare opportunity to implement and evaluate the extent to which these enrichment programs would impact on the performance of the twenty gifted learners from three chosen South

African high schools and compare the findings to those of other researchers in other countries and continents.

This is because the current South African school curriculum requires the use of a participative approach to teaching and the promotion of reflective learning among the learners (Jacobs et al. 2011: 3). Permission to conduct the research was obtained from the respective principals (see Appendix N).

### **1.3 PROBLEM STATEMENT**

**1.3.1** The research sought to establish the impact of enrichment programs on the performance of selected gifted Science learners. This was against the background that some quarters of the education fraternity are of the opinion that the gifted learners need little or no help at all whereas the other sector feels this group of learners needs as much help as the mentally-challenged learner, though in a different way.

### **1.4 RESEARCH QUESTION**

**1.4.1** How do enrichment programs affect the performance of gifted science learners?

**1.4.2.** Which enrichment programs can best be used for gifted science learners?

### **1.5 AIM OF THE RESEARCH**

To investigate the impact of enrichment programs on the performance of gifted Science learners.

### **1.6 DEFINITION OF CONCEPTS**

In order to understand the context in which these concepts are used the following definitions are provided for clarity:



**1.6.1** Enrichment programs : these are programs that provide richer and more varied content through strategies that supplement normal grade level work, for example learning centers, field trips, Saturday programs, and independent study (Child 2004: 268; Henson & Eller 1999: 181).

**1.6.2** Gifted: one who gives evidence of high performance capability in areas such as intellectual, creative, artistic, or leadership capability, or in specific academic fields, and who requires services or activities not ordinarily provided by the school in order to fully develop such capabilities (Henson & Eller 1999: 181, Santrock 2004: 200).

**1.6.3** Performance: the extent to which one has acquired a skill, or grasped and apply new concepts (The New Choice English Dictionary 1999 s.v. performance).

**1.6.4** .Science: a subject that investigates physical and chemical phenomena through scientific enquiry, application of scientific models, theories and laws in order to explain and predict events in the physical environment, that is Physics in this case.( Department of Education Physical Sciences CAPS document Grade 10 to 12; 2011: 8; Hartmann-Petersen; Gerrans and Hartmann-Petersen 2007: 233).

**1.6.5** Learner: one who gains knowledge of or skills in, through the guidance of a skilled or knowledgeable person and in the context of this research is in the eleventh grade in school (The New Choice English Dictionary 1999 s.v. learner).

## **1.7 LIMITATIONS OF STUDY**

The research focused on giving twenty gifted Science learners several enrichment programs such as extra work, Saturday classes, research projects, field trips, and independent study. Since the gifted Science learners were drawn from grade elevens at only three selected high schools in Fezile-Dabi district in the Free State province, the sample wasn't large enough for the results to be generalized to all gifted Science learners in the country.

## **1.8 CHAPTER OUTLINE**

### **CHAPTER I**

This chapter consists of the following; introduction/background to the research, statement of the problem, research question, aim of the research, motivation for the research, definition of concepts, and limitations of the study.

### **CHAPTER 2**

Theoretical background to the study will be provided in this chapter.

### **CHAPTER 3**

This chapter will consist of the research design and methodology as well as data collection methods, statement of ethics, and sampling of the participants.

### **CHAPTER 4**

Data presentation, analysis and interpretation will be presented in this chapter thus answering the research question as well as discussion of the results of the research.

### **CHAPTER 5**

This chapter will consist of summary of the research, recommendations, and conclusion of the study.

The next chapter, Chapter 2, details relevant literature reviewed by the researcher in conducting this research. The literature includes definitions of giftedness, enrichment, as well as examples of, and advantages of selected popular enrichment programs.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

The world needs to provide advanced Science education so that all our learners have the opportunity to better understand the rapidly changing world around them and have the option to pursue a career in science, engineering or technology. South Africa's success as a knowledge economy is dependent on a highly skilled, informed and scientifically literate workforce who receive a strong and supportive foundation of Science education throughout their schooling regardless of their ability, race or economic status (Batterham 2000: 49).

Possibly the main reason why science is a priority is the dire shortage of South African learners who gain the necessary qualifications to follow careers in science. For example of the 554 664 National Senior Certificate candidates in 2008, only 217 300 wrote Physical Sciences (39.2%). Of these only 54.9% achieved 30% and above, and only 28.3% achieved 40% and above, meaning a small fraction pursued careers in science. Since many matriculants who pass Physical Sciences do not pursue scientific careers afterwards, there are not enough scientists in the country (Jacobs et al. 2011: 72). Even some of those who passed, is that the best they could do?

In spite of a worldwide consensus regarding the value of giftedness, there are still those politicians who fail to take the needs of gifted learners into account in educational policies. There are still teachers ignorant through faulty training, who still believe that there is no need to study giftedness or cater for the gifted Science learners in the classroom (Landsberg, Kruger & Nel 2006: 469). There are also those in the education circles who still persist in regarding giftedness as an elitist concept.

Watters and Diezmann (2003: 46) add that the provision of support for gifted learners in most countries is often left to learning support teachers or gifted education co-

coordinators. Rarely do teachers of Science provide these learners with opportunities for enrichment within the formal school structures. This is despite the strong interest that many gifted learners have in Science from a very tender age. The education of gifted learners in Science has received scant attention in the literature despite considerable advances being made in the field (Heller, Monks, Sternberg & Subotnik 2000). Extensive research in the area of giftedness has shown the importance of a stimulating, challenging and supportive environment.

It is the learning environment that the educational system has the greatest potential to address, while some gifted Science learners will challenge obstacles, modify their environment and overcome adversity, some gifted Science learners require a nurturing and stimulating environment both at home and school to maximize their potential and to help shape the directions they will take (Watters & Diezmann 2003: 46).

Furthermore, assessment of learners' performances in Science for the most part is still norm-referenced, group oriented and focused on production of knowledge, something that doesn't augur well with gifted learners' abilities (Batterham 2000: 49; Becker 2003: 7). Most, if not all Science educators, according to my experience, rely solely on assessment tools drawn up and provided by Subject Learning Facilitators who don't have a clue about the composition of learners for whom they are drawing up those assessment tools.

## **2.2 DEFINITIONS OF GIFTED LEARNERS**

If giftedness were defined solely on the basis of superior cognitive ability as evidenced by scores on a standardized intelligence test, then, theoretically, 2.3% of the general population would be gifted by virtue of an IQ score 2 standard deviations or more above the mean. The same theoretical statistical approach predicts that about 1 in 1 000 people would be highly gifted by attaining an IQ score of 145 (3 standard deviations above the mean), and roughly 1 in 10 000 would be considered exceptionally or profoundly gifted (Heward 2014: 486).

Not only is intelligence testing a theoretically thorny, inexact, and sometimes biased process (particularly when applied to learners from culturally and linguistically different backgrounds on whom the tests were not normed), the concept of giftedness has long been expanded to encompass special talents and the potential for intellectual, creative, and superior performance (Vaughn, Bos and Schumm 2011: 412).

Early 19<sup>th</sup>- century works, including a classic study by Sir Francis Galton (1869), focused on the concept of genius. He was the first to offer a definition of genius that used observable characteristics or outcomes. Sir Galton was of the idea that the largest proportion of human intelligence was fixed and immutable (Heward 2014: 486). His view eventually came to be enshrined as the theory of fixed intelligence, wherein people believed they were born and died with the same amount of intelligence regardless of their life experience.

Two events in the early 1900s cemented the marriage of the theory of fixed intelligence to a method of measuring it. First, in 1905 the French government commissioned two psychologists, Alfred Binet and Theophile Simon, to develop a means of separating groups of slow learners from other learners in order to provide them with appropriate educational services (Heward 2014: 487).

Second these scales were then translated into English and refined by Lewis Terman at Stanford University in 1916 for the U.S. government to use in sorting soldiers for a variety of duties in World War 1, and the scale was to be known as the Stanford-Binet scale (Smith et al 2008: 448). The result of these events was the emergence of a single number, the “intelligence quotient” or “IQ”, which came to represent the overall intellectual abilities of a person. IQ tests and related tools became the dominant process for determining the intellectual differences among human beings and continue to be widely used today.

Another psychologist who strived to define giftedness is Terman in the early 1920s. Collectively the Terman work is titled Genetic Studies of Genius. Terman and colleagues identified 1 500 individuals with high IQs (that is, over 140), collected data on their mental and physical traits, and also studied their lives longitudinally (Smith et al. 2008: 388). The research was important because it represented a major attempt to look closely at individuals who were exceptional and dispelled some misconceptions relating to high intelligence and neurotic behavior.

However, Terman's work also led to some misconceptions. First, he equated genius with IQ, thus excluding other areas such as artistic ability. Second, Terman stressed the strong association of genius and genetics, thus precluding that some variability in intelligence can occur due to psychological factors and other life-related opportunities (Heward 2014: 487; Smith et al. 2008: 388). Throughout the years, other definitional perspectives emerged through the works of various psychologists, and educationists. Detailed below are some of the modern, accepted definitions of giftedness.

Gifted learners are those identified by professionally qualified persons, such as psychologists, teachers, and principals, who, by virtue of outstanding abilities are capable of high performance. These are learners who require differentiated educational programs and/or services beyond those normally provided by the regular school program in order to realize their contribution to self and society. Students capable of high performance include those with demonstrated achievement and potential ability in the following areas:

- General intellectual ability
- Specific academic aptitude
- Creative or productive thinking
- Leadership ability
- Visual or performing arts
- Psychomotor ability

(Vaughn, Bos & Schumm 2003: 315).

It is evident, therefore, that gifted learners are not homogenous in their thinking strategies. Some gifted learners are convergent thinkers who approach tasks in a sequenced, linear fashion while others are divergent thinkers who employ creativity and innovation to express ideas.

Learners who are intellectually gifted normally respond to questions more quickly and appropriately than their age peers such that given several alternatives, they will usually select the best course of action, the preferred outcome, or the most accurate response (Hughes & Rollins 2009: 34). They often have difficulty communicating with their chronological peers about academic matters and prefer to associate with older children or adults of equal or better ability.

Landsberg, Kruger and Nel (2006: 474) define gifted learners as being identified by their exceptional competency in some area of ability or performance. It is this unusual quality or area of talent that makes them different from others. The key to understanding their giftedness lies in understanding the unusual, extraordinary nature of gifted behavior, whether it be exceptional creativity, musical talent, leadership qualities, sporting ability or intellectual reasoning ability.

Being gifted, therefore, means being different from others with respect to the particular area of talent, write Landsberg et al. (2006: 474). These students exhibit high performance capability in intellectual, creative and/or artistic areas, possess an unusual leadership capacity, or excel in specific academic fields, and require services or activities not ordinarily provided by the schools (Vaughn et al. 2003: 315).

Gifted learners often like to work undisturbed for lengthy periods but when the task is sufficiently challenging, they will seek capable peers to exchange ideas and pool resources (Diezmann & Watters 2001: 9). Gifted learners are proficient at learning new content or facts and should be encouraged to pursue the learning of information at their own pace. If they master a particular concept, they need to be provided with more advanced or qualitatively more complex material.

Their learning characteristics are best served by thematic, broad-based, and integrative content, rather than just single-subject material (Santrock 2004: 202, Watters & Diezmann 2003: 50). During my teaching experience I discovered that if not given challenging work, these gifted Science learners can be very disruptive, lose interest in learning, and their behavior mistaken for ADHD.

Clark (2008: 6) views giftedness as a label used to indicate a high level of intelligence, it has a dynamic quality that can be furthered only by participation in learning experiences that challenge and extend the child's level of intelligence, ability, and interest. Gifted learners hence are exceptional learners, each with their own innate specific capacity to excel in domains commensurate with their intellectual capability.

This is made possible by their early language development. Many gifted learners begin communicating with words long before their first birthday, though not all gifted learners, as I have discovered during my professional journey, are highly verbal or show early use of language. This makes some of these (the vocal) dominate class, group or family discussions (Landsberg et al. 2006: 472).

A potentially gifted learner might ask questions that are unusual (for example: what makes sticky tape sticky on one side and smooth on the other?). They also ask many searching questions about topics in which young learners do not ordinarily have an interest (for example; who started schooling and why?). During one of my Natural Sciences lessons on The Water Cycle, I asked my grade 9 class what would happen if we were to wake up one day and find all dams and rivers in South Africa dry. One of my learners, whom I consider gifted, said that would lead to the decrease in the local price of fish and temporarily increase the country's fish exports.

Gifted Science learners also possess the ability to understand complex concepts, perceive relationships and think abstractly. They evaluate themselves and others including noticing discrepancies between what people say and what they do, coupled with having a



long attention span, high activity level, less need for sleep, and advanced ability to play with puzzles, mazes and numbers (Maunganidze & Nyamuyakura-Shoniwa 2001: 28).

Newman and Hubner (2012: 102) define giftedness as referring to cognitive superiority, creativity and motivation in combination and of sufficient magnitude to set the learner apart from the vast majority of age-mates and make it possible for him or her to contribute something of particular value to society and to be identified for special services. They tend to be curious and, because they learn quickly, have a large knowledge base when they have had appropriate learning opportunities.

Gifted learners demonstrate originality and creativity and can think divergently, producing different answers and creative solutions. They also tend to resist authority, reject routine and ignore conventions - characteristics not likely to make them popular with teachers (Engelbrecht & Green 2003: 195). Their definition focuses largely on the intellectual ability of the learner in the academic circles.

A number of interesting observations can be noted from the above definitions. First, attention is given to potential- some of these learners have not yet produced significant accomplishments may be considered gifted. Second, the need for special services or activities for these learners is clearly stated; along with the observation that such intervention is not ordinarily provided. Finally, the fact that gifted learners come from a range of diverse backgrounds is affirmed.

From these definitions also, intelligence, creativity, and talent have emerged central to the various definitions of giftedness. These learners give evidence of high achievement or high potential capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic fields, and who need services and activities not ordinarily provided by the school in order to fully develop these capabilities (Heward 2014: 480).

Giftedness, therefore, is a complex human characteristic that encompasses a wide range of abilities, skills, and traits. Whereas definitions of giftedness are social constructs (that is, they are not absolute but vary according to situation), without doubt, gifted learners have special educational needs. Some learners have special talents, but rarely do these match the stereotypes and myths that people may have of giftedness (Heward 2014: 482). These learners may not be outstanding in academics, but they may have exceptional abilities in areas such as music, dance, art, or leadership. Gifted learners are also found in all gender, cultural, economic, linguistic, and disability groups.

To differentiate gifted learners from other learners in class, the following are characteristics of gifted learners:

- rapidly acquire, retain, and use large amounts of information,
- intense intellectual curiosity,
- fascination with basic words and simple ideas,
- perfectionism and need for precision,
- appreciate multiple and opposing points of view,
- perceive the operation of larger systems of knowledge that may not be recognized by the typical learner,
- acquire and manipulate abstract symbol systems,
- solve problems by reframing the question and creating novel solutions,
- intense need for mental stimulation and challenge,
- difficulty conforming to the thinking/ logic/ reasoning of others,
- early moral and existential concerns,
- tendency toward introversion- independence and isolation,
- heightened capacity for seeing unusual and diverse relationships, integration of ideas, and disciplines,
- early differential patterns for thought processing (for example thinking in alternatives, abstract terms, sensing consequences, making generalizations, visual thinking, use of metaphors and analogies),
- readily see cause-and-effect relationships,
- have interests that are both wildly eclectic and intensely focused,

- can see relationships among seemingly unrelated objects, ideas, or facts,
- unusual intensity, persistent goal-directed behavior, and
- show idealism and a sense of justice, which appear at an early age.

(Clark 2008; Davis et al. 2011; Heward 2014; Maker 2005; Piirto 2007; Rief & Heimburge 2006; Smith et al. 2008).

In identifying gifted learners for the purposes of this study, psychologists, teachers and principals of the three schools that were used in this research were given the above characteristics as guidelines, as well as achievements tests which the learners wrote. In this way, common criteria were used to identify gifted learners from the three schools, focusing on grade eleven (11) Physical Sciences.

It should be kept in mind, however, that not all characteristics apply to an individual learner. Also, some learners have specific disabilities impairing certain functioning (for example reading skill, academic performance in various areas) while they are still gifted.

Comprehensive and equitable assessment for identification of gifted learners includes the following:

- group and individual intelligence tests,
- achievements tests,
- proficiency tests,
- authentic performances and/or products,
- teacher nomination based on reports of learner behavior in the classroom,
- parent/family/caregiver nomination,
- self-nomination,
- peer nomination, and
- Extracurricular and leisure activities.

(Heward 2014: 490).

In this research gifted learners were identified by school psychologists, some were also nominated by teachers, and principals basing on their performance in achievement tests, as well as following the guidelines cited above. This is because IQ tests are subjective and not conclusive on their own. The achievement tests were the same for all learners in the three schools.

These learners who, by way of having certain learning characteristics such as superior memory, observational powers, curiosity, creativity, and the ability to learn school-related subject matters rapidly and accurately with a minimum of drill and repetition, have a right to an education that is differentiated according to those characteristics (Piirto 2007: 37).

Very simply, this means that learning opportunities provided to these learners must differ according to learners' needs and abilities. Differentiation includes the content of what the learners learn, the processes used in learning situations, and the final products that learners develop. Furthermore difference lies in the depth, scope, pace, and self-directedness of the expectations (Smith et al. 2008: 398).

For the purposes of this study, the researcher considered Heward (2014: 480)'s definition of gifted learners which states that these are learners, children, or youth who give evidence of high achievement capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic areas, and who need services and activities not ordinarily provided by the school in order to fully develop those capabilities.

Focus was on the learners' continued academic performance in Physical Sciences as well as comparing their behavior with characteristics of gifted learners cited earlier in this research. This, according to Heward (2014: 481), is because exceptional performance in young learners may be evident on tests and other measures of ability or as an exceptionally rapid rate of learning, compared to other learners of the same age, experience, and environment, or in actual achievement in a domain.

### **2.3 DEFINITIONS OF ENRICHMENT**

A diabetic patient needs insulin. An ADHD student needs Ritalin. What medicine do we give gifted Science learners in the classroom? They require the curriculum to be differentiated to meet their specific needs (Johnson 2000). When these gifted learners are not presented with learning experiences that are appropriate to their abilities, they lose motivation and in time can lose interest in school. If gifted learners are given tasks that are too easy, which is very common in a mixed ability classroom, they may not become engaged in the activity and consequently will not be learning (Siegle 2005: 30).

Studies have shown that formal instruction in elementary school classes often lacks challenges for the gifted learner since most subjects have a relatively narrow range of topics, minimal investigation of concepts and repeated drill and practice (Davis & Rimm 2003: 118). A national study conducted in Australia cited by Stepanek (1999) in Rogers (2002: 281) found that an average of 35 to 50 percent of the regular curriculum could be eliminated for gifted learners. Rogers (2002: 281) also cites research showing that gifted learners can complete a year of grade-level concepts in three to six months. Some type of telescoping of the regular curriculum needs to occur to enable these learners to be successful (Sousa 2003: 14).

In South Africa, Skuy, Mentin, Nkwe-Artrott and Hickson (1990) in Engelbrecht and Green (2003: 197) found in the Soweto Gifted Child Program that disadvantaged gifted learners in a program designed to develop thinking (Instrumental Enrichment) combined with attention to socio-emotional development and creativity gained more than the control group subjected to Instrumental Enrichment or the regular curriculum only. Curricular have been under revision in South Africa, but perhaps the best improvement of all would be to encourage learners to pursue their own curiosity about the natural world.

Almost twenty years after the introduction of outcome-based-education, which in its transformative manifestation should enable the student to demonstrate genuine learning outcomes, there still exists practices that assume all Science learners will achieve the

same outcome at the same time. Learners are compelled, by the curriculum, to move at the same pace, write the same examinations, and be assessed using the same assessment tools. Contemporary views of learning suggest that learners need to personally, and in a social context, make sense of new experiences through active engagement with ideas and phenomena (Engelbrecht & Green 2003: 193, Landsberg, Kruger & Nel 2006: 469).

To change the culture of passive learning, which prevails in many South African classrooms, we need to heed Postman and Weingartner's criticism of the late 1960s' American classrooms in which all learners, irrespective of academic capability, mostly sat and listened to teachers in order to remember enough to pass tests without ever questioning the authority of teachers and textbooks on the learning content, where learners were almost never required to make observations, formulate definitions or perform any intellectual operations that go beyond repeating what someone says is true (Jacobs et al. 2011: 11).

Modern day teachers, therefore, need to find opportunities for these gifted Science learners such as designing open-minded problems, setting up cooperative learning groups of high ability learners, even finding different (enrichment) programs sponsored by different universities and companies, teaching/learning charts, DVDs, workbooks (Sousa 2003: 142). In a way their curriculum needs to be differentiated, because learners' experiences are as different and unique as their intellectual abilities, cognitive styles and psychomotor abilities (Jacobs et al. 2011: 11).

Because of their unique learning styles, both affective and academic, gifted Science learners require differentiated instruction and curriculum that is a better match for them individually than the curriculum most often found in mixed ability classrooms. This arises when a school adopts a curriculum that typically comes with only one textbook for all learners at each grade level. These books are aimed at average abilities within that grade level, and many times at the lowest reading level. Consequently the gifted learners' advanced needs are not usually considered (Rakow 2005: 32; Rogers 2002: 280).

Inquiry-based, discovering learning approaches that emphasize open-ended problem-solving with multiple solutions or multiple paths to solutions are what gifted learners need to be successful, and this comes in the form of enrichment programs since pedagogical and curriculum practices in the regular class do not cater for their specific needs and indeed may even exacerbate failure (West-Burnham 2006: 45).

Landsberg et al. (2006: 480) view enrichment as supplementing the ordinary curriculum by means of activities that afford the learners an opportunity to broaden as well as deepen knowledge in a given field or learning area, for example, by means of doing a project, investigations, field trips, learning corners, or problem solving activities. This involves more than just a broadening or deepening of knowledge - there is also the matter of how knowledge is acquired by means of research. Enrichment ensures that Science is much more than a simple encyclopedic collection of facts which learners can benefit from by acquiring certain basic skills and competencies.

Enrichment actually stresses the acquisition of new physical knowledge and the necessity for understanding rather than memorizing basic scientific concepts (Hall, Strangman & Meyer 2003: 3). Considering curriculum implementation in most Science classrooms, educators are only worried about memorization of facts to ensure a high pass rate. But is justice being done to the gifted learner? Renzulli (2005: 32) adds that enrichment programs inculcate in the gifted Science learner high flexibility and reversibility of mental processes, give energy and persistence in solving problems, ability to visualize patterns and spatial relationships, and scientific perception of the world.

Enrichment, therefore, refers to techniques that provide topics, skill development, materials, or experiences that extend the depth of coverage beyond the typical curriculum. In its broadest interpretation, enrichment encompasses a number of modifications in standard educational practices. In its narrowest interpretation, enrichment means providing interesting and stimulating tributaries to the mainstream of school (Smith et al. 2008: 404).

The content that the teacher brings to the learners is intended to enrich their existing understanding of reality rather than replace it. The teacher can achieve this enrichment by allowing learners' experiences to surface during class discussions (Jacobs et al. 2011: 11).

Enrichment programs can take the form of films, independent study and independent projects, learning centers, field trips, Saturday programs, mentors and mentorship, small group investigations, games, puzzles and academic competitions. These activities foster in the gifted Science learner skills such as observation, classification, recognition and use of space-time relations, recognitions and use of numbers and number relations, measurement, communication, inferences, prediction, and the general ability to use scientific process in problem-dissection and solving (Sheets 2006: 7).

In South Africa gifted Science learners can also enroll for the National Science Olympiad which is run by the South African Agency for Science and Technology Advancement (SAASTA).

Other academic competitions also include the SA Natural, Life and Physical Sciences Olympiads, the Mini quiz organized by Mintek, a National Science Council specializing in mineral and metallurgical technology, and the SAIMEchE Technology Olympiad. Enrichment programs, as highlighted earlier, can also include research projects.

## **2.4 TYPES OF ENRICHMENT PROGRAMS**

The following are some of the most popular enrichment programs that can be used in a Physical Sciences class:

### **2.4.1 RESEARCH PROJECTS**

A project is a piece of work that involves collecting detailed information about something (Macmillan English Dictionary 2006 s.v. project).



In designing projects for the gifted science learners, the educator should provide some activities that can be done independently or in groups based on learner choice keeping in mind that if gifted learners always work independently, they are gaining no more than they could do at home. They also need appropriate instruction, interaction with other gifted learners, and regular feedback from the educator.

Strategies especially recommended for these learners (in the form of projects and problem-solving activities) are: integration of content across disciplines, extension and deepening of content, provision of advanced reading and independent learning contracts based on interest (Engelbrecht & Green 2003: 197).

Through enrichment programs, learners are able to work on an activity that meets their specific needs and learning styles, which includes inquiry-based, discovering learning approaches emphasizing open-ended problem-solving with multiple solutions or multiple ways to solving a solution. These gifted Science learners are fully engaged in learning while taking material from the regular classroom to a more abstract level. They are able to work with other learners with similar abilities, and are able to discuss higher-level scientific thinking with intellectual peers who understand their way of thinking.

Teachers also reap benefits by knowing that the gifted learners in their classroom are having their unique needs met, consequently also have time to work with the other learners in their classrooms knowing that the more capable Science learners are working at a more conceptual level in the enrichment group (Sousa 2003: 142).

The South African adult community, teachers included, has operated within a culture that encouraged the suppression rather than the expression of individual views. It is necessary to break this habit in order to foster critical and reflective thinking among learners, and this can be achieved through giving learners individual or group projects that require learners to study content-related issues in their communities or to follow current international issues (Jacobs et al. 2011: 11).

For example, taking the topic Chemical systems; after teaching them the production of Ammonia (the Haber process), the gifted learners can carry out research projects on the Contact and Oswald processes individually and then go on to look at uses and dangers of artificial fertilizers such as eutrophication and algae bloom as a group (Department of Basic Education Physical Sciences CAPS document 2011: 115).

This removes the ceiling on what is learnt, and the gifted learners' abilities to build a richer, more diverse, and efficiently organized knowledge base are cultivated. The learners can later present their findings orally in class, or submit written reports (Jacobs et al. 2011: 11). In this research the gifted learners were required to submit written reports which were then marked by the researcher using a common rubric.

Projects, when used for enrichment, offer a stimulating educational environment which will enable gifted Science learners to fully develop their talents and abilities as well as circumvent problematic weaknesses at the same time promoting abstract thinking and creative production (Maunganidze & Nyamukura-Shoniwa 2001: 75). Some of the gifted learners, from what I have experienced can do up to ten different research projects per year, that's ten times the Department of Education's requirements.

Projects give the gifted Science learners access to a broad and balanced curriculum (including areas of weakness), investigation of real problems, encouragement to reflect on their own thinking and learning processes, and appropriate pace of work, opportunities to work in a variety of ways, regular goal setting, progress discussions with the teachers and the experience of success as a result of effort (Engelbrecht & Green 2003: 196).

Since gifted learners can assimilate knowledge rapidly, projects give them the opportunity to use that knowledge productively as they (projects) offer the basis for discovering, serving and nurturing academic giftedness (Landsberg et al. 2006: 472), qualities required in solving today's scientific problems.

Considering the same topic (Chemical Systems), the other part of the project could look at dangers and ways of preventing eutrophication. This would interest them as gifted learners have a high sense of social responsibility and frequently have an interest in solving meaningful, significant world or local problems, seeing beyond the discipline areas.

Alternatively the gifted Science learners could be left to choose projects of own liking. In lower primary this is not all that different from normal curriculum practices, but it needs to be appreciated that gifted learners are likely to be faster, more intensely involved and more abstract in their approach and solutions to problems.

By high school, they have the maturity and insight to devise their own projects in which they can explore problems of interest to them or undertaking projects for entry into the numerous competitions that exist, such as the ESKOM Young Scientist Expo, or any of the Olympiads mentioned earlier (Engelbrecht & Green 2003: 198). At each step in executing the project, the gifted learners will interpret new knowledge in the context of what they already understand.

Rather than putting fully formed knowledge into learners' minds, projects help the learners construct scientifically valid interpretations of the world and guide them in altering their scientific misconceptions (Santrock 2004: 360). Some projects help gifted learners think about and visualize how scientific principles work and stress learner-learner and teacher- learner collaborative interaction.

The last step would be for the gifted learners to compile their findings and present them to the teacher, who in turn should mark and give feedback to the learners as soon as possible (West-Burnham 2006: 7). Projects, as an enrichment program, offer a curriculum that is differentiated in terms of learning environment, content, process and product. The environment is modified so that it becomes receptive, non-judgmental, and learner-centered, generally complex, connects the school experience with the greater

world, provides some physical movement, and generally encourages inquiry and independence (Maunganidze & Nyamuyakura-Shoniwa 2001: 81).

They encourage group interaction (with highly able and motivated students sparking each other in the task), variable pacing, freedom of choice, and debriefing (encouraging gifted learners to be aware of and able to articulate their reasoning or conclusion to a problem or question) (Davis & Rimm 2003: 120). Even when working on group projects, each individual learner must have a specific responsibility. The teacher must also provide opportunities for every learner to demonstrate his or her own understanding of the learning content by writing reports (Jacobs et al. 2011: 18).

Projects also offer a platform for subject integration thus broadening and deepening the learners' knowledge in different subject areas. Rakow (2005: 121) notes, "because of gifted learners" precocious abilities to discover analogies, parallels, contradictions, and contrasts in areas where their typical peers may see just the obvious; an interdisciplinary approach provides them a broader canvas for exploration and integration". When designing projects for the gifted Science learners, Johnson 2000 in Vaughn et al. (2003: 411) advises teachers to:

- Give pre-assessment so that learners who already know the material do not have to repeat it but may be provided with instruction and activities that are meaningful,
- Create assessments that allow for differences in understanding, creating and accomplishment, give the gifted learners a chance to show what they have learnt,
- Use inquiry-based, discovering learning approaches that emphasize open-minded problems with multiple solutions or multiple paths to solutions. Allow learners to design their own ways to find the answers to complex questions (Department of Basic Education: Physical Sciences CAPS document 2011: 11).

Many gifted learners like and indeed crave-independent learning. Gifted learners who learn how to work independently through projects not only gain a great deal of knowledge and personal satisfaction by exploring topics in breadth and depth, but also develop strategies for inquiry and knowledge acquisition that will help them become lifelong learners (Vaughn et al. 2003: 331).

## **2.4.2 FIELD TRIPS**

The teacher who wants to afford gifted Science learners enrichment can also take these learners on field trips. A field trip is a visit to a place that gives learners the chance to study something in the real environment, rather than in a classroom or laboratory (Macmillan English Dictionary 2006 s.v. fieldtrip).

Since researchers have found that learners who are gifted learn at a faster pace, process information more rapidly, are better at reasoning, use better strategies, and monitor their understanding better than their non-gifted counterparts, taking them on fieldtrips will do them more good than harm as there is an abundance of materials and tasks available to challenge these learners and this holds their interests and also challenges their intellect (Davis & Rimm 2003: 120, Engelbrecht & Green 2003: 196).

The intent of field trips is to provide gifted learners with supplementary learning opportunities that help them branch beyond the basic curriculum presented in the general classroom. From my experience, I deduced that fieldtrips as an enrichment program expose the gifted Science learners to material that is of a high level of complexity (sophistication) and/or material that is of high interest (novelty).

Learners are helped by academics and scientists (retired and practicing) to get beyond simple memorization of facts or mastery of skills through well-planned and structured activities that enable the gifted to think critically and creatively, and helping them identify and solve problems (Child 2004: 268, Vaughn et al. 2003: 331).

Looking at the South African Physical Sciences curriculum, fieldtrips can be grossly beneficial, for example, in the following topics:

- Production of Nitric acid, and Sulphuric acid, Manufacture of ammonia, ammonium nitrate and ammonium sulphate, the gifted science learners can visit a Sasol company plant,
- Electricity and Magnetism: looking at generation of electricity, manufacture and use of generators, capacitors, and transformers, the learners can pay ESKOM a visit,
- All Physics and Chemistry experiments: the learners can visit either Sci-bono discovery centre, Science Exploratory Museum at Gold Reef City or any centre for science education nearest them (Department of Basic Education Physical Science CAPS document 2011: 107).

Alternatively the gifted Science learners can embark on single trip to the Sasol-sponsored Techno-X or other Science exhibitions where most corporate bodies and companies as well as all universities in South Africa will be exhibiting. Here academics and scientists are available during the exhibition period.

During the field trip the educators engage in ongoing assessment of learners' abilities, interests, and need to identify individual "talent pool" learners who would profit by engaging in more advanced independent research and enrichment programs. The gifted learners learn how to access information, evaluate it, and make decisions about or act upon that information, have opportunities to create new products, come up with fresh ideas, and synthesize the idea of others in an innovative way through field trips (West-Burnham 2006: 45).

Rather transmitting a predetermined curriculum to gifted learners, during the field trip the teacher acts more as guide to channel the learners natural curiosity in educationally productive directions (Hughes & Rollins 2009: 38). The use of field trips as an enrichment program is frequently justified in Science education because through the

skills and knowledge developed in this enrichment activity gifted Science learners are better prepared as citizens in a technological society.

Field trips also offer a way of understanding the world and our interactions with it in a broader cultural sense as empowerment from science rather than induction into science is a more important way of thinking about the purpose of school science (Moscovici 2000: 2).

Field trips contribute to the establishment of a scientifically literate society whose members confront social and technological problems, and instill effective problem solving, particularly novel problem solving in the gifted learners. This replaces the compulsive orientation towards content, epistemological beliefs of educators and discipline-based role learning that characterizes the majority of high school Science teaching that has the impact of generating highly negative attitudes towards Science in many gifted Science learners.

Thus, Science practiced as authentic problem solving can meet the intellectual needs of gifted Science learners. In turn, the investment in these individuals will yield high returns for all humanity through their leadership in Science, their contributions to knowledge development, and their engagement in the unknown problems of the new century (Rakow 2005: 32).

Gifted learners are afforded the opportunity to assimilate new experiences into existing knowledge structures through modeling, scaffolding, and meta-cognition rather than merely knowledge accumulation, through this enrichment program (Diezmann & Watters 2001: 9).

Enrichment can also be afforded through the use of films.

### 2.4.3 FILMS

Where textbooks, class discussions, and the laboratory leave off, films take over. The films might not be of the usual “enrichment” sort. Some introduce the learner to an area which s/he will traverse later, others may present a simple experiment for the learner to duplicate, some may include experiments which cannot be completed in the school laboratory, and still others may present the more difficult portions of the school curriculum (Newman & Hubner 2012: 110). In this technological era, the films can be loaded onto DVDs or online where resources permit. The gifted Science learners will then watch the DVD during their own time after doing some background reading on the topic presented in the DVD.

Films provide richer and more varied content, prevent boredom, present more challenging activities that are tailored for the particular learner, and do away with the narrowness of the regular curriculum and the dangers of pushing students too fast or dragging them, integrate activities that require creativity and critical thinking, and offers autonomy as well as motivation, key components identified by Ng and Nicholas (2007: 191) when they suggest that gifted learners need to be highly motivated, independent learners who have the desire to learn and who extend themselves both academically and socially in order to succeed. For example the DVD can be on grade 11 Mechanics:

- Explaining the uses of equations of motion such as:  $v = u + at$ ;  $a = F/m$ ;  $a = v - u/t$  (Department of Basic Education Physical Science CAPS document 2011:50),
- Working out examples applying the equations,
- Worksheet according to Bloom’s Taxonomy, and
- Memoranda to the worksheets.

This type of enrichment accommodates differences in learner background knowledge, readiness, interest, and flexibility (Siegle 2006: 40).



#### **2.4.4 ONLINE ENRICHMENT ACTIVITIES**

An online homeroom can also be established using a wiki, email, Moodleroom, podcasting, blogs, eLearning, or any social networking site. The teacher then embeds introductory multimedia resources and activities in the online homeroom for learners to explore. This enables the gifted learners to share information with their ability mates (Siegle 2006: 41). The gifted Science learners share resources and develop their research questions through discussion forums, collaborative documents, and the wiki.

The goal of this enrichment facility is to produce a multimedia product that is appropriate to the field that the gifted learner is studying and present it to a real audience at their convenient time through the internet. Though not so popular in the past, most of our learners I see in my class today walk with the internet on their cell phones in their pockets.

Besides being used by educators with their learners, the model can be adopted and independently run through a state education department thus allowing gifted learners from one school collaborate with other gifted learners from a variety of schools within the district and/or province. Connecting gifted learners to each other develops a sense of community and keeps learners motivated in their learning (Swan 2003 in Bourne & Moore 2003: 13) as well as establishing formal discussion groups that address common concerns of gifted learners including multipotentiality, perfectionism, asynchrony, peer relations, excessive self-criticism, and career planning.

This enrichment program is particularly crucial for gifted Science learners who often are geographically or physically separated from their peers. Swan (2003) affirms stating that using the internet to create social learning communities for gifted learners who are isolated geographically from their peers can provide much-needed socialization and advanced academic content for this underserved population.

The four main benefits of using this enrichment program according to a research by Siegle (2005: 34) are:

- Gifted learners gain increased technological skills and increased confidence using the computer for collaborative and self-directed learning,
- Gifted learners connect with other gifted learners and address many effective concerns of being gifted,
- They master benchmarks related to their specific courses through blog posts, quizzes, projects, and examinations, and
- An improvement in the gifted learners' research and writing skills.

Consequently, by combining social networking and multimedia lessons developed around advanced content, this creates a gifted program that teaches meaningful curriculum and 21<sup>st</sup> century skills and encourages critical thinking and creativity in the gifted Science learner (Ng & Nicholas 2007: 193).

#### **2.4.5 LEARNING CENTRES**

Teachers can also establish learning centres where they provide additional reading materials in the form of worksheets and memoranda on different topics, quizzes, and games, to supplement the subject textbooks, as a form of enrichment. The learning centre can take the form of a whole classroom or, if space is limited a corner or two in the regular classroom can suffice. Teachers can use the learning centre to both enrich the gifted learners' curriculum and remediate their curriculum gaps (Kuhn 2007: 110).

The goal of a learning centre is to develop an atmosphere within which learners feel sufficiently free to explore and make discoveries while being given limited guidance. The intent is to maximize each learner's growth and individual success by meeting each gifted learner where s/he is and assisting in the learning process. The gifted Science learners can also visit learning centres nearest them such as Boitjorisong Science Learning Centre, Kutlwanong Center for Mathematics, Science and Technology, or any

centres established by the state or corporate institutions (Hall, Strangman & Meyer 2003: 30).

There is a greater chance of producing original ideas when the mind of the gifted learner is allowed to run riot in attempting to solve a problem in the learning centre. The ideas come out freely and without regard for their feasibility. In other words, think now; evaluate later (Child 2004: 269). In a way learning centres provide opportunities for in-depth, content-based learning while providing for exploring learning, prevents boredom by providing supplementary activities with the gifted science learners selecting many of their own activities from among a variety the educator prepares (Santrock 2006: 248).

The level and pace of instruction is thus upgraded to fit the gifted learners' abilities, achievement levels, and interest. Learning centres, if used for enrichment, promote logical deduction and convergent problem-solving which make a gifted learner a scientist who does not want to have a one-sided view of the world. Instead s/he will endeavor to generate multiple solutions to problems and this kind of a learner thrives on experiments and wants to use all the available sources to acquire information and knowledge (Maunganidze & Nyamuyakura-Shoniwa 2001: 71).

Study has also shown that gifted learners are significantly more likely to retain Science content accurately when taught 2 to 3 times faster than 'normal' class pace (Rogers 2002: 281) and this could be done through provision of enrichment programs such as practical investigations, projects, learning centers or field trips to meet the needs of scientifically gifted learners.

Neglect of our gifted learners, including those who come from limited economic circumstances, will make it impossible for South Africa to compete in a global economy driven by new ideas. This might explain why the country always fares badly in the Third International Mathematics and Science study assessments (Renzulli 2005: 3). These learners are seen as crucial contributors to a technological society in coming generations and should be afforded opportunities to fully-realize their potential.

If not afforded enrichment activities much of what is taught, if they remember it longer than the next examination, is unlikely to be ever used by learners when they become adults. “Learning less-better” is a cliché that is perhaps well worth considering unless they are given opportunities to engage in meaningful and worthwhile experiences in science through various enrichment programs (Moscovici 2000: 2, Sousa 2003: 142).

Van Tassel-Baska and Stambaugh (2006) in Newman and Hubner (2012: 102) contend that no curriculum area better challenges the natural curiosity and intellectual spirit of gifted learners than Science through enrichment programs as these challenge the learners.

According to Parker and Oliver (2009) in Newman and Hubner (2012: 104) in raising the challenge level for gifted Science learners through enrichment programs researchers in gifted education have identified three critical constructs:

- Subject-matter content knowledge,
- Pedagogical content knowledge, and
- Knowledge of gifted learners.

Enrichment programs provide the gifted Science learner with more challenging and meaningful learning experiences and this gives them the opportunity to impact on South Africa’s scientific, technological and social future (Engelbrecht & Green 2003: 196).

Santrock (2004: 202) adds that enrichment programs provide learners with opportunities for learning that are usually not present in the curriculum and can be made available in the regular classroom through independent study, in after-school, through mentoring programs, and through study arrangements. One teaching strategy that is used in all classrooms, but can also be used as enrichment to challenge the abilities of the gifted Science learner, according to Landsberg et al. (2006: 483), is that of direct instruction.

#### **2.4.6 DIRECT INSTRUCTION**

Direct instruction is sometimes referred to as “chalk and talk”, and it is a teacher-centered approach where the teacher delivers content in a structured way, directing the activities of the learners and maintaining a focus on academic content. To be used for enrichment, this approach requires the use of Bloom’s taxonomy to ensure the teaching/learning process doesn’t deteriorate into a process which requires learners to merely memorize and reproduce (Vaughn et al. 2003: 411). Here the teacher develops questions in a hierarchical order, from simple to complex, where normally only the gifted learner would answer the complex questions.

Gifted learners need to be challenged to think, to reason and to be able to explain and justify their thoughts. Higher-level thinking can be developed in the classroom through enrichment programs like projects, Saturday programs, quizzes, assignments that draw upon Bloom’s taxonomy affirms (Santrock 2004: 202). The major idea of the taxonomy in enrichment programs is that learning outcomes can be arranged in a hierarchy from less to more complex.

#### **2.4.7 RENZULLI’S TRIAD MODEL**

Another researcher in gifted education, Renzulli came up with enrichment Triad Model also called the school wide Enrichment Model which can be used for all learners in a particular grade doing Physical Science. The model’s ideas on teaching gifted learners are also in line with the principles of problem solving. According to his Enrichment Triad, the role of the learner is transferred from that of an exercise-doer to that of a first-hand inquirer (Landsberg et al. 2006: 481). The Enrichment Triad has three levels of enrichment with the first two levels comprising general exploratory activities and group skills training for all learners in a group or class.

Level one of the enrichment model comprises general exploratory activities intended to expose learners to various topics in which they may develop interest. A variety of

strategies may be used to expose learners to a while range of topics from which they can select research problems. This can be done through provision of interest centers, exhibitions, libraries , workshops, magazines, slides, cassettes, DVDs, models, field study tours, or brainstorming sessions (Renzulli 2005: 33). Level one thus provides a logical prelude to the next stage of the enrichment model.

Level two enrichment of the model involves teaching-learning activities which centre on the stimulation of higher-order thinking and feeling processes and skills. Such enrichment consists mainly of exercises enabling learners assimilate subject matter and to resolve problems inherent in it (Renzulli, Leppien & Hays 2000: 36). This level also involves exercises to stimulate critical and divergent thinking and enhance problem-solving, analytical, synthetic and hypothesizing skills, and comparative and productive thinking.

Techniques such as brainstorming are used to enhance fluency of ideas, flexibility, and originality and other appropriate thinking and feeling skills. The following cognitive and affective processes are, for instance, included in this enrichment level: brainstorming, observation, classification, categorization, hypothesizing, awareness, appreciation, synthesis fluency, flexibility, originality, elaboration, value clarification and commitment (Landsberg et al. 2006: 483).

These two levels of the Enrichment Model are of crucial importance for the gifted learner since they stimulate interest and promote specific processes of thinking and feeling with a view to the third level of enrichment: the investigation of actual problems.

Level three of the enrichment model involves individual and cooperative problem solving and the heart of this level is the fact that gifted learners are trained in methods of inquiry with the emphasis being on innovation in learning. This phase of the Triad involves the investigation of real problems by appropriate methods where learners study theoretical structures, examine raw data and discover generations in their chosen topics (Renzulli et al. 2000: 37).

Only a few learners (the gifted) will reach the third level of the Triad which involves finding the problems, formulating the problem, analyzing the problem, applying research methods and formulating specific deductions. The gifted learners' work is often directed at some kind of product, and this attitude towards a problem situation may be regarded as the essential difference between the scientist, who discovers areas of inquiry, and the technicians, who deals with presented areas of inquiry (Landsberg et al. 2006: 483).

Because investigation is emphasized, this model is clearly in line with the tenets of outcome-based education as noted in the Department of Basic Education Physical Sciences CAPS document (2011: 4).

#### **2.4.8 SKYPING**

The Science teacher, in this technological era, can also make use of skypeing to communicate with his/her gifted Science learners via voice, text message, file transfer and link exchange simultaneously. The service allows learners to communicate with peers by voice using a microphone, video by using webcam, and instant messaging over the internet. Phone calls may be placed to recipients on the traditional telephone networks. Although Skype is a commercial product, its free version is being used with increasing frequency among teachers and learners interested in global educational projects (Heinla, Kasesalu & Tallinn 2003: 104).

Through such programs, learners are encouraged to make sense of Science using their current ideas. They are challenged to describe, predict, explain, justify, debate, and defend the adequacy of their understanding, therefore, dialogue is key (Woolfolk 2010: 476).

The video conferencing aspect of the software is valuable in that it provides a way to connect learners who speak different languages, hold virtual field trips and reach out to

experts in the science field. These experiences allow the gifted Science learners a chance to apply what they are learning in the classroom to real-life experiences.

Skype provides the science teachers with a way to make their classrooms more interactive, interesting, educative, and enriching as learners are afforded the opportunity to reconstruct outside reality by building accurate mental representations such as propositional networks, concepts, cause and effect patterns, and condition-action production rules that reflect “the way things really are” (Kuhn 2007: 112).

The more the gifted learner learns through skyping the deeper and broader his or her experience is the closer that person’s knowledge will reflect objective reality (Heinla, Kasesalu & Tallinn 2003: 104).

Skype also saves the gifted learners from being wounded by the teacher’s words or school practices that embarrass, label, or demean. It also allows learners to work on activities and share information with others across the globe, avoiding heavy emphasis on grades and competition (Olson 2008: 46).

By using skype, Piaget’s notions of assimilation, disequilibrium, and accommodation operate here. Gifted learners try to make new information fit existing ideas (assimilation), but when the fit simply won’t work and disequilibrium occurs, then accommodation or changes in cognitive structures follow. All this occurs as learners work at different paces, sometimes exercising varied learning options, and are assessed using indicators that fit their interests and needs (Jackson & Davis 2000: 23).

In my opinion, skyping provides interactive teaching and learning, offers a unique, integrated platform that brings together three pillars of teaching: content, instruction, and assessment. It also increases learner engagement, while supporting learner-centered collaborative learning and providing real time assessment feedback to the Science teacher.



## **2.5 BENEFITS DERIVED FROM ENRICHMENT PROGRAMS**

Since enrichment programs address higher level outcomes, learners move away from simple recall and low-level understanding of concepts and place emphasis on the ability to apply and synthesize knowledge to complex problems. In the classroom, the gifted learners are given different tasks at varying levels of difficulty (differentiation by ‘input’) and/or required to give more advanced responses than their peers (differentiation by ‘output’) (Child 2004: 269).

DeLacy (2004: 40) regards enrichment as providing richer and more varied content through strategies that supplement normal grade level work. Other examples of enrichment programs identified by the author are Saturday classes, summer and/or winter programs, simulations, and games. In South Africa learners benefit from government sponsored Saturday and winter programs. The learners are provided with free tuition, transport and food, thus eradicating economic discrepancies among the learners.

Some parents, however, opt for Saturday and winter programs run by universities such as North-West University (Vaal Triangle Campus), Vaal University of Technology (Vanderbijlpark Campus), in the Gauteng province, or those run by private schools, colleges, or independent tutors. These programs involve giving the gifted Science learner an extended, modified curriculum both in content and presentation, and according to Passow (1992) in Child (2004: 268) enrichment programs have four principles, viz; modification in breadth of approach, pace of presentation, content of material, and teaching process skills such as critical thinking, problem-solving communication, and social skill and any gifted Science learner subjected to enrichment stands to benefit.

The gifted Science learner therefore, typically engages in certain kinds of thinking and behavior such as regularly making careful observations, collecting, organizing, and analyzing data, measuring, graphing, and understanding spatial relations, paying attention to and regulating their own thinking, and knowing when and how to apply their

knowledge to solve problems if subjected to enrichment programs such as those mentioned above (Chapman 2000 in Santrock 2004: 360).

Enrichment programs such as learning centres, extension work, library corners, and projects help the gifted Science learners to distinguish between fruitful errors and misconceptions, between errors that are on the right path but stem from incomplete understanding, and plainly wrong ideas that need to be replaced by more accurate conceptions, thus cultivating the “incremental” theory of intelligence where one believes that hard work and effort can increase intelligence (Sheets 2006: 7).

Sheets (2006: 7), explains the beliefs of these gifted Science learners subjected to enrichment programs, “The more you learn, the smarter you are. Mistakes are learning opportunities; they are paths to solving a problem”. These learners are more willing to take risks because the outcome does not necessarily reflect their intelligence (Sheets 2006: 7). From my experience in the classroom, I discovered that most gifted Science learners are risk takers, they try several approaches to solving a problem, and are not ashamed to acknowledge where they went wrong.

Enrichment programs, therefore, provide the gifted Science learners with an environment where risk-taking is tolerated, where ideas are cherished and encouraged (irrespective of conformity) and where independence, creativity and autonomy are the norm (Ng & Nicholas 2007: 191). Such learning environments are tolerant of learning styles, strengths and idiosyncratic behaviors that in a normal classroom may be disruptive. As individuals, gifted Science learners have much to gain from the challenge of abstract thinking, creative problem-solving, and intellectual self-actualization that can be achieved through the scientific enterprise in the form of enrichment programs (Rogers 2002: 64).

Other enrichment programs such as learning centres, assignments, simulations, and field trips provide tools to vary the curriculum so that learners who have already mastered given material can progress, or whose potential giftedness is not cultivated by the

standard curriculum can pursue an area in greater depth. The open-ended nature of such programs allows all gifted Science learners to explore issues to the extent and depth that they can be challenged. The gifted Science learners can be encouraged, guided and expected to produce outcomes at a much higher level (Rogers 2007: 63).

These enrichment programs, also, through modeling, coaching and scaffolding provide the impetus for learners to engage in articulation, reflection, exploration and problem-solving (Siegle 2005: 30). Through enrichment programs the gifted Science learners are challenged, they make the choice to work hard, and they are rewarded with success (Watson & Ryan 2007: 39). In the classroom situation, I have noticed, the gifted can even shout with joy, jump, clap, or unconsciously bang the table if they get the answer correct.

When the curriculum does not challenge the gifted Science learners and it becomes expected that they do well because they are smart, they are not given the baby steps to understand that intelligence is incremental, and their self-esteem can become shattered, with the fear of failure, they quit taking risks and can become underachievers. This can be prevented if they are given materials that are challenging, through enrichment programs, from an early age (Sheets 2006: 8).

Through enrichment programs such as small group investigations, and projects, gifted Science learners are given considerable freedom and spontaneity in choosing activities. They are allowed to move from one activity to another as they desire with the teacher acting as a facilitator rather than a director of learning where s/he merely shows the learners how to perform intellectual activities, demonstrate interesting ways to explore curriculum materials, and offers help *when* the learners request it. Such enrichment programs enhance abstractness, complexity, variety, and inquiry in the gifted Science learners (Santrock 2006: 247).

The South African education framework revolves around seven critical principles on which the education system is based and which teachers instill in learners to help them

become fully functional individuals who maintain civilized norms, lead rewarding lives and create a thriving society. These seven principles are problem-solving, working with others, self-management, research, communicating effectively, science/technology and understanding the world as a set of related systems, and for the gifted learner these can surely be realized through provision of enrichment programs (Jacobs et al. 2011: 91).

## **2.6 CONCLUSION**

Conclusively, from the above it can be concluded that gifted Science learners exposed to enrichment programs will be able to, among other things: critically examine the complexity of knowledge and information, produce a variety of authentic projects using 21<sup>st</sup> century tools that demonstrate understanding in multiple fields and disciplines, conduct thoughtful research, remain motivated and well behaved in class, ask and assess multifaceted questions in a variety of fields and disciplines, set and achieve reasonable personal and academic goals, assume leadership and participatory roles in group learning situations, have positive self-esteem and self-concept, as well as think creatively and critically to identify and suggest possible solutions to real-world problems (Engelbrecht & Green 2003: 197; Landsberg et al. 2006: 480; Rogers 2002: 281; Santrock 2004: 203; West-Burnham 2007).

From this discussion, it should be clear that an enrichment program is neither selected at will nor according to personal taste, but should be suitable for integration into a specific lesson/ topic.

The next chapter presents the research design, methods used to collect and analyze data, sampling techniques used in conducting this research as well as a statement on research ethics.

## **CHAPTER 3**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 INTRODUCTION**

Every research requires a research design that is carefully tailored to the exact needs of the problem. Research designs have two essential components; observation, and an analysis of the relationships between the variables. Research methodology is a description of methods chosen, of their limitation and resources, of clarifying their presuppositions and consequences. These chosen methods should complement one another and have “goodness of fit” to deliver data and findings that will reflect the research question and suit the research purpose (McMillan & Schumacher 2010: 257).

Three categories of research design can be distinguished, classified according to the level of scientific rigor involved in proving the casual relationship, viz: pre-experimental designs, quasi-experimental designs, and experimental designs (Bless & Higson-Smith 2000: 67).

Three experimental designs are the pre-test/ post-test control group design, the post-test only control group design, and factorial designs (Bless & Higson-Smith 2000: 67).

#### **3.2 RESEARCH METHODS AND DESIGN**

McMillan and Schumacher (2010: 20) define a research design as that which describes the procedures for conducting the study, including when, from whom, and under what conditions that data will be obtained. In a way the research design indicates the general plan of action, that is, how the research will be set up, what happens to the participants, and what methods of data collection are used.

The purpose, therefore, of a research design is to specify a plan for generating empirical evidence that will be used to answer the research questions. Since the intent was to use a design that would result in drawing the most valid, credible conclusions from the answers to the research question, this research assumed a more quantitative focus where the researcher emphasized objectivity in measuring and describing phenomena using numbers, structure, statistics, and control.

Mackenzie and Knipe (2006: 195) define a research design as a procedure for collecting, analyzing, and mixing both quantitative and qualitative data at some stage of the research process within a single study to understand a research problem more completely. The researcher adopted this approach as both quantitative and qualitative sets of data are compatible and can thus be used in a single study (Elliot & Lukes 2008: 100).

According to Elliot and Lukes (2008: 100) qualitative and quantitative approaches represent different ends on a continuum and should not be viewed as polar opposites. The researcher settled for the triangulation method because it is prudent to look at a situation from different angles. The use of both quantitative and qualitative methods in this study ensured the two complemented each other's deficiencies. Since this study used triangulation, data was represented through numbers and analyzed through words, and statistics. This research, as indicated earlier on, assumed a more quantitative approach.

Bless and Higson-Smith (2000: 63) state that a research design as a specification of the most adequate operations to be performed in order to test a specific hypothesis under given conditions.

Two major sub classifications of quantitative design are experimental and non-experimental. Experimental comes from the word experiment which means a way of learning something by varying some condition and observing the effect on something else (McMillan & Schumacher 2010: 257). Characteristics of experimental research include:

- Statistical equivalence of subjects in intervention and control and /or comparison groups (this is achieved through random assignment of participants),
- Researcher-controlled interventions independently and uniformly applied to all subjects,
- Measurement of each dependent variable,
- Use of inferential statistics, and
- Rigorous control of conditions and extraneous variables (Bless & Higson-Smith 2000: 63).

In an experimental design, therefore, the researcher intervenes with a procedure that determines what the participants will experience. The researcher, hence, has control over what will happen to the participants by systematically imposing or withholding specified intervention (Farkas 2003: 42; Miller & Salkind 2002: 12). The researcher then made comparisons between participants who had had and those who had not had the intervention.

Experimental designs therefore investigate cause-and-effect relationships between interventions and outcomes (Farkas 2003: 42). The experimentation method allows learners to experience reality and discover things for themselves. A more detailed definition of experimentation method is that it consists of actions and observation performed to prove or disapprove a hypothesis, or to research a casual relationship between phenomena (Jacobs et al. 2011: 209).

However experimental research has its own challenges especially in the educational field. One of the difficulties in planning experimental research is knowing whether the interventions will be strong enough- that is, if the treatment condition is providing feedback to learners, will the feedback make enough of an impact to affect learners' attitudes? Would feedback given over several consecutive days make a difference? In other words, either the treatment should be tested in advance to ensure that it is powerful enough to make an impact or sufficient time should be allocated to give the treatment a

chance to work (McMillan & Schumacher 2010: 262). This can be an especially difficult problem in educational research because many factors such as achievement, attitudes, motivation, and self-concept, may affect the dependent variables, and it might be hard to single out a specific independent variable that will have a meaningful, unique effect, given all other influences.

Also, experimental treatments are sometimes insufficiently distinct from treatments given comparison groups for a statistical difference to be possible. Another important consideration in designing an experiment is to be sure that the treatment or intervention has occurred as planned, which is called fidelity of intervention (McMillan & Schumacher 2010: 262). To ensure that the intervention was implemented as designed, the researcher followed O'Donnell (2008)'s criteria cited in McMillan and Schumacher (2010: 263), detailed below:

- adherence.....whether each component of the intervention is delivered as designed,
- duration.....whether the intervention was implemented with a sufficient length and number of sessions,
- quality of delivery....whether the techniques, processes, and procedures as prescribed are delivered,
- participant responsiveness...whether participants are engaged in and involved with program activities and content, and
- Program differentiation...whether features that distinguish the intervention from other programs are present.

In this research the researcher gathered data from the participants by monitoring the intervention to assure fidelity. The intervention in this research were enrichment programs (Saturday classes, research projects, field trips, DVDs) given to the experimental group. The researcher ensured the control group did not get the intervention so as to determine the impact of the intervention on the experimental group only. The Saturday extra classes were given by university lecturers at the Vaal University of Technology as well as North-West University (Vaal Campus). For the field



trip, the experimental group was taken to the Sasol fertilizer-producing plant in Sasolburg. These learners were then given DVDs to watch on the same topic. They watched the DVDs in the presence of the researcher to ensure no one in the control group had access to the DVDs.

On the other hand, non-experimental research designs describe phenomena and examine relationships between different phenomena without any direct manipulation of conditions that are experienced.

Considering the topic for this research, it is evident that intervention was provided in the form of enrichment programs to one group of twenty gifted science learners, with the other group, also with twenty students, not being subjected to any form of intervention. This research's purpose was to investigate cause - and - effect relationships between interventions (enrichment) and measured outcomes (performance). Hess and Henig (2008) in McMillan and Schumacher (2010: 260) warn that the real challenge is to design the procedures so that the results obtained can be reasonably generalized to other people and environments, thereby balancing internal and external validity in a design.

A simple experiment involves two groups, one called the intervention, experimental, or treatment group and the other called the control or comparison group (Bless & Higson-Smith 2000: 73). Each group is then assigned one level (intervention) of the independent variable (Farkas 2003: 43). In this research the control group received no intervention at all. The researcher identified forty gifted Science learners in Grade 11 at three selected schools and randomly assigned them to one of the two groups (either control or experimental) after having written the first pre-test, with twenty gifted learners in each group.

With random assignment, every participant used in the research has an equal chance of being in each group. One group (the experimental) was given enrichment programs while the other was the control and did not receive any form of intervention. Researcher-controlled interventions, or direct manipulation of the intervention, are perhaps the most

distinct feature of experimental research. Manipulation in this sense meant that the researcher decided on and controlled the specific intervention, treatment, or condition for each group of participants (Clements & Sarama 2008: 444). In this research, as highlighted earlier on, the experimental group received intervention in the form of enrichment programs.

Another important consideration in designing experimental research is to be sure that the treatment or intervention has occurred as planned, which is fidelity of intervention, continue Clements and Sarama (2008: 444). In this research the intervention was in the form of research projects, assignments, DVDs, extra lessons, and field trips.

### **3.3 SAMPLING**

A sample is the group of participants from whom the data are collected (McMillan & Schumacher 2010: 129). The sample can be selected from a larger group of persons, identified as a population, or can simply refer to the group of participants from whom data are collected. Cohen, Manion and Morrison (2007) state that sampling is a procedure that researchers use to select a smaller group of people, places, or things to study from a population of interest.

There are two major categories of different sampling techniques: Probability and non-probability, note Bless and Higson-Smith (2000: 83). The type of probability sampling used in this research was random sampling.

With random sampling, each member out of the chosen forty gifted Science learners had an equal probability of being selected into one of the two groups. Bias is avoided because there is a high probability that all the population characteristics will be represented in the sample (Pealer, Weiler, Piggs, Miller and Dorman 2001: 547). There are four types of random sampling, and these are simple random sampling, systematic sampling, stratified random sampling, and cluster sampling.

However, since the population used in this research was small, simple random sampling was used. In simple random sampling, participants are selected from the population so that all members have the same probability of being chosen. Forty gifted Science learners who are in Grade 11 at three selected schools in the Free State province were identified with the help of teachers, parents, and the schools' psychologists (see below for full details on how the forty gifted science learners were identified).

Cohen et al. (2007) assert that the quality of a piece of research lies not only in the appropriateness of methodology or instrumentation, but also on the suitability of the sampling strategy adopted hence the researcher settled for simple random sampling for this research.

Simple random sampling requires each member of the population to be assigned a number or be available electronically. In this research, all the forty gifted Science learners were assigned numbers from 001 to 040. The numbers were put in a hat after the learners had written the first pretest (Pre-test 1) and drawn so that the learners could be placed into either of the two groups (experimental, or control). Throughout the research, the learners were referred to using those numbers. This helped get rid of sampling bias. Each group had twenty gifted Science learners and learners used the same numbers throughout the research.

In identifying gifted learners for this research, the researcher considered three high schools whose learners came from almost the same socio-economic backgrounds. Most of their parents are middle-income employees, with the majority of them working for ESKOM and Anglo-American companies. The three schools are in the same district, same location, and are urban schools with satisfactorily equipped laboratories. Their science teachers are all qualified and have more than five years teaching experience, in the subject. The schools are mixed gender schools, electrified, have clean water and boast of adequate resources, and offer English as their Home Language.

The schools' psychologists developed an achievement test which was given to all grade 11 science learners. The learners wrote the tests on the same day, same time, under the same conditions. Their IQ scores were computed by comparing the mental age score to the learner's actual chronological age using the formula:

$$\text{Intelligence Quotient} = \text{Mental Age} / \text{Chronological Age} \times 100$$

(McMillan & Schumacher 2010: 118). However, this has a disadvantage in that IQ scores calculated on the basis of mental age do not have the same meaning as the learners get older. To cope with this, the schools' psychologists used the concept of deviation IQ. The deviation IQ score is a number that tells exactly how much above or below the average a person scored on the test, compared to others in the same age group (McMillan & Schumacher 2010: 118).

The psychologists, teachers, and principals also used guidelines for identifying gifted learners (outlined in Chapter 2 of this research). Sixty gifted learners were identified and then given another achievement test developed by the same schools' psychologists, finally bringing the number of identified gifted learners to forty, twenty-eight girls and twelve boys.

### **3.4 DATA COLLECTION AND ANALYSIS**

In Social Sciences such as education several methods are used to collect data especially in experimental researches (Bless & Higson-Smith 2000: 103). In this research data was collected using achievement tests, pre-tests and post-tests in this case, and interviews. Achievement tests measure what the learner has learnt. An advantage of achievement tests is that they have a more restricted coverage, are more closely tied to school subjects, and measure more recent learning than aptitude tests (McMillan & Schumacher 2010: 191).

There are many standardized achievement tests, examples of which are diagnostic, norm-referenced and criterion-referenced, with some emphasizing principles and skills rather

than knowledge of specific facts (Woolfolk 2010: 496). The choice of achievement test depends on the purpose of the research. If the research is concerned with achievement in a specific school subject, then it would be best to use a test that measures only that subject rather than using a battery survey.

Since this research focused on comparing the performance of gifted Science learners only norm-referenced tests, referred to as pre-tests and post-tests in this research, were used to collect data, because the purpose of norm-referenced tests is to differentiate between learners and to achieve this, the test items need to be fairly difficult (Bless & Higson-Smith 2000: 121). Copies of the two pre-tests and the two post-tests given to the learners as well as the memoranda used to mark the learners' work are included at the end of this dissertation (see Appendices B to I).

To test for the reliability of the scores the learners wrote the same post-tests twice and the scores were compared by the researcher.

Another tool that was used to collect data was the interview. An interview involves direct personal contact with the participant who is asked to answer questions relating to the research (Henning, Gravett and van Rensburg 2003: 11).

In this research interviews were necessitated by the fact that “frequently there is a need for more specific and detailed information which can facilitate comparison of the reactions of different participants”; write Bless and Higson-Smith (2000: 105). Hence to obtain learners' perceptions and evaluation of enrichment programs, the researcher interviewed all twenty learners who were in the experimental group.

Since interviews take several forms, for this research the researcher chose to use the phenomenological interview. This is a specific type of in-depth interview used to study the meanings or essence of a lived experience among selected participants (McMillan & Schumacher 2010: 356). The researcher conducted a single, comprehensive interview with each learner to learn about their experiences, and evaluation of enrichment programs. Phenomenological studies investigate what was experienced, how it was

experienced, and finally the meanings that the learners assign to experience (Bless & Higson-Smith 2000: 104).

It must be noted however, that interviews were used as a follow up to the two pre-tests and two post-tests written by the learners. An interview is a two way conversation in which an interviewer asks the respondent questions to collect data and to learn about ideas, beliefs, views, opinions, and behaviors of the respondents (Henning et al. 2003: 12).

Henning et al. (2003: 12) further assert that recording an interview must be done meticulously hence in this research all interviews were tape-recorded as well as taking down notes at the same time. This way the researcher ensured he would still have the information should the recorder fail to function properly. Tape or digital recording the interview ensures completeness of the verbal interaction and provides material for reliability checks (McMillan & Schumacher 2010: 360). Immediately following the interview, the researcher transcribed the tape. This ensured all data was captured accurately while still fresh for future analysis (Henning et al. 2003: 39).

A structured interview, in which questions were written before hand, was used to collect the data since these are direct and help overcome misunderstandings and misinterpretations of words and questions.

The questions given in the interview were related directly to the purpose of the research as they sought to establish learners' experience and evaluation of enrichment programs given to them and the questions were presented to each learner in exactly the same way to minimize the role and influence of the researcher and to enable a more objective comparison of results (Bless & Higson-Smith 2000: 105). A copy of the interview questions is attached (see Appendix L).

After the data had been collected it had to be analyzed. In analyzing data for this research, descriptive statistics were used. The use of descriptive statistics is the most

fundamental way to summarize data, and it is indispensable in interpreting the results of quantitative research in that descriptive statistics transform a set of numbers or observations into devices that describe or characterize data (Utley 2007: 92). Descriptive statistics can be described as either univariate or bivariate.

Univariate analysis is done to summarize data on a single characteristic or variable, usually the dependent variable, whereas bivariate analysis is used when there is a correlation among variables or when different groups are compared (McMillan & Schumacher 2010: 151). Bivariate procedures include correlation, comparing frequencies, comparing percentages, comparing means, and comparing medians. In this research the last four procedures were used to analyze the data collected.

A frequency distribution shows how often each score occurred. The marks were listed from highest to lowest and created what is called a rank-order distribution. The rank-order distribution was transformed to a frequency distribution by indicating the number of times each score was attained, for example;

TABLE 1: EXAMPLE OF FREQUENCY DISTRIBUTION TABLE

Scores in rank order	Tallies	Frequency (f)
50	111	3
49	11	2
48	111	3

(Gorin 2007: 459; McMillan & Schumacher 2010: 152)

Similar frequency distribution tables were drawn for the two groups in each test they wrote. After the frequency distribution tables were drawn, data for the two groups was then displayed pictorially on a histogram for respective tests. On the histograms drawn in this dissertation the vertical dimension on the graph (y-axis) lists the scores, and the

horizontal dimension of the histogram displays numbers representing learners. Columns were drawn in the graphs to correspond with the scores obtained.

The frequency tables and histograms showing scores obtained by learners were drawn for each of the groups (experimental and control) in the research, and then compared. This is because the nature of data analysis, according to Bless and Higson-Smith (2000: 137) can take many different forms depending upon the nature of the research question and design, and the nature of the data itself.

The means and medians of both groups were also calculated and analyzed. The mean is simply the arithmetic average of all the scores whereas the median is the point that divides a rank-ordered distribution into halves that contain an equal number of scores in each half (Woolfolk 2010: 508). The means and medians for both groups were also compared for the two pre-tests and the two post-tests they wrote.

### **3.5 VALIDITY AND RELIABILITY**

The central aim of research design is to establish a relationship between the independent and dependent variables with a high degree of certainty (Bless & Higson-Smith 2000: 80). McMillan and Schumacher (2010: 104) define validity as the degree to which scientific explanations of phenomena match reality. This is sometimes referred to as experimental validity and refers to the truthfulness of findings and conclusions.

Validity according to Denzin and Lincoln (2000) has to do with the degree of capturing the reality of the situation under investigation. Some of the aspects to be considered under validity are honesty, depth, richness, and scope of the data generated, while how the participants were approached, and the extent of the triangulation can also be included.

There are four types of design validity in quantitative research, viz: statistical conclusion validity, internal validity, external validity, and construct validity. Statistical conclusion validity entails the appropriate use of statistical tests to determine whether purported



relationships are a reflection of actual relationships (Gorin 2007: 461). This can be transformed into the question; is there a relationship among the variables? Statistics are used to determine whether a relationship exists between two or more variables, and the issue here is the extent to which the calculated statistics accurately portray the actual relationship (Shadish, Cook and Campbell (2002) in McMillan & Schumacher (2010: 108).

Internal validity is concerned with the question, “Do the observed changes in the dependent variable actually relate to changes in the independent variable?” (Bless & Higson-Smith 2000: 80). Internal validity summarily means casual truthfulness. However two conditions must be present to establish that a threat is plausible;

- the threat must influence the dependent variables, and
- The threat must represent a factor or variable that differs in amount or intensity across levels of the independent variable.

In a way a factor could influence the dependent variables but would not be a threat if it affects the dependent variables of both groups equally. Categories of threats to internal validity include history (uncontrolled events that affect the dependent variable), selection (group composition differences), statistical regression, pretesting, attrition (when participants systematically drop out or are lost during the research), diffusion, subject effects, and experimenter effects.

In order to obtain high internal validity a research design should control as many extraneous variables as possible (Utley 2007: 93). To curb selection as a threat the learners were allocated to groups through random sampling, and learners of similar performance (gifted) were chosen. Attrition was prevented by ensuring data collection was conducted over a maximum of seven weeks.

External validity refers to the generalizability of the results and the two general categories are population external validity and ecological external validity (Woolfolk 2010: 498). Population external validity refers to the extent to which the results can be

generalized to other people, who have the same characteristics as those in the experiment, in this case giftedness in Science education (McMillan & Schumacher 2010: 116). In this way the sample is therefore representative of the population in question.

Ecological external validity refers to the conditions of the research and the extent to which generalizing the results is limited to similar conditions, such as the nature of the independent and dependent variables ( enrichment programs and performance, in this case), physical surroundings, pretest or posttest sensitization, and effects caused by the presence of the researcher (Wyss, Tai & Sadler 2007: 47).

In this research the researcher ensured that the study simulated reality as closely as possible through provision of enrichment programs such as carrying out research projects, going on field trips, provision of extra lessons, and watching DVDs.

The researcher started off by teaching the forty gifted learners the same topic (chemical systems- artificial fertilizers) in the same room at the same time (Department of Basic Education Physical Sciences CAPS Document 2011: 115). The learners were given four-one hour lessons on the topic. The experimental group then went on a field trip to the Sasol fertilizer producing company in Sasolburg where they went on a tour around the plant. While at the plant, they were given lessons on the manufacture, uses, and disadvantages of artificial fertilizers.

Extra literature on the topic was also given to these gifted learners. The same group then attended Saturday classes at the North-West University (Vaal Triangle campus) on the same topic, where they were taught by science lecturers at that university. The lessons presented the concepts at an advanced level covering some aspects (such as eutrophication, Ostwald process, gasification) which were not taught in class by the researcher while the control group was present.

Afterwards the experimental group carried out a research project in which they were again looking at the manufacture, use, and disadvantages of artificial fertilizers. Here

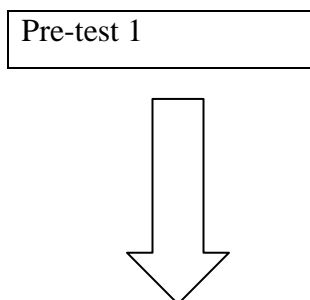
they also looked at chemical equations involved in the manufacture of these fertilizers. These equations were not taught by the researcher in class but were to be found in the post-test. The forty gifted learners then wrote the same post-test under the same conditions.

The researcher then taught the forty gifted learners another topic (Chemical Change-electrolytic and galvanic cells). They were given four-one hour lessons. Gifted learners in the experimental group were then given DVDs on the same topic to watch under the supervision of the researcher. This was to ensure that learners from the control group did not have access to the DVDs.

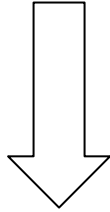
The same group then attended extra classes at the North-West University (Vaal Triangle Campus) as well as at the Vaal University of Technology (Vaal Campus), where they were taught by science gurus. Their lessons included aspects of the topic (such as differences between the two cells, calculating standard potentials, and writing net cell reaction equations) which were not taught by the researcher during class lessons. These concepts were taught at an advanced level with a faster pacing.

Use of a variety of methods as well as resource persons enhanced the learners' interest in science. The forty gifted learners then wrote the same post-test under the supervision of the researcher. The researcher's role during the field trip, extra classes at universities, DVD watching, and research execution, was largely participant observation except when he had to deliver the lessons to the gifted learners, thereby assuming a participant role. This was to eradicate any researcher- effects which could have been effected on the learners by the researcher, thereby ensuring differences in the learners' performance was due to the enrichment programs given.

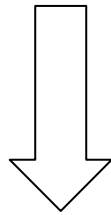
Diagrammatically, the data collection process can be summed up as thus;



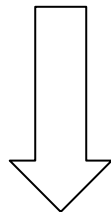
Teaching the whole  
group same topic



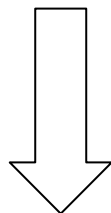
Giving enrichment to  
experimental group



Post-test 1



Pre-test 2



Teaching whole group  
second topic

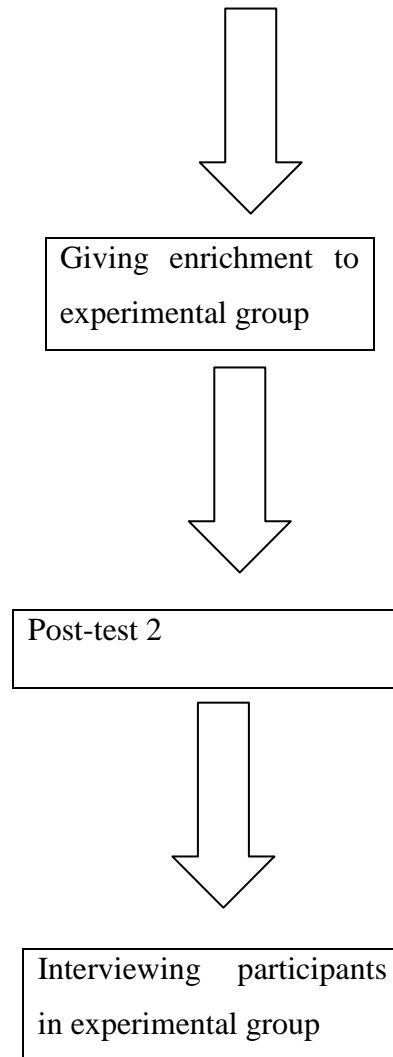


FIGURE 1: Summary of data collection process.

In carrying out the research the researcher also considered construct validity.

McMillan and Schumacher (2010:115) state that construct validity refers to inferences that are made from the nature of the measurement and interventions used to the constructs they purportedly represent. There are many ways of measuring learner achievement and doing curriculum alignments, so if one test is used and only one model of curriculum alignment is proposed, construct validity will be weak. In this research two pre-tests and two post-tests were given to measure the effect of the intervention.

In this research, validity was enhanced by having learners read the data that was collected from them during the interviews, as well as giving them back their test scripts after each test to let them check the quality and accuracy of the researcher's marking and recording of scores.

Wyss et al. (2007: 49) define reliability as the extent to which measures are free from error and suggest that questions should actually not be ambiguous, assessment should be done when participants are of sound health using error-free tools, in a good mood, and highly motivated. The objective in selecting or evaluating instruments, then, is to look for evidence that error has been controlled as much as possible.

Even though the reliability coefficient ranges from .00 to .99 the higher the coefficient the higher the reliability. These recommendations were implemented and adhered to throughout the research as learners wrote the tests when they were all of sound health, had no other test to prepare for, and had no classes to rush to. Learners were assigned to groups randomly, and the researcher made sure the research would not take too long to avoid attrition, diffusion, and maturation. The learners were also made to re-write the same post-tests one week apart to test the reliability of the scores.

### **3.6 STATEMENT ON RESEARCH ETHICS**

Since most educational research deals with human beings, it is necessary to understand the ethical and legal responsibilities of conducting research. Ethics generally are concerned with beliefs about what is right or wrong from a moral perspective (Booyse, Le Roux, Seroto & Wolhuter 2011: 34).

Throughout the research the problem of persuading participants to co-operate with the researcher cannot be ruled out. While lack of co-operation can be disastrous in a research project, learners had the right to refuse to participate, and this is a right the researcher had to respect. Ethical principles were applied throughout the research

process since research findings might be used by other researchers (Booyse et al. 2011: 34).

Accuracy and honesty of the data is a fundamental requirement to ensure trustworthiness and the validity and usefulness of information (McMillan & Schumacher 2010: 34). Ethical rights of learners respected in this study were; informed consent; confidentiality and anonymity, voluntary participation, and full disclosure or deception. Permission to conduct the research at schools was sought from the respective principals (see Appendix P).

### **3.6.1 Informed consent**

This was achieved by providing learners with an explanation of the research, an opportunity to terminate their participation at any time with no penalty, and full disclosure of any risks associated with the research. An individual must agree in writing to participate in a research or to supply information after being informed of and understanding the risks that could be involved (Booyse et al. 2011: 34). Consent was obtained by asking the learners and their parents to co-sign a form that indicated understanding of the research and consent to participate (see Appendix A).

In this research, since the participants were minors, their parents were asked to co-sign their children or dependents' assent forms after the assent form had been read and explained to them (see Appendix A). This research was quite unobtrusive and had no risks for the gifted Science learners. The signed consent forms were stored separately from the results of the study.

### **3.6.2 Confidentiality and anonymity**

The privacy of research participants must be protected. This means that access to participants' characteristics, responses, behavior, and other information is restricted to the researcher (Bless & Higson-Smith 2000: 100).

In this research participants' privacy was ensured through two principles: confidentiality and anonymity. This ascertained no one had access to individual data or the names of the participants except the researcher and that the learners knew before they participated who will have access to the data. Confidentiality was ensured by making certain that the data could not be linked to individual participants by name hence allocation of numbers to the learners. McMillan and Schumacher (2010: 122) suggest this can be achieved through;

- collecting the data anonymously,
- using a system to link names to data that can be destroyed,
- asking the participants to use aliases or numbers, and
- Reporting only group, not individual results.

Considering the first point Booyse et al. (2011: 35) add that anonymity means that those studying or reading the research results will not be able to establish the identity of the research participants on the basis of their responses. To ensure anonymity, the researcher generally uses pseudonyms or impersonal codes in the reporting of research findings. In this research learners were allocated numbers from 001. This way only the researcher and the respective learner knew, for example, who 001 was.

### **3.6.3 Voluntary participation**

Bless and Higson-Smith (2000: 100) hold the view that participation in research must be voluntary and people can refuse to divulge certain information about them. On the other hand McMillan and Schumacher (2010: 118) state that voluntary participation means that participants cannot be compelled, coerced, or required to participate. It therefore means that no one should be forced to participate in research, and also includes the use of information contained in a database if there is any chance that individual identities can be associated with specific data for results, as well as relatively passive data collection.

In this research, the participants were gifted Science learners in grade eleven who volunteered to participate and were informed that they could withdraw from the research



at any time they felt like, without fear of reprimand or punishment (see copy of assent form: Appendix A).

### **3.6.4 Full disclosure or deception**

Johnson and Christensen (2008) in McMillan and Schumacher (2010: 117) advise researchers to be open and honest with participants about all aspects of the study they are taking part in. This usually involves a full disclosure of the purpose of the research, but there are circumstances in which either withholding information about the research or deceiving the participants may be justified. By withholding information, the participants are informed about only part of the purpose of the research. This may be done in studies where full disclosure would seriously affect the validity of the results (McMillan & Schumacher 2010: 118; Woolfolk 2011: 498).

These authors (McMillan & Schumacher 2010: 118; and Woolfolk 2011: 498) believe that deception should be used only in cases where;

- the significance of the potential results is greater than the detrimental effects of lying,
- deception is the only valid way to carry out the study, and
- Appropriate debriefing is used, in which the researcher informs the participants of the nature of and reason for deception following the completion of the research.

During this research, however, no information was withheld from the participants, as they were informed about all aspects of the research. No psychological advantage was taken of the participants. The learners were told how the research was going to proceed, as well as what it was about.

### **3.7 CONCLUSION**

This research assumed a simple experimental design with two groups of participants, the control, and experimental who were assigned to their respective groups by means of

simple random sampling. Data was collected using two pre-tests and two post-tests (see Appendices B to I). In collecting data the following research ethics were observed; voluntary participation, confidentiality, informed consent, full disclosure or deception, and validity and reliability.

Once data collection had been finalized, the data was then analyzed and interpreted in the next chapter. This analysis was conducted so that the researcher could detect consistent patterns within the data, such as the consistent co-variance of two or more variables. Furthermore the data analysis process allowed the researcher to generalize the findings from the sample used in the research, to the larger population in which the researcher was interested, in this case gifted Science learners (Bless & Higson-Smith 2000: 137)

The next chapter, which is Chapter 4, details research findings, data presentation and analysis of learners' performance as well as their responses to interview questions.

## **CHAPTER FOUR**

### **DATA PRESENTATION, ANALYSIS AND INTERPRETATION**

#### **4.1 INTRODUCTION:**

This chapter focused on data presentation and analysis. The data had been collected after the learners were given a pre-test to write (referred to as pre-test 1). After the first pre-test the learners were allocated into either of the two groups (experimental or control). Afterwards all learners from both groups had lessons on the same topic presented to them by the researcher (manufacture, use, and disadvantages of fertilizers).

The experimental group then had enrichment programs given to them in the form of a field trip to the Sasol plant that manufactures fertilizers, as well as carrying out a research project on the manufacture, uses and dangers of fertilizers, as well as attending extra lessons at the North-West University. The forty learners then wrote the same post-test (referred to as post-test 1 in this research). Their work was marked by the researcher using the same memorandum and the scores were recorded.

The learners were then made to re-write the same post-test to test the reliability of the test. Afterwards the learners wrote a second pre-test (pre-test 2) on different concepts from the first one. Their marks were again recorded after the work had been marked using a memorandum before they had lessons presented to them by the researcher on the topic 'Electrolytic and galvanic cells'.

The next stage saw the experimental group watching DVDs, having extra lessons given to them by university lecturers from the North-West University, and being given extra work and literature on the same topic. The forty learners then wrote the same post-test (post-test 2). The work was marked using the same memorandum for all learners and their marks were recorded. The learners then re-wrote the same post-test to test for the reliability of the post-test.

The learners in the experimental group then had one – on - one interviews with the researcher on their experiences and evaluation of the enrichment programs they had been given during the study. The interviews consisted of five open-ended questions which the learners answered. Their responses were written down as well as being taped by the researcher. Using both methods (writing and tape recording) ensured accurate capturing of responses.

The marks (referred to as scores in this research) and responses from the interviews were then presented, analyzed and discussed.

In this chapter the data from the research activities is discussed qualitatively and quantitatively in a bid to answer the research question. Scores (as percentages) obtained by all learners in both groups (control and experimental) for the two pre-tests and two post-tests were presented and analyzed as well as responses from interviews held by the experimental group.

The data was collected from only forty gifted learners from three schools in the Fezile-Dabi district. This makes it difficult to generalize the results of the study to all gifted science learners throughout the whole country, taking into consideration the number and socio-economic background of the participants as well as the nature of their schools (urban with adequate resources and experienced, qualified science teachers).

## **4.2 Data presentation and analysis**

### **4.2.1 Pre-test 1**

All forty (40) gifted learners were given a pre-test to write before they were allocated into groups. The pre-test consisted of ten (10) multiple choice questions of two marks each and three long questions with sub-questions totaling eighteen (18) and twelve (12) marks respectively (see Appendix B). This brought the total mark for the pre-test to fifty (50)

marks. The questions were derived from the topic Mechanics (Department of Education: Physical Sciences CAPS document 2011: 10).

The pre-test was written under examination conditions where the learners were seated each on a separate table and invigilated by the researcher, starting to write at the same time. The pre-test was written in one (1) hour. The pre-test was then marked by the researcher using a memorandum (see Appendix C) and the marks (also referred to as scores in this dissertation) were converted to a percentage for easy analysis and comparison.

The following table (Table 2) contains scores for the first pre-test, as percentages, obtained by all forty (40) learners who took part in the research. The first column contains numbers representing the learners (as learners were not referred to using their names) and the second column contains scores, as percentages, obtained by learners. The learners were arranged (in this table) in chronological order, that is from learner 001 to learner 040. The letter N stands for the total number of learners who wrote the first pre-test, that is forty (40) learners.

**TABLE 2**

**First pre-test scores for all the forty learners taking part in the research (N = 40)**

LEARNER	SCORE (%)
001	62
002	68
003	68
004	72
005	70
006	76
007	70
008	74

009	68
010	74
011	62
012	70
013	74
014	68
015	62
016	68
017	70
018	68
019	68
020	74
021	72
022	68
023	70
024	70
025	72
026	76
027	62
028	76
029	68
030	72
031	70
032	76
033	74
034	74
035	68
036	70
037	74
038	62

039	68
040	70

The lowest mark obtained by the gifted learners was 62% while the highest was 76%. Five learners obtained 62%, eleven got 68%, nine obtained 70%, four got 72%, seven got 74%, and four got the highest mark which was 76%. The mode (most common mark) for this first pre-test was 68%, obtained by eleven learners.

The range for the test was 14 %, found by subtracting the lowest score from the highest while the median (middle score) was 70 %.

Learners who obtained the same score were placed in a hat and the numbers drawn allocating them into one of the groups, either control or experimental, to ensure learners of almost same giftedness were distributed evenly. Results of the grouping were as follows:

The first learners to have their numbers placed in a hat and allocated to a group were those who obtained a score of 62% in the first pre-test. As highlighted earlier, this was done to ensure learners of same giftedness were distributed evenly. Learners 001 and 015 were placed into the control group whereas learners 011, 027 and 038 were placed into the experimental group.

The following table (Table 3) shows the groups to which respective learners who obtained 62% were drawn to. There were five learners who obtained this score and two of them (learner 001 and 015) were drawn to the control group with learners 011, 027 and 038 being drawn to the experimental group.

The first column represents the learners with the second column showing the group into which respective learners had been drawn.

**TABLE 3: Learners who obtained 62% (N = 5)**

LEARNER	GROUP ALLOCATED TO
001	Control
011	Experimental
015	Control
027	Experimental
038	Experimental

Next to be allocated groups were learners who obtained 68%. Learners 002, 009, 016, 018, 029, and 039 were drawn to the experimental group whereas learners 003, 014, 019, 022, and 035 were drawn to the control group.

Table 4 below shows the groups into which respective learners who obtained 68 % were drawn to. There were eleven learners who obtained this score and as highlighted above, six learners were drawn to the experimental group while five learners were drawn into the control group.

**TABLE 4: Learners who obtained 68 % (N = 11)**

LEARNER	GROUP ALLOCATED TO
002	Experimental
003	Control
009	Experimental
014	Control
016	Experimental
018	Experimental
019	Control
022	Control
029	Experimental



035	Control
039	Experimental

After allocating learners who got 68% into groups, the researcher then drew numbers representing those nine learners who had obtained 70%.

Of the nine learners who obtained 70 %, learners 005, 017, 036, and 040 were drawn to the experimental group with learners 007, 012, 023, 024, and 031 being drawn to the control group. This is summarized in Table 5 below in which the left-hand column represents the respective learners, with the right-hand column representing the groups into which specific learners were drawn into.

**TABLE 5: Learners who obtained 70 % (N = 9)**

LEARNER	GROUP ALLOCATED TO
005	Experimental
007	Control
012	Control
017	Experimental
023	Control
024	Control
031	Control
036	Experimental
040	Experimental

Next to be allocated into groups were learners who obtained 72%.

Four learners obtained 72 % hence two learners were allocated to each group. Learners 004 and 025 were drawn to the control group with learners 021 and 030 being drawn to the experimental group. This is summarized in Table 6 below, where N stands for the total number of learners who obtained 72 % that is four learners.

**TABLE 6: Learners who obtained 72 % (N = 4)**

LEARNER	GROUP ALLOCATED TO
004	Control
021	Experimental
025	Control
030	Experimental

The researcher went on to allocate groups to the seven learners who had obtained 74%.

Learners 008, 013 and 033 were drawn to the experimental group while learners 010, 020, 034 and 037 were drawn to the control group. All in all six learners obtained 74 %, therefore three learners were drawn to each group. Like in the previous tables, the left-hand column represents learners with the right-hand column representing the groups to which respective learners were drawn. This is represented in Table 7 below.

**TABLE 7: Learners who obtained 74 % (N = 7)**

LEARNER	GROUP ALLOCATED TO
008	Experimental
010	Control
013	Experimental
020	Control
033	Experimental
034	Control
037	Control

The remaining four learners were those who had obtained 76% and were the next to be drawn to groups.

Learners 006 and 028 were drawn to the experimental group while learners 026 and 032 were drawn to the control group. The right-hand column of the table (Table 8) represents the groups to which the learners were drawn and the left-hand column represents the learners. This is represented in Table 8 (on the next page).

**TABLE 8: Learners who obtained 76 % (N = 4)**

LEARNER	GROUP ALLOCATED TO
006	Experimental
026	Control
028	Experimental
032	Control

The scores obtained by all learners drawn to the control group were added and their sum divided by twenty (the number of learners in that group) to calculate the mean:

$$X = \frac{62+62+68+68+68+68+68+70+70+70+70+70+72+72+74+74+74+74+76+76}{20} = \frac{1406}{20} = 70.3$$

Where X is the mean

The same was done for the experimental group and the results were as follows:

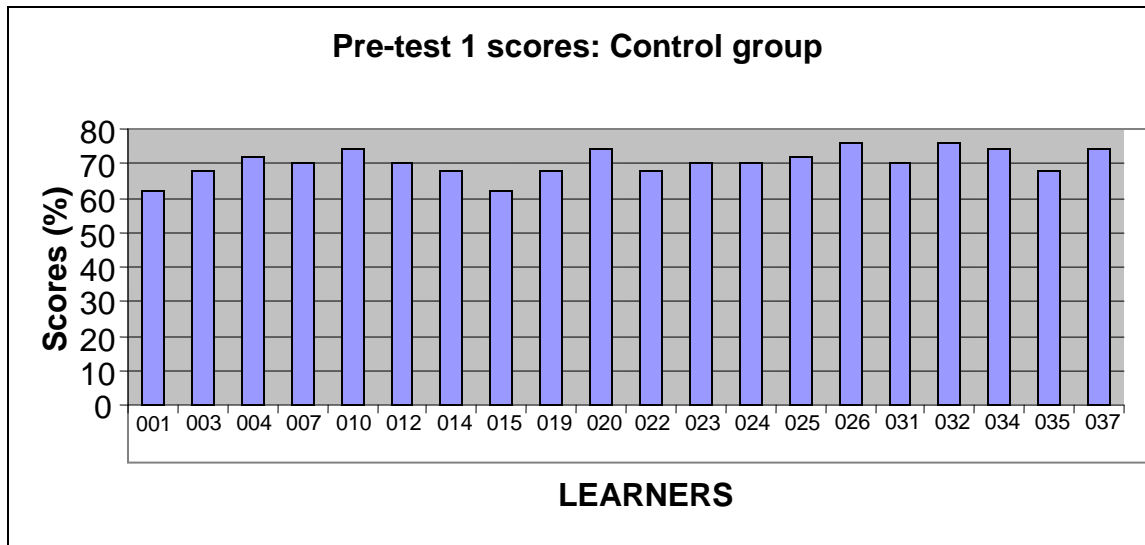
$$X = \frac{62+62+62+68+68+68+68+68+68+70+70+70+70+72+72+74+74+74+76+76}{20} = \frac{1392}{20} = 69.6$$

Learners drawn to the control group had a mean of 70.3 % for the first pre-test whereas those drawn to the experimental group had a mean of 69.6 %, representing a difference of 0.7 % in favor of the control group. The median for both groups was the same, (70 %). The following is a diagrammatic representation of control group learners' scores for pre-

test 1. Scores obtained by learners are on the y-axis and numbers representing learners on the x-axis.

Figure 2 below shows the scores obtained by the twenty learners drawn to the control group. The left-hand side of the graph (y-axis) shows the scores obtained by learners, in percentages while the bottom side (x- axis) of the graph represents the respective learners, starting with learner 001 to learner 037.

**FIGURE 2: Pre-test 1 scores: Control group**



Considering the diagram above, Figure 2, it is evident that the performance of learners drawn to the control group for the first pre-test (pre-test 1) was not greatly scattered as their scores ranged from 62 % to 76 %. The mean for their scores was 70.3 % while 68 % and 70 % were the most common scores, obtained by five learners each.

The median (middle score) was 70 %. Seven learners in this group scored below the mean and median while eight scored above the two measures of central tendency. Two learners, learners 026 and 032 obtained the highest score, of 76 %. The total scores for all learners who were in the control group was 1406 out of a possible 2 000, thus bringing the average to 70.3 %.

The following diagram (Figure 3) represents scores obtained in pre-test 1 by learners who were in the experimental group. The y-axis represents the scores with the x-axis representing the learners, from learner 002 to learner 040.

**FIGURE 3: Pre-test 1 scores: Experimental group**

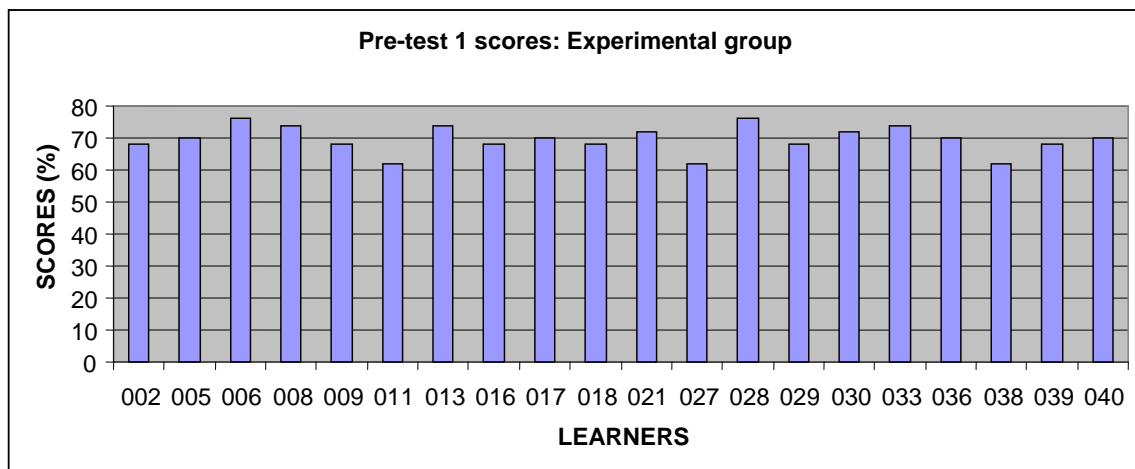


Figure 3 above shows scores obtained by learners who were in the experimental group for the first pre-test (pre-test 1). The lowest score in the group was 62 % obtained by learners 011, 027 and 038 while the highest score was 76 % obtained by learners 006 and 028. The mean for the experimental group was 69.6 %, which was lower than that for the control group by 0.7 % in the same test.

The median for this group was 70 % with nine learners scoring below the median while seven learners in the experimental group scored above the median. The total scores for all learners who were in the experimental group was 1392 out of a possible 2 000, bringing their average to 69.6 %. Learners 011, 027, 038, 002, 009, 016, 018, 029, and 039 scored below the mean (69.6 %) for the group.

As can be seen from the two diagrams above, learners drawn to the control group had better scores compared to their counterparts in the experimental group.

#### **4.2.2 Post-test 1**

After both groups had written the same first pre-test, all forty learners had lessons on the manufacture, uses, and disadvantages of overusing fertilizers presented by the researcher (Department of Education: Physical Sciences CAPS document 2011: 11). The experimental group was then given a research project on the same topic, Chemical Systems. They (learners who were in the experimental group) also went on a field trip to the Sasol plant in Sasolburg which manufactures fertilizers.

At the Sasol plant the learners (from the experimental group) had a tour around the plant and had lessons from four experts in the manufacture, uses, and disadvantages of overusing fertilizers, being aspects covered in the research projects. They were also given extra literature on the same topic and were shown and given DVDs. These learners also attended extra lessons at the plant for three days, each session being three hours long.

The research project given to the learners who were in the experimental group (see Appendix K) was submitted after two weeks from the date of issue. For the research project learners from the experimental group were asked to present a research project of about two thousand words in which they would highlight the need for artificial fertilizers, the manufacture of at least two artificial fertilizers, Contact and Oswald processes, dangers of overuse of fertilizers paying special attention to soil leaching, algae bloom, and eutrophication.

The learners carried out their research as individuals and presented their work after a fortnight. The research projects were assessed using a rubric (see Appendix J) and marked out of forty marks. Learners obtained information from the Sasol plant, internet, as well as from their textbooks. After the research project was submitted learners from both groups wrote the same post-test on the topic covered. Learners who were in the control group were not given any enrichment programs.

The post-test was out of fifty (50) marks. The questions were on the topic Chemical Systems focusing on manufacture, uses, and disadvantages of overusing fertilizers (Department of Education: Physical Sciences CAPS document 2011: 11). The test had four questions with sub-questions (see Appendix D) and the learners wrote it in one hour under examination conditions. The researcher then marked the learners' work using a memorandum (see Appendix E). The marks obtained by the learners were converted to a percentage for easier analysis and comparison.

The following table, Table 9 shows scores obtained by the twenty learners, as percentages, who were in the control group for the first post-test (Post-test1). The left-hand column represents learners in chronological order that is from learner 001 to learner 037, while the right-hand column represents the respective scores, as percentages, obtained by the learners. N stands for the total number of learners in the control group who wrote the first post-test (20 learners).

**TABLE 9: Post-test 1 scores: Control group (N = 20)**

LEARNER	SCORE (%)
001	70
003	72
004	74
007	76
010	80
012	82
014	76
015	72
019	76
020	78
022	76
023	76

024	80
025	82
026	82
031	80
032	82
034	78
035	80
037	80

The lowest score obtained in this group was 70% with the highest being 82%. The range was 12 % (82 % minus 70 %). The median for this group was 78% and the modes (most common scores) were 76 % and 80 %. The modes were obtained by learners 007, 014, 019, 022, and 023 (76 %) and 010, 024, 031, 035, and 037 (80 %). The lowest score of 70 % was obtained by learner 001 while learners 012, 025, 026 and 032 obtained the highest score of 82 %.

The researcher then added all scores obtained in the first post-test by learners who were in the control group to establish the mean for the group:

$$70+72+74+76+80+82+76+72+76+78+76+76+80+82+82+80+82+78+80+80 = 1552$$

The total scores for learners from the control group for the first post-test (post-test 1) was 1552 out of a possible 2 000.

The sum of the scores was then divided by the sample size (20):

$$1552/20 = 77.6$$

The mean for the control group for the first post-test was therefore 77.6 %. Nine learners in this group scored below the mean and these learners were 001, 003, 004, 007, 014,

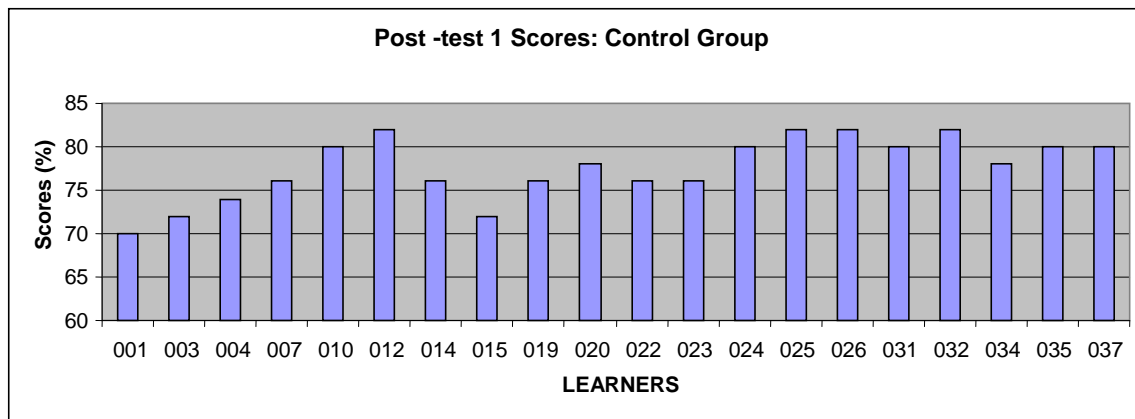


015, 019, 022, and 023 while learners 010, 012, 020, 024, 025, 026, 031, 032, 034, 035, 037 scored above the mean for the group in this test (post-test 1).

Below is a diagrammatic representation of scores obtained by the twenty learners who were in the control group for post-test 1 (Figure 4).

The y-axis on the graph (Figure 4) represents the scores, as percentages (from 60 % to 85 %), obtained by learners while the x-axis represents the respective learners, from learner 001 to learner 037.

**FIGURE 4: Post-test 1 scores: Control group**



To establish the number of learners who obtained a particular score for post-test 1 from the control group, the researcher drew a frequency distribution table (see Table 10 below). The table has four columns in which the first column represents the scores (as percentages) obtained by the learners. The second column represents the respective learners who obtained a particular score (for example learners 012, 025, 026 and 032 obtained 82 %) while the third column contains the tally for the respective scores (for example 4 learners got 82 %) and the fourth column represents the frequencies for the respective scores. All in all twenty learners from the control group (N= 20) wrote post-test1.

**TABLE 10: Frequency distribution: Post-test 1 scores for the control group (N = 20)**

SCORE (%)	LEARNER(S)	TALLY	FREQUENCY(f)
82	012,025,026,032	III	4
80	010,024,031,035,037	IIII	5
78	020,034	II	2
76	007,014,019,022,023	IIII	5
74	004	I	1
72	003,015	II	2
70	001	I	1

The modes (most common scores) for the control group in the first post-test were 80% and 76%, obtained by five learners each. From the table above, Table 10, four learners scored the highest (82 %), while five obtained 80 %, two got 78 %, another five got 76 %, 74 % was obtained by one learner, a further two learners got 72 % and only one got 70 %. The least common scores were therefore 74 % and 70 %.

The researcher then recorded the scores, as percentages, obtained by the twenty learners in the experimental group for post-test 1. The scores were then represented on a table (see Table 11 below) with the left-hand column representing the learners and the right-hand column representing the scores obtained by respective learners. For example learner 002 obtained 90 %. The learners were arranged, on the table, in chronological order, that is from learner 002 to learner 040 with the letter N representing the total number of learners who were in the experimental group who wrote the test.

**TABLE 11: Post-test 1 scores: Experimental group (N = 20)**

LEARNER	SCORE (%)
002	90
005	96

006	94
008	90
009	90
011	96
013	90
016	92
017	92
018	92
021	90
027	94
028	96
029	94
030	88
033	94
036	92
038	96
039	90
040	92

The scores obtained by learners who were in the experimental group for the first post-test were added together:

$$90+96+94+90+90+96+90+92+92+92+90+94+96+94+88+94+92+96+90+92 = 1848.$$

The total scores for the experimental group in this test (post-test 1) was 1848 out of a possible 2 000. Their sum was divided by 20 to obtain the mean:

$1848/20 = 92.4 \%$ . In the experimental group twelve learners scored below the mean of 92.4 %. These learners were 002, 008, 009, 013, 016, 017,018,021, 030,036, 039, and 040. Learners who scored above the mean were learners 005,006, 011, 027,028, 029, 033, and 038.

Considering the means for the two groups it is crystal clear that the experimental group performed better than the control group since their mean was higher. There was a difference of 14.8 %, in favor of the experimental group. The difference in performance was likely due to the enrichment programs given to learners who were in the experimental group as they had an opportunity to visit the Sasol plant where they saw the actual production of fertilizers, had extra lessons and were given extra literature on the same topic.

The lowest score obtained by a learner who was in the control group was 70% whereas the highest for that group was 82% representing a range of 12 %. For the experimental group the lowest score was 88%, higher than the highest score for the control group and the highest was 96% representing a range of 8 %. This shows that scores for learners who were in the experimental group aren't widely spread out.

Nine learners from the control group scored below the mean for the group, with eleven from the experimental group scoring below the mean for their respective group.

To establish the exact number of learners from the experimental group who obtained a particular score, the researcher drew a frequency distribution table (Table 12 below). The first column represents the scores, as percentages, obtained by the learners. The second column represents the learners who obtained a particular score (for example learners 005,011, 028 and 038 got 96 %) while the third column represents the tally (for example 4 learners obtained 96 %) with the fourth column representing the actual frequencies for respective scores.

**TABLE 12: Frequency distribution; Post-test 1 scores for the experimental group (N = 20)**

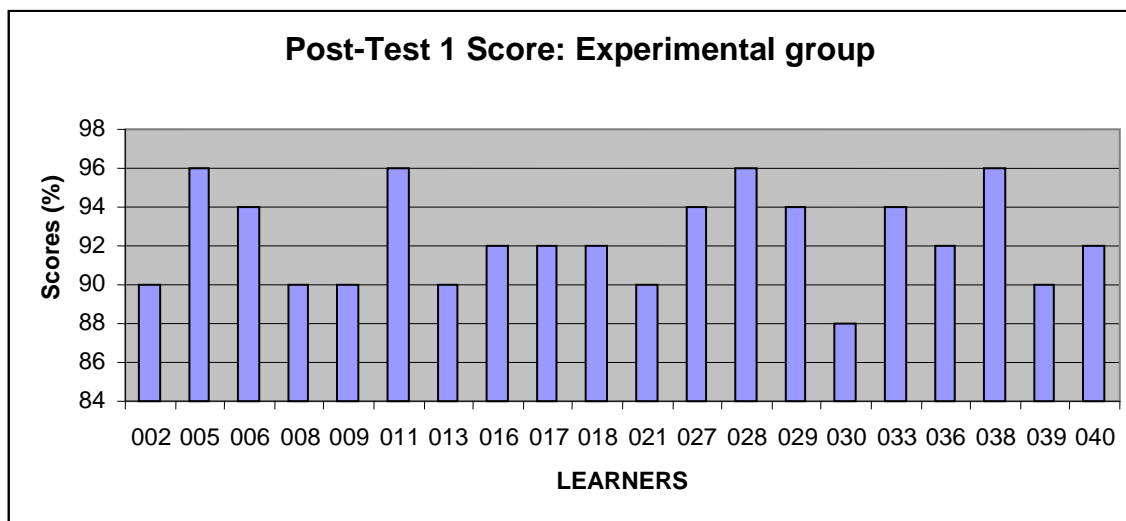
SCORE (%)	LEARNER(S)	TALLY	FREQUENCY(f)
96	005,011,028,038	IIII	4
94	006,027,029,033	IIII	4
92	016,017,018,036,040	IIIII	5
90	002,008,009,013,021,039	IIIII I	6
88	030	I	1

The most common score (mode) for the experimental group in the first post-test was 90%, obtained by 6 of the twenty learners. These learners who obtained a score of 90 % were learners 002, 008, 009, 013, 021, and 039. The highest score of 96 % was obtained by learners 005, 011, 028, and 038 in the experimental group for the first post-test (post-test 1). A further four learners (006, 027, 029, and 033) obtained 94 %, while 92 % was obtained by learners 016, 017, 018, 036, and 040. Learner 030 got the lowest score of 88 % in this test in the experimental group.

Scores obtained by learners from the experimental group were also represented diagrammatically.

Figure 5 below represents the scores obtained in post-test 1 by the twenty learners who were in the experimental group. The y-axis represents the scores, as percentages (from 84 % to 98 %) while the x-axis represents the learners, from learner 002 to learner 040. For example, according to Figure 5 learner 002 obtained 90 %.

**FIGURE 5: Post-test 1 scores: Experimental group**



Considering the diagram above, Figure 5, the lowest score obtained by a learner from the experimental group for post-test 1 was 88 %, obtained by learner 030 and the highest score (96 %), was obtained by learners 005, 011, 028, and 038. The scores for this group for post-test 1 ranged from 88 % to 96 %, representing a range of 8 % (96 % - 88 %). All twenty learners from the experimental group who wrote the first post-test (post-test 1) obtained distinctions (more than 80 %).

#### **Test reliability: Post-test 1**

After a week the forty learners were made to re-write the same post-test and their scores remained the same. This signaled a high reliability. Unstable traits such as mood, if they were present, did not affect the learners' performance at all. The time limit, memorandum used for marking, the questions, and venue remained the same.

#### **4.2.3 Pre-test two**

The gifted Science learners from both groups were then given a second pre-test different from the first one to write. The pre-test was based on the topic Matter and Materials paying attention to Organic molecules (Department of Education Physical Sciences

CAPS document 2011: 11), consisting of five one-word items, ten multiple choice questions carrying a total of twenty-five (25) marks and one long question with sub-questions carrying a further twenty-five (25) marks, leaving a total for the whole paper at fifty (50) marks (see Appendix F).

The second pre-test, like the first one, was marked using a memorandum (see Appendix G) and the scores were again converted to a percentage for easier comparison.

Table 13 (on the next page) shows scores obtained by the twenty learners who were in the control group for the second pre-test (pre-test 2).

On the left-hand column of the table are numbers representing learners in chronological order (from learner 001 to learner 037) with corresponding scores on the right-hand side. For example learner 001 obtained 66 % and learner 010 got 72%.

**TABLE 13: Pre-test 2 scores: Control group (N = 20)**

LEARNER	SCORE (%)
001	66
003	66
004	68
007	70
010	72
012	72
014	70
015	68
019	68
020	66
022	66
023	64

024	70
025	70
026	70
031	70
032	70
034	66
035	68
037	68

The lowest score obtained in this group for pre-test 2 was 64%, obtained by learner 023. The highest score was 72%, obtained by learners 010, and 012. Five of the learners (001, 003, 020, 022, and 034) obtained 66% with learners 004, 015, 019, 035, and 037 scoring 68%. The mode for the group was 70%, obtained by learners 007, 014, 024, 025, 026, 031, and 032.

The researcher then added all scores obtained for the second pre-test by learners who were in the control group to establish the mean:

$$66+66+68+70+72+72+70+68+68+66+66+64+70+70+70+70+70+66+68+68 = 1368$$

The total scores obtained by all learners from the control group for the second pre-test (pre-test 2) was 1368 out of a possible 2 000.

The sum was then divided by 20 (being the number of learners in the group):

$$1368/20 = 68.4$$

The mean was therefore 68.4 %.

Learners 001, 003, 004, 015, 019, 020, 022, 023, 034, 035 and 037 scored below the mean for the group in this test while learners 007, 010, 012, 014, 024, 025, 026, 031, and 032 obtained scores above the mean.

A frequency distribution table (Table 14 below) was then drawn to show the number of learners who obtained a particular score in pre-test 2 in the control group. In the first



column from the left-hand side are scores (from 72 % down to 64 %). The second column indicates the specific learners who obtained a particular score (for example learners 010 and 012 obtained 72 %) and the third column represents the tally for a respective score (for example 2 learners obtained 72 %). The last column signals the frequencies for the respective scores, for example 2 for 72 % and 7 for 70 %.

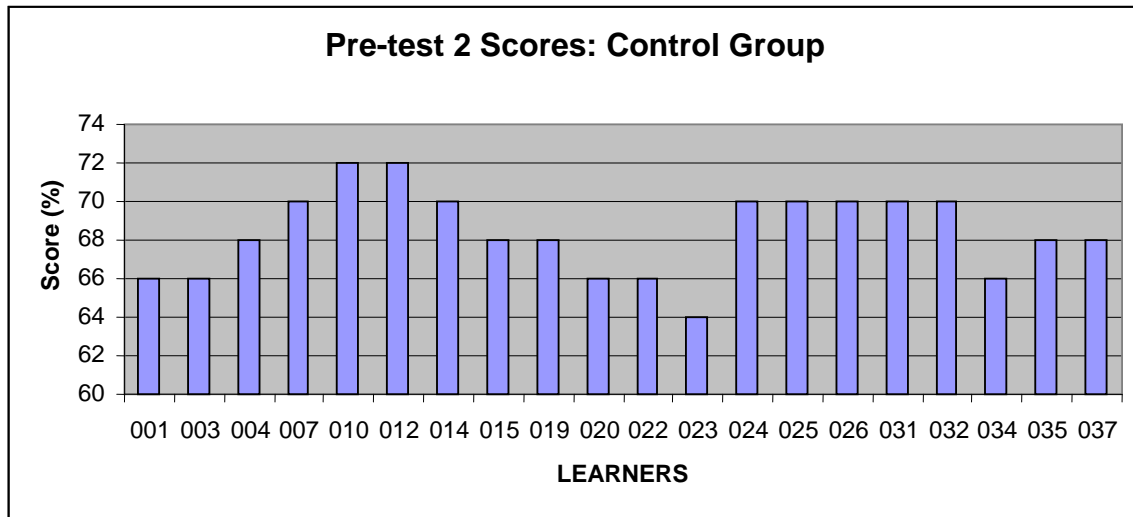
**TABLE 14: Frequency distribution: Pre-test 2 scores: Control group (N = 20)**

SCORES (%)	LEARNER(S)	TALLY	FREQUENCY(f)
72	010,012	II	2
70	007,014,024,025,026,031,032	IIII II	7
68	004,015,019,035,037	IIII	5
66	001,003,020,022,034	IIII	5
64	023	I	1

From Table 14 it is evident the mode for the control group in the second pre-test was 70%, obtained by seven learners. Learners 010 and 012 obtained the highest score of 72 % while learner 023 obtained the lowest score (64 %). Seven learners ( 007, 014, 024, 025, 026, 031, and 032 obtained 70 %, learners 004, 015, 019, 035, and 037 obtained 68 % and the remaining five learners (001, 003, 020, 022, and 034) obtained 66 % each.

The diagram below, Figure 5 is a diagrammatic representation of scores obtained by the twenty learners who were in the control group for the second pre-test (pre-test 2). On the left-hand side are scores obtained by the learners (from 60 % 74 %) and numbers representing the learners are on the x-axis, from learner 001 to learner 037. For example learner 023, according to the diagram, obtained 64 %.

**FIGURE 6: Pre-test 2 scores: Control group**



Learners 010 and 012 obtained the highest score of 72 % while learner 023 obtained the lowest score (64 %). Learners 001, 003, 020, 022, and 034 obtained 66 %, learners 004, 015, 019, 035, and 037 got 68 %. These eleven learners (001, 003, 004, 015, 019, 020, 022, 023, 034, 035, and 037) obtained scores below the mean of 68.4 %.

After the answer scripts for the twenty learners who were in the experimental group had been marked and recorded for the second pre-test (pre-test 2) the researcher then presented the scores on a table with two columns (see Table 15 below). The first column contains numbers representing learners with the second column representing their respective scores. For example learner 002 obtained 68 %. The learners were arranged in numerical order, from learner 002 to learner 040 and their scores, as percentages, written against them.

**TABLE 15: Pre-test 2 scores: Experimental group (N = 20)**

LEARNER	SCORE (%)
002	68
005	66
006	70

008	64
009	72
011	70
013	68
016	70
017	64
018	68
021	70
027	68
028	70
029	64
030	64
033	68
036	66
038	70
039	68
040	70

The lowest score obtained in this group was 64%, same as for the control group. This score was obtained by learners 008, 017, 029, and 030. Two learners, 005 and 036 obtained 66% each while six learners (002, 013, 018, 027, 033, and 039) scored 68%. The mode for the group was 70%, obtained by learners 006, 011, 016, 021, 028, 038, and 040. The highest score (72%) was obtained by learner 009.

Scores obtained in the second pre-test by learners who were in the experimental group were added and then the sum divided by twenty to establish the mean for the group:

$$68+66+70+64+72+70+68+70+64+68+70+68+70+64+64+68+66+70+68+70 = 1358/20 = 67.9$$

The mean for the control group for the second pre-test was 68.4% whereas that for the experimental group was 67.9 %. In this particular test learners in the control group performed better than their counterparts in the experimental group. The highest and lowest scores for both groups were 72 % and 64 % respectively, representing a range of 8 %.

A frequency distribution table (Table 16 below) for the twenty learners who were in the experimental group was drawn for the second pre-test (pre-test 2). The first column from the left-hand side on Table 16 below contains scores obtained by the learners in descending order, from 72 % down to 64 %.

The second column has numbers representing the learners who obtained a particular score, for example learners 006, 011, 016, 021, 028, 038 and 040 obtained 70 %. The third column contains tallies for respective scores, for example I for 72 % and the last column has frequencies for the respective scores, for example 1 for 72 % because only one learner in that group obtained 72 % in that particular test.

**TABLE 16: Pre-test 2 scores: Experimental group (N = 20)**

SCORE (%)	LEARNER(S)	TALLY	FREQUENCY(f)
72	009	I	1
70	006,011,016,021,028,038,040	IIII I	7
68	002,013,018,027,033,039	IIII I	6
66	005,036	II	2
64	008,017,029,030,	III	4

Looking at the frequency distribution table above (Table 16) the mode for the experimental group in this particular test was 70%, obtained by seven learners as in the control group. The learners who obtained 70 % were learners 006, 011, 016, 021, 028, 038, and 040. Learner 009 obtained the highest score of 72 %, learners 002, 013, 018,

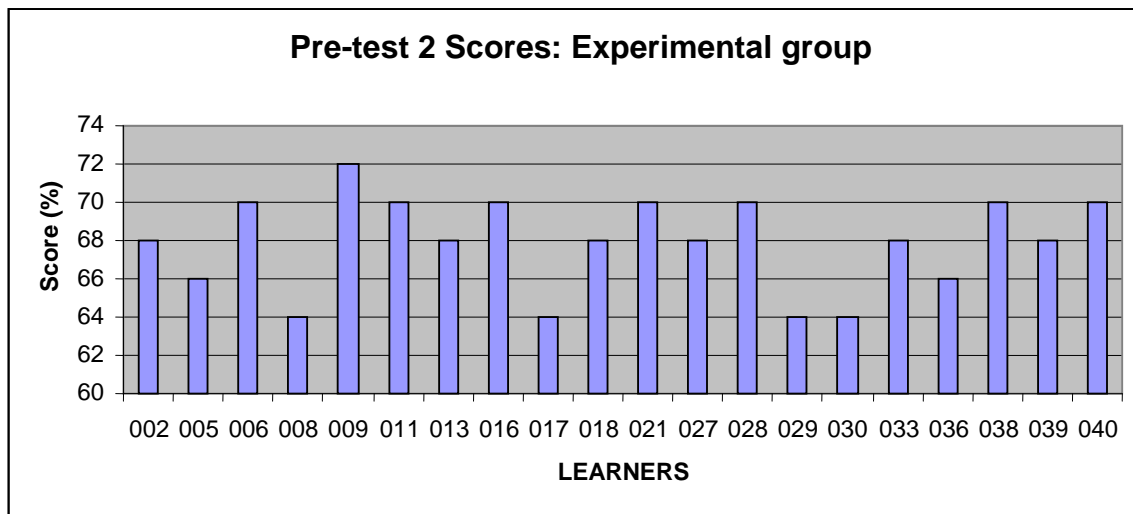
027, 033, and 039 got 68 %. Learners 005 and 036 obtained 66 % each while learners 008, 017, 029, and 030 obtained the lowest score of 64 %.

The researcher then presented the scores obtained by the twenty learners who were in the experimental group for the second pre-test (pre-test 2) on a diagram, Figure 6 (on the next page).

On the left-hand side of the diagram (y-axis) are scores obtained by learners (from 60 % up to 74 %) while numbers representing learners (learner 002 to learner 040) are on the x-axis (bottom side of the diagram).

According to Figure 7 learner 006 obtained 70 %. The lowest score obtained by learners in this group for this test was 64 % while the highest score was 72 %.

**FIGURE 7: Pre-test 2 scores: Experimental group**



Learners 008, 017, 029, and 030 obtained the lowest score of 64 % in the second pre-test (pre-test 2) in this group (experimental). They were followed by learners 005, and 036

who obtained 66 % each. Learners 002, 013, 018, 027, 033, and 039 obtained 68 % each while learners 006, 011, 016, 021, 028, 038, and 040 got 70 % for the second pre-test. Learner 009 got the highest score of 72 % in this particular test.

Although the lowest and highest scores for both groups were the same (64 % and 72 % respectively), as well as their mode (70 %), learners who were in the control group performed better than those who were in the experimental group, considering their means (67.9 % for experimental group, and 68.4 % for the control group). The range for their scores was the same ( $72\% - 64\% = 8\%$ ).

#### **4.2.4. Post-test 2**

All the learners from both groups were given five lessons in the topic Chemical Change paying attention to electrolytic and galvanic cells (Department of Education Physical Sciences document 2011: 11). Each lesson was one hour long and the learners were taught in the same room at the same time by the researcher. Learners who were in the experimental group were then given DVDs to go and watch at home. The DVDs had lessons on the topic in question as well as worksheets, memoranda, and extra notes. The learners from this group watched the DVDs for a week. For three days the experimental group attended extra lessons at North-West University (Vaal Triangle Campus) on the same topic where they were taught by gurus in Chemistry.

When the experimental group was done with its enrichment on the topic in question both groups wrote a post-test (referred to as post-test 2) on the same topic (see Appendix H). The second post-test, with a total of fifty (50) marks, had four long questions with sub-questions and was written in one hour under examination conditions and the learners were being invigilated by the researcher. The learners' work was marked using a memorandum (see Appendix I) and their scores were converted to a percentage for easier comparison.

The following table, Table 17, shows scores obtained by the twenty learners who were in the control group for the second post-test (post-test 2). The left-hand side of the table contains numbers representing learners (learner 001 to learner 037) while the second column contains the learners' respective scores, for example learner 004 obtained 76 %. N represents the total number of learners who were in the control group and wrote the second posttest that is 20 learners.

**TABLE 17: Post-test 2 scores: Control group (N = 20)**

LEARNER	SCORE (%)
001	80
003	78
004	76
007	74
010	78
012	80
014	72
015	80
019	74
020	78
022	76
023	76
024	78
025	76
026	78
031	80
032	76
034	78
035	80
037	72

The lowest score was 72 % obtained by learners 014 and 037. Two learners (007 and 019) obtained 74 % with five learners (004, 022, 023, 025, and 032) obtaining 76%. A further six learners (003, 010, 020, 024, 026, and 034) got 78% and the highest score of 80 % was obtained by the remaining five learners (001, 012, 015, 031, and 035).

The researcher then added all scores obtained by learners who were in the control group for the second post-test to determine the mean:

$$80+78+76+74+78+80+72+80+74+78+76+76+78+76+78+80+76+78+80+72 = 1540/20 = 77$$

The mean was 77 %.

Learners 014,037,007,019,004,022,023,025,032 got scores below the mean (<77 %) whereas learners 003,010,020,024,026,034,001,012,015,031as well as 035 obtained scores above the mean.

To determine the exact number of learners from the control group who obtained a particular score in the second post-test (post-test 2), a frequency distribution table was drawn, Table 18. The first column from the left-hand side contains scores, as percentages, obtained by learners. The second column contains numbers representing learners who obtained a particular score, for example learners 007 and 019 obtained 74 %. The third column contains the respective tallies with the last column showing the frequencies for the particular scores, for example 2 learners obtained 72 %.



**TABLE 18: Frequency distribution: Post-test 2 scores control group (N = 20)**

SCORES (%)	LEARNER(S)	TALLY	FREQUENCY(f)
80	001,012,015,031,035	IIII	5
78	003,010,020,024,026,034	IIII I	6
76	004,022,023,025,032	IIII	5
74	007,019	II	2
72	014,037	II	2

Two learners (014 and 037) obtained the least score of 72 %. Learners 007 and 019 got 74 % while learners 004, 022, 023, 025 and 032 obtained 76 % in the second post-test. Learners who got 78 % were learners 003, 010, 020, 024, 026 and 034, with the highest score of 80 % being obtained by learners 001, 012, 015, 031 and 035.

Considering the mean for this group (77 %), nine learners, learners 014, 037, 007, 019, 004, 022, 023, 025 and 032 got scores below the mean. The remaining eleven learners (001, 012, 015, 031, 035, 003, 010, 020, 024, 026 and 034) obtained scores higher than the mean.

The researcher then represented scores obtained by the twenty learners who were in the control group in the second post-test (post-test 2) on a diagram. The y-axis represents the scores, as percentages, obtained by the learners while the x-axis represents the learners, for example learner 001 obtained 80 %. This is shown in Figure 8 on the next page.

**FIGURE 8: Post-test 2 scores: Control group**

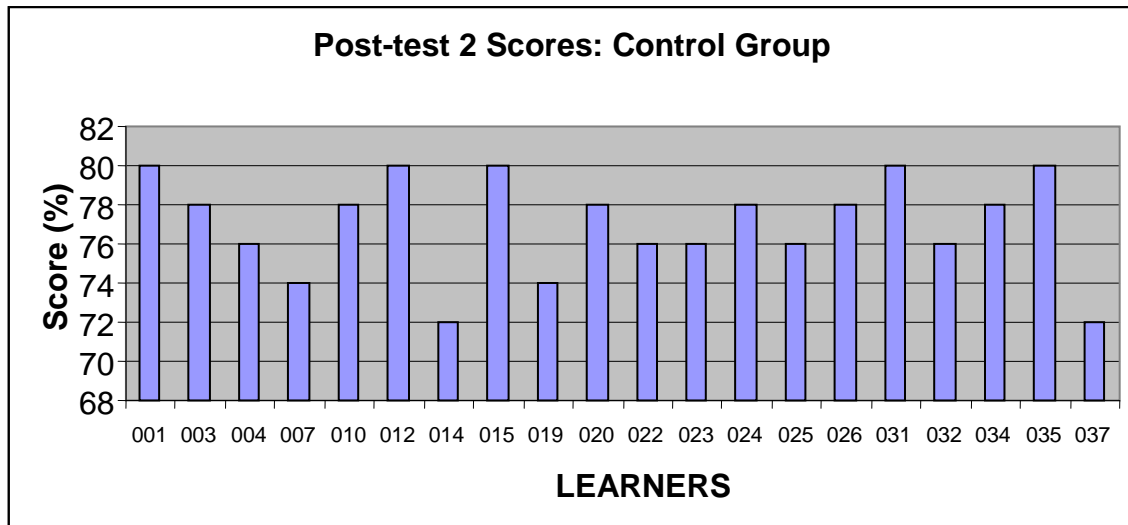


Figure 8 above shows that the lowest score of 72 % was obtained by learners 014 and 037. Learners 007 and 019 obtained 74 % each while learners 004, 022, 023, 025 and 032 got 76 % each. Learners 003, 010, 020, 024, 026 and 034 got 78 % apiece. The highest score of 80 % was obtained by learners 001, 012, 015, 031 and 035.

The following table, Table 19, shows scores, as percentages, obtained by the twenty learners in the experimental group for the second post-test (post-test 2). The first column shows the learners, arranged in ascending order, while the second column shows the scores obtained by each learner, for example learner 002 obtained 96 %.

**TABLE 19: Post-test 2 scores: Experimental group (N = 20)**

LEARNER	SCORE (%)
002	96
005	94
006	92
008	96

009	90
011	94
013	96
016	92
017	92
018	94
021	96
027	92
028	96
029	92
030	94
033	94
036	94
038	96
039	94
040	90

The lowest score in this group was 90 %, obtained by two learners, 009 and 040. Learners 006, 016, 017, 027, and 029 scored 92 %. The most common score was 94 % obtained by learners 005, 011, 018, 030, 033, 036, and 039. The highest score of 96 % was obtained by learners 002, 008, 013, 021, 028, and 038.

The researcher then established the mean for the experimental group for the second post-test by adding all their scores and divided the sum by twenty (the number of learners who were in the group):

$$96+94+92+96+90+94+96+92+92+94+96+92+96+92+94+94+94+96+94+90 = 1874/20 = 93.7$$

The mean was thus 93.7 %.

From the experimental group only seven of the twenty learners (006, 009, 016, 017, 027, 029 and 040) obtained scores below the mean ( $< 93.7\%$ ). Learners 002, 005, 008, 011, 013, 018, 021, 028, 030, 033, 036, 038 and 039 got scores above the mean. All twenty learners who were in this group, however, passed the second post-test with distinctions ( $80\% +$ ). Their total scores were 1874 out of a possible 2 000. The mode (most common score) for this group in post-test 2 was  $94\%$  obtained by seven learners (005, 011, 018, 030, 033, 036, and 039)

For the second post-test the control group had a mean of  $77\%$  compared to  $93.7\%$  for the experimental group. This clearly shows the experimental group performed better than the control group. The range for the experimental group was  $6\%$  obtained by subtracting  $90\%$  from  $96\%$  and that for the control group was  $8\%$  resulting from the difference between  $80\%$  and  $72\%$ .

Looking at the results obtained in the second post-test, gifted learners who had the privilege of enrichment programs again scored higher than their counter-parts in the control group. The difference between their respective means was  $16.7\%$ .

All gifted learners who were in the experimental group performed much better than those in the control group. The highest score obtained in the control group was  $80\%$ , way below the lowest score for the experimental group which was  $90\%$ .

Table 20 (on the next page) shows the frequency distribution for scores obtained by the twenty learners in the experimental group for post-test 2. The first column shows the scores obtained by learners, as percentages, in descending order.

The second column shows the learners who obtained corresponding scores, for example learners 009 and 040 obtained  $90\%$ . The third column shows the respective tallies while the fourth column shows the frequencies, for example 2 learners in this group obtained  $90\%$  for post-test 2.

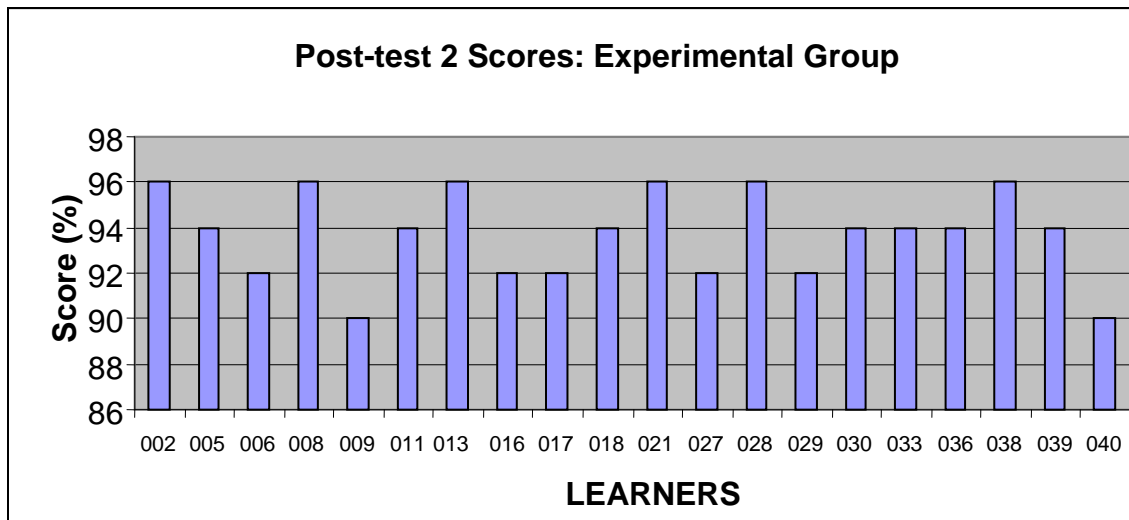
**TABLE 20: Frequency distribution: scores for Post-test 2 Experimental group (N = 20)**

SCORES (%)	LEARNER(S)	TALLY	FREQUENCY(f)
96	002,008,013,021,028,038	IIII I	6
94	005,011,018,030,033,036,039	IIII II	7
92	006,016,017,027,029	IIII	5
90	009,040	II	2

The most common score obtained by learners who were in this group for this test (post-test 2) was 94 % obtained by learners 005, 011, 018, 030, 033, 036 and 039. Learners 002, 008, 013, 021, 028 and 038 got the highest score of 96 %. Learners 006, 016, 017, 027 and 029 got 92 % while two learners, 009 and 040, obtained the lowest score of 90 %. All twenty learners from the experimental group obtained scores of at least 90 %.

Figure 9 below shows scores, as percentages, obtained by the twenty learners from the experimental group in the second post-test (post-test 2). The left-hand side of the diagram shows the scores, as percentages, while the bottom part of the diagram shows the learners, from learner 002 to learner 040.

**FIGURE 9: Post-test 2 scores: Experimental group**



All learners from the experimental group obtained scores of at least 90 % in the second post-test. The highest score (96 %) was obtained by learners 002, 008, 013, 021, 028 and 038. learners 005, 011, 018, 030, 033, 036 and 039 got 94 % each. Learners 006, 016, 017, 027 and 029 obtained 92 % each with the lowest score of 90 % being obtained by learner 009 and 040. This showed excellent performance as all learners scored at least 90 % indicating good mastery of the concepts learnt.

### **Test reliability: Post-test 2**

After a week the learners from both groups were made to re-write the same post-test (Post-test 2) under the same conditions as before. The work was marked using the same memorandum. Surprisingly all learners obtained the same scores as they had obtained at first. This proved a high reliability of the test.

### **4.2.5 Analysis of interview questions and responses**

Interviews are another tool for collecting data from participants in a research. An interview involves direct personal contact between the researcher and the participants who are asked to answer questions relating to the research. Interviews take several forms and for this research the researcher used the phenomenological interview (see Chapter 3). This is a specific type of in-depth interview used to study the meanings or essence of a lived experience among selected participants (McMillan & Schumacher 2010: 356).

Phenomenological studies investigate what was experienced, how it was experienced, and finally the meanings that the learners assign to experience (Bless & Higson- Smith 2000: 104). The researcher conducted a single, one - on - one interview with each of the twenty learners who were in the experimental group to establish their experiences, and evaluations of the enrichment programs given to them during the research.

Each learner was asked five open-ended questions and were given as much time as they needed to answer the questions orally. The questions were written before hand to

overcome misunderstanding and mis-interpretation of words and questions. The five questions were related to the purpose of the research as they sought to establish learners' experiences and evaluation of enrichment programs given to them.

The same questions were given to the twenty learners who were in the experimental group in exactly the same way to ensure a more objective comparison of results. For a copy of the interview questions please see Appendix L. The researcher tape- recorded learners' responses to the interview questions, with learners' permission while at the same time taking down notes. The researcher tape- recorded learners' responses to ensure completeness of the verbal interaction and it also provides material for reliability checks (Henning et al. 2002: 39; McMillan & Schumacher 2010: 360).

Using both methods (note-taking and tape-recording) ensured learners' responses were still captured in the event of one of the methods erring. After the interviews, the researcher immediately transcribed the tape. This was to make sure that all data was captured accurately while still fresh. For a copy of transcripts of learners' responses please see Appendix M. After transcribing all learners' responses the researcher then analyzed the responses and the following is a question by question analysis of learners' responses:

### **QUESTION 1:**

What were the most beneficial aspects of the enrichment programs you were given?

Of the twenty learners interviewed sixteen of them (60 % of the experimental group) concurred that all activities they were given were beneficial to them, two learners (027 and 006 representing 10 % of the group) were for DVDs and field trip, another two (039 and 028, that's another 10 %) for DVDs and extra lessons, one (013) claimed only the field trip was of great benefit while the remaining one (036) valued field trip and extra lessons.

Learners claimed the activities challenged them academically and made them work hard and excel. Learner 005 actually said, “I found all activities highly beneficial as they *challenged* me and made me *work extra hard*”. According to DeLacy (2004: 40) enrichment gives the gifted learner a richer and more varied content which makes them eager to learn and excel.

Enrichment therefore not only keeps the learners busy, but it also challenges and motivates them. It (enrichment) brings reality to the classroom as well as variety thereby keeping the learners motivated. Learner 016 said “I enjoyed going on the field trip as well as attending extra classes. That broke the monotonous daily routine. But seriously this opened my mind and made me understand better”. Concepts are, in some cases, brought live to class instead of the abstractness normally presented by teachers, as highlighted by some learners such as learner 036 who said, “I would give my vote to the field trip to Sasol where I saw the *actual* production of fertilizers...”

Learners’ self-esteem and self-confidence are also boosted as the learners are afforded an opportunity for them to work on their own, thus being made masters of their own learning. Enrichment programs such as DVDs give learners the opportunity to go through the lesson at their own time and pace, as highlighted by learner 006 in response to question 2 when she said, “watching DVDs instead of watching the teacher was funny and motivating. *I played them over and over again thereby repeating the lessons to myself, in my room, at my own time and pace...* I was able to *comprehend* every single thing”.

Instead of leaving the lesson when the bell goes, DVDs enable learners to take the lessons outside the four walls thereby extending tuition time. Besides motivating learners, enrichment makes them work hard. Learner 028 conceded “all programs were beneficial and funny... in fact DVDs, extra classes and the field trip to Sasol plant were the best. They kept me *motivated* and *on my toes to learn extra hard*”.



When the learners are pushed hard this also results in them attaining higher and better marks. Therefore these programs instill in the learner a sense of hard work, and while they add more effort in their studies this increases their intelligence (Sheets 2006: 7). Enrichment therefore makes the learners work extra hard, understand better, co-operate with one another, and attain higher marks.

## QUESTION 2

How did participating in the enrichment programs affect you?

Learner 002 actually said the enrichment programs made them use untapped potentials they have and also challenged them to perform better while learner 028 said enrichment programs “made me realize I had energy and *brains I didn’t know* existed. It took me to *greater academic heights*”.

All twenty learners (that’s 100 % of the interviewed learners) indicated they felt special, challenged by the programs, had their self-esteem and self-confidence boosted, used their spare time positively and according to learner 033 “ being given such quality work made me feel *proud, motivated and focused* on my school work”. In a way enrichment ensures learners stay focused on their prime goal, which is to realize their potentials.

Learners given such programs also tend to help one another instead of against each other and can even end up teaching their peers (learner 036 in response to question 2). Enrichment programs therefore give learners the most important driving force in education, intrinsic motivation. Once learners are motivated, have a high self-esteem and positive self-concept they surely are likely to perform better (for example learners 009, 011, 033, 005, 013, 030, 040, 006, 036, 008, 027, and 029).

Not a single learner had a negative feeling about their participation in the enrichment programs signaling their willingness, preparedness, and zeal to be challenged. Gifted learners, hence, need enrichment in order to realize their potential.

### QUESTION 3

Were the enrichment programs given to you appropriate for your level?

Learner 029 felt the enrichment programs weren't of the appropriate level, stating that "no, they were too easy and boring to do. They (enrichment programs) need to be more challenging and varied". The other nineteen learners (95 % of the experimental group) felt the programs were of the right level. Learner 036 added that the enrichment programs were "the perfect level. No being *held back* by the rest of the class, and *no easy questions* which we normally answer without thinking hard".

Gifted learners, therefore, do not want to be held back by their less gifted peers but prefer to move forward once they have completed the given tasks. This helps them realize their potentials and also help in maintaining class discipline. If not properly challenged gifted learners tend to lose focus, become restless, disruptive, and can resist authority (Child 2004: 253).

They also felt the programs were varied, challenging, and demanded them to work harder, read extensively and research widely. Learner 008 said "definitely, they (enrichment programs) made me work *harder and read widely* for answers to given questions". Benefits of enrichment are therefore invaluable as these programs instill in the learner the need to work hard, give them enjoyment, and satisfaction through mastery of concepts as well as keeping the learners "motivated to do better and score higher grades (learner 039).

Through varied activities each learner's area of interest and ability is addressed. This ensures maximum intellectual growth in all learners afforded enrichment (Hall, Strangman, and Meyer 2003: 3) though these activities should not take the place of the teacher.

#### QUESTION 4

Based on your recent experience, do you think enrichment programs should be given to all learners?

Learners 013, 027, 029, 028, and 036 shared the view that enrichment programs should be given to gifted learners only, representing 25 % of the interviewed learners. Learner 027 actually said, “No, I disagree. These programs should be given to the academically-able learners because the other ones (non- gifted) will be frustrated and quit the activities”.

Learners 018, 017, and 040 (15 %) were of the opinion that enrichment programs should be given to all learners “but more programs should be given to those who are more capable so that people’s egos won’t be bruised”. This is in line with Renzulli’s Triad model (Renzulli 2005: 33) in which he suggested that all learners should be given enrichment but on varying degrees depending on their abilities. This view to offer enrichment at different levels is also supported by Child (2004: 269).

Twelve of the learners interviewed (60 % of the experimental group) held the opinion that all learners need and deserve enrichment programs because “they add variety to the daily routine...keeps the class focused, busy, challenged, motivated, and no one will misbehave (learner 009). Enrichment programs also “add to where the teacher has left and therefore should be given to all learners, as we all need to excel in our studies”, (learner 005).

Gifted learners therefore value enrichment and don’t see it as a teacher- substitute but as something that adds value to concepts that have been learnt in the classroom and motivates them to perform better, thus stretching their giftedness to the fullest extent thus benefiting the society. Learner 033 agreed to this by stating that enrichment programs are “...great because what I discovered is that these programs motivate, challenge, and make you focus on your school work giving you the quest to perform better”.

Enrichment in a way, therefore, offers the learner the kind of motivation no one can give them, intrinsic.

Enrichment also brings "...different learning methods in class. This will keep us motivated and willing to learn" (learner 002) and is supported by Ng and Nicholas (2007: 191) who claim that enrichment programs offer autonomy, and bring to the class different learning styles.

## **QUESTION 5**

What were the most difficult aspects of the enrichment program?

Learners 021, 040, and 011 stated they didn't encounter any difficulties at all. These made up 15 % of the experimental group. The other seventeen learners (85 %) shared the view that the research project gave them problems. Most of the learners stated that at their schools they weren't given many research projects to carryout.

This might be due to the fact that the Department of Education advocates for only one research project per year per grade for Physical Sciences. This was supported by learner 028 who opened up stating that "it was the second research project I have done in my school career".

If not given the opportunity to carry out more researches, "finding information, reading it, and then writing a research project [is] cumbersome...more research is needed" (learner 009). The fact that the research project proved "difficult and *challenging*" (learner 017) for the learners, made them eager to work on it and had the zeal to produce master-pieces. Challenge is one thing gifted learners require and embrace it with both hands if it's given to them.

### 4.3 SUMMARY OF RESEARCH FINDINGS:

From the data obtained, there was a significant improvement in the performance of the gifted learners in the experimental group for both post-tests. This was due to the positive impact of enrichment programs they had received on topics they wrote post-tests in.

The performance for both groups (control and experimental) was summarized as follows:

**TABLE 21: Comparison of the different means for the two groups**

GROUP	X:PRE-TEST1	X:POST-TEST1	X:PRE-TEST2	X:POST-TEST2
Control	70.3	77.6	68.4	77
Experimental	69.6	92.4	67.9	93.7

Where X is the mean

Considering the means for the first pre-test for each group, the difference between the two groups was 0.7 % (70.3 %-69.6 %). The control group performed better than the experimental group in the first pre-test.

After the experimental group was given enrichment programs and the two groups wrote the same post-test, the difference between their means rose to 14.8 % (92.4 %-77.6 %). This time the experimental group performed way better than the control group. This was after the experimental group had been afforded enrichment programs.

A second pre-test, different from the first one, was given to the gifted learners and the means for both groups were 68.4 % for the control group and 67.9 % for the experimental group. The control group performed better than the experimental group in this test.

The experimental group was then given some enrichment programs on a topic different from the first one and both groups wrote the same post-test derived from the topic which the experimental group had been afforded enrichment and the mean for the control group was 77 % while that for the experimental group was 93.7 %, representing a difference of 16.7 % in favor of the experimental group.

In both pre-tests the control group performed better than the experimental group. The experimental group only performed better in post-tests, after they had been given enrichment signaling the positive impact of enrichment programs.

This comparison can be summed up as:

#### **POST-TEST 1 COMPARISON (Control group and experimental group)**

$$T = \frac{\bar{X}_1 - \bar{X}_2}{S}$$

$$S_2^2 = 12.67$$

$$S_1^2 = 5.86$$

standard deviation

92.4 = experimental, 77.6 = control group

$$\bar{X}_1 = 92.4 \quad \bar{X}_2 = 77.6$$

$$n_1 = 20$$

$$n_2 = 20$$

$$V = n_1 + n_2 - 2$$

$$V = 20 + 20 - 2$$

Degrees of freedom

$$V = 38$$

$$H_0: u_1 = u_2$$

$$H_1: u_1 \neq u_2$$

$$S_p = \sqrt{\frac{(n_1 - 1) S_1^2 + (n_2 - 1) S_2^2}{n_1 + n_2 - 2}}$$

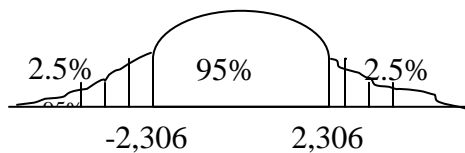
$$S_p = \sqrt{\frac{(20-1)5.86 + (20-1)12.67}{20+20-2}}$$

$$S_p = 3.04$$

$$T = \frac{\bar{X}_1 - \bar{X}_2 - D_0}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$T = \frac{77.6 - 69.6}{3.04 \sqrt{\frac{1}{20} + \frac{1}{20}}}$$

$$T = 8.322$$



From tables

$T_{38} =$  (at 5% level)

$T >$

Reject  $H_0$  at 5% significance level hence there is sufficient evidence to claim that the means from the two experiments differ significantly (McMillan & Schumacher 2010: 300)

Considering the control group, the results from their first pre-test and the first post-test were not very different. However it was a different story with the experimental group.

## Post-test 2 comparison: Experimental and control groups

$$\bar{X}_1 = 93.7$$

$$\bar{X}_2 = 77$$

$$S_1^2 = 3.72$$

$$S_2^2 = 6.25$$

$$\begin{aligned} V &= n_1 + n_2 - 2 \\ &= 20 + 20 - 2 \\ &= 38 \end{aligned}$$

$$H_0: u_1 = u_2$$

$$H_a: u_1 \neq u_2$$

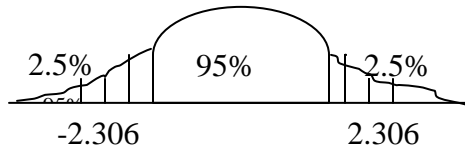
$$\begin{aligned} Sp &= \sqrt{\frac{(n_1-1) S_1^2 + (n_2-1) S_2^2}{n_1 + n_2 - 2}} \\ &= \sqrt{\frac{(20-1)3.72 + (20-1)6.25}{20 + 20 - 2}} \\ &= 4.985 \end{aligned}$$

$$\begin{aligned} T &= \frac{\bar{X}_1 - \bar{X}_2 - D_0}{\sqrt{Sp^2 \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}} \\ &= \frac{93.7 - 77}{4.985 \sqrt{\frac{1}{20} + \frac{1}{20}}} \\ &= 10.594 \end{aligned}$$



From the tables:

$$T_8 = 2.306 \quad (\text{at 5\% level})$$



Therefore the researcher rejected  $H_0$  since 7.182 lies in the reject region. From the calculations, there is sufficient evidence to claim that the means from the two groups differ significantly at 5% level (McMillan & Schumacher 2010: 301). This difference in performance, as stated earlier on, can be attributed to the enrichment programs afforded to gifted Science learners in the experimental group.

#### **4.4 DISCUSSION OF RESULTS OF THE RESEARCH**

For the first pre-test the control group had a mean of 70.3 % (see Table 2) whereas the experimental group had a mean of 69.6 %. This is an indication that learners in the control group performed better than those in the experimental group in this particular test. There was a difference of 0.7 % between their respective means.

The learners then attended the same lessons presented by the researcher on fertilizers. The experimental group was then given enrichment in the form of a field trip, watching DVDs, carrying out a research project, and attended extra lessons for three days. Afterwards all learners wrote the same post-test on fertilizers (see Appendix D and E) and it emerged the mean for the control group was 77.6 % (see Table 9), with that for the experimental group being 92.4 % (see Table 11). This represented a difference of 14.8 %. The highest mark obtained in the control group (82 %) was less than the lowest mark obtained by a learner in the experimental group (88 %). All learners in the experimental group performed better than those in the control group.

For the second pre-test the mean for the control group was 68.4 % (see Table 13) and that for the experimental group was 67.9 % (see Table 15). This showed that learners in the control group performed better than those in the experimental group. There was a difference of 0.5 % between their respective means.

After writing the second pre-test, learners had lessons presented to them by the researcher at the same time, same venue, on the topic Electrolytic and galvanic cells. The experimental group was then shown DVDs for a week, given extra worksheets and literature on the same topic, and then attended extra lessons at North-West University for three days, where they had more lessons on the same topic.

The forty gifted learners then wrote the same post-test on electrolytic and galvanic cells. The mean for the control group for this particular test was 77 % whereas that for the experimental group stood at 93.7 %. This represented a difference of 16.7 %, in favor of the experimental group. The highest mark obtained in the control group was 80 %, again less than the lowest mark obtained in the experimental group, 96 % (see Tables 17 and 19).

Considering the two post-tests, learners in the experimental group performed way better than those in the control group. Since the two groups had the same lessons in class and wrote the same tests, the difference in performance was highly attributed to the enrichment programs afforded to learners in the experimental group. By giving enrichment to the experimental group, each learners' growth and success was being maximized by meeting each of them where s/he was and assist catapulting them in the learning process, as enrichment programs broaden, deepen, and develop learners' experiences and minds (Lemmer & Van Wyk 2010: 153).

Since enrichment programs, given in the form of field trips, extra lessons, DVDs, research projects, and extra work, addressed higher level outcomes, learners moved away from simple recall and low-level understanding of concepts to being able to apply and

synthesize knowledge in complex problems. The enrichment programs were of varying levels of difficulty (differentiation by 'input') and required learners to give more advanced responses.

This helped them perform better (in both post-tests) than learners in the control group who were not given enrichment programs. Enrichment programs make learners realize that "the more you learn, the smarter you are" (Sheets 2006: 7) and they challenge learners, make them decide to work hard, and reward them with success (Watson & Ryan 2007: 39). Hence after they tasted success in the first post-test, they were motivated to perform even better in the second post-test (see Tables 11 and 19).

Enrichment given to the experimental group enhanced abstractness, complexity, variety, and inquiry in the gifted Science learners 'making them be able to understand, and answer correctly, most of the higher order-questions given to them in the two posttests.

This view is shared by Landsberg et al. (2006: 480), Rogers (2002: 281), and Santrock (2006: 247) when they state that gifted Science learners given enrichment programs will be able to, among other things, critically examine the complexity of knowledge and information, remain motivated, assess multifaceted questions in a variety of fields and discipline, set personal and academic goals, and most importantly, perform better than gifted learners not given enrichment programs.

Considering scores obtained by learners in the control group, the differences between their means for pre-test 1 and post-test 1 (70.3 % and 77.6 %), as well as pre-test 2 and post-test 2 (68.4 % and 77 %), was smaller compared to those of the experimental group (69.6 % and 92.4 % ; and 67. 9 % and 93.7 % respectively). This difference, as highlighted earlier, was due to the enrichment programs given to the latter group.

Looking at the interviews carried out with the learners in the experimental group, all learners (100 %) conceded enrichment programs were highly beneficial to them though they differed in the types of enrichment programs they valued. They also stated that

enrichment programs motivated them, challenged them to perform better, kept them busy, and above all tapped the under-utilized potentials in them. Some of them chose DVDs and extra lessons (10 %), another 10 % chose field trips and DVDs, 5 % chose field trips only while the other 5% opted for field trips and research projects with 70 % attaching the same value to all enrichment programs they were given.

All twenty learners (100 %) in the experimental group felt special, honored, challenged, had their self-esteem, confidence and self-concepts boosted by participating in the enrichment programs. However of these 95 % of them felt the programs they were given were of the right level and motivating. Only 5 % felt the programs were too easy and boring.

The majority of the learners interviewed (60 %) were of the opinion that all learners should be given enrichment since it catapults their performance. 15 % of the learners agreed that every learner should be given enrichment but at varying levels depending on one's ability. 25 % of the interviewed learners felt enrichment should be given to gifted learners only to avoid frustrating the non-gifted ones. These (25 %) view enrichment as being difficult activities thus suitable for the gifted ones only.

85 % of the learners interviewed had difficulties in carrying out research projects. This showed how neglected this teaching method is. The other reason could be that the Department of Education requires learners to carry out just one research project for Physical Science per year. From the interviews gifted learners appreciate it when they are being challenged, given the autonomy to work on their own, like to work uninterrupted, and prefer varied learning techniques in the classroom as well as work at different levels (Child 2004 :269; Ng & Nicholas 2007: 191; Sheets 2006: 7).

## **4.5 CONCLUSION**

This chapter focused on data presentation and analysis for the two groups. In analyzing the data, descriptive (frequency tables and graphs), and inferential statistics were used. The results from the study suggest that enrichment programs play a vital role in enhancing gifted learners' performance as there was a significant difference between the performances of the control group and the experimental group in both posttests. Learners in the control group performed better than those in the experimental group in pre-tests only, and in post-tests, after they had been given enrichment, the experimental group performed better.

Enrichment programs help the educators and learners to modify the curriculum in such a way that it is appropriate for high ability students. The results showed that gifted learners in the experimental group developed better understanding of the concepts; their analytical, inductive and deductive abilities were also stimulated and enriched through diverse and independent study. This is supported by Lemmer and Van Wyk 2010: 153) when they state that if gifted learners are given enrichment they tend to perform better, remain focused, motivated, and understand concepts better.

In the next chapter summary of the research, recommendations and the conclusion are presented.

## **Chapter 5**

### **5.1 Introduction**

The purpose for conducting this research was to establish the impact of enrichment programs on the performance of gifted Science learners. Results obtained during the research, analysis of the data collected, and summary of research findings were presented in the previous chapter. This chapter focuses on summary of the research, conclusion of the research, and recommendations made based on the data collected during the research.

### **5.2 Summary of the research**

Chapter 1:

This chapter focused on the background of the research problem. Most governments, universities, and non-governmental organisations focus largely on ‘at-risk’ learners (the mentally-challenged) and pay little or no attention at all to gifted learners. Some teachers actually believe gifted learners can look after themselves, while others used gifted learners as ‘substitute’ teachers to teach their non-gifted classmates.

Previous research established that if gifted learners are not fully challenged, they may end up underachieving in class, be disruptive, and even bunk classes. This chapter also contains the research question (Can the performance of gifted Science learners increase through giving enrichment programs such as research projects, independent study, extra work, Saturday classes, and field trips?) as well as the aim of the research, which was to investigate the impact of enrichment programs on the performance of gifted Science learners. The chapter also dealt with definitions of key terms used in the research as well as limitations of the study.

## Chapter 2:

This chapter focused on literature review. From the literature reviewed, most authors advocate for a differentiated curriculum for gifted learners. The most common types of curriculum differentiation are segregation, acceleration, and enrichment. Enrichment is when learners are given extra, advanced work to do either in class or at home. Enrichment supplements the ordinary curriculum by means of activities that afford the learners an opportunity to broaden and deepen knowledge in a given field of learning area.

From the literature reviewed, it emerged that enrichment programs ensure that Science is much more than a simple encyclopedic collection of facts which learners can benefit from by acquiring certain basic skills and competencies as they (enrichment programs) stress the acquisition of new physical knowledge and the necessity for understanding scientific concepts (Hall et al. 2003: 3).

Another aspect of enrichment programs is that they inculcate in the gifted Science learner high flexibility and reversibility of mental processes, give energy and persistence in solving problems, ability to visualize patterns and spatial relationships, and scientific perception of the world (Sheets 2006: 7; Siegle 2005: 30). Enrichment programs also encourage group interaction, variable pacing, freedom of choice, and debriefing (Davis & Rimm 2003: 120; Rakow 2005: 121; Rogers 2002: 281) thus making learning more challenging and meaningful.

## Chapter 3:

This chapter focused on the research design and methodology used during the research. This research assumed an experimental design in which the researcher had control over what happened to the participants by systematically imposing specified intervention in the form of enrichment programs. Experimental designs investigate cause – and – effect relationship between interventions and outcomes (Farkas 2003: 42). This chapter also

looked at the type of sampling used in this research – random sampling. This is the type of sampling in which each member in the chosen sample has an equal probability of being selected into any of the experimental groups. If the population is small, as it was in this particular research, simple random sampling is used (Pealer et al. 2001: 547).

Simple random sampling requires each member of the population to be assigned a number or be available electronically. Throughout the research participants will be known by such numbers. This ensures participant confidentiality and erases bias (Wyss et al. 2007: 47). Chapter three (3) also highlighted on ethical principles that were applied throughout the research process. These included informed consent, confidentiality and anonymity, voluntary participation, and full disclosure or deception (MacMillan & Schumacher 2010: 117; Woolfolk 2011: 498).

#### Chapter 4:

This chapter focused on data presentation, analysis and interpretation, as well as summary of research findings. The data was collected quantitatively (through two pre-tests and two post-tests) as well as qualitatively (through one – on –one interview with the twenty learners who were in the experimental group. Learners wrote the first pre-test after which they had lessons delivered to them by the researcher. The twenty gifted Science learners who were in the experimental group then received enrichment on the same topic they had had lessons on. After that all learners wrote the same post-test on the same topic they had been taught by the researcher. The learners' marks were recorded.

The forty learners then wrote a second pre-test on a different topic from the first one. These gifted Science learners then had lessons delivered to them by the researcher. Afterwards those who were in the experimental group received enrichment on the same topic before all learners wrote the second post-test on the same topic. Their marks were again recorded, compared and analyzed. Test reliability was assessed by letting the learners re-write the same post-tests a week after the respective initial sittings.



Chapter four (4) also looked at how interviews were used during the research to investigate what was experienced (enrichment programs), how it was experienced, and to establish the meanings that the learners assigned to this experience (Bless & Higson-Smith 2000: 104). Each of the twenty learners who were in the experimental group was asked five questions, in the same order and using the same wording to establish their evaluation of the enrichment programs they had been given.

In analyzing data, descriptive statistics were used. Frequency distribution tables as well as histograms were used to analyse all learners' marks for the four tests they had written. The mean, mode, and median for each test were also established and analysed.

Considering the gifted learners' performance in the first pre-test, those who were placed in the control group had a mean score of 70.3% while those in the experimental group had a mean score of 69.6%. Afterwards the whole group had lessons delivered to them by the researcher before the experimental group was given enrichment. For enrichment, the experimental group was taken on a field trip, given extra classes, given extra literature, and carried out a research project on the same topic they had been taught by the researcher (see Chapters 2 and 3 for details).

The enrichment was on the same topic though it presented concepts at a higher level, and faster pace. Afterwards all learners wrote the same post-test, in which the control group now had a mean score of 77.6% (see Table 9) while that for the experimental group was 92.4% (see Table 11), representing a difference of 14.8%. This difference in performance, in favor of the experimental group, can be accredited to the enrichment programs the experimental group received. This explains why all gifted learners in the experimental group performed better than those in the control group.

To ascertain whether the difference in performance was due to the enrichment programs afforded to the experimental group, the researcher then gave the forty gifted learners a second pre-test on a topic different from the first. The control group had a mean score of 68.4% (see Table 13) while that for the experimental group was 67.9% (see Table 15).

Given a level play field (where no enrichment was given), the control group again outperformed the experimental group. The twenty gifted learners in the experimental group were then given extra classes by university lecturers on the same topic, were made to watch DVDs, and were given extra literature, which the control group did not have access to (see Chapters 2 and 3).

The forty learners then wrote the same post-test, on the same topic, and the mean for the control and experimental groups were 77% and 93.7% respectively (see 4.3 and 4.4). This difference in performance, again, can be attributed to the enrichment programs which were given to the experimental group. This (enrichment) enhanced learners' interest in the subject, deepened their knowledge of concepts, and heightened their performance. All gifted learners in the experimental group (100%) conceded that their performance was enhanced by the enrichment programs they received (see Chapter 4, responses to interview questions, questions 1 and 2).

### **5.3 Conclusion of the research**

When the forty gifted learners wrote the first pre-test (pre-test 1) the mean for the twenty learners who were in the control group was 70.3% while that for those who were in the experimental group was 69.6 %. This represented a higher performance of 0.7 % in favor of the control group. When they wrote the first post-test (post-test 1), the mean for the control group was 77.6 % while that for the experimental group shot to 92.4 %, a difference of 14.8 % in their performance.

In the second pre-test (pre-test 2) the control group, again, had a higher mean than the experimental group, 68.4 % and 67.9 % respectively. The results for the second post-test were however different from those for the second pre-test. The control group had a mean of 77 % while their counterparts in the experimental group had a mean of 93.7 %.

In both pre-tests learners in the control group did better than those in the experimental group, with a combined difference of 1.2 % in favor of the control group. After the

experimental group had been given enrichment, learners in this group performed better than those in the control group. In the first post-test the mean for the experimental group was 92.4 %, 14.8 % higher than that for the control group, and in the second post-test the experimental group had a mean of 93.7 % while that for the control group was 16.7 % lower.

Although learners who were in the control group performed slightly higher than those who were in the experimental group in both pre-tests, the same could not be said for the post-tests. In both post-tests the experimental group obtained higher scores than those in the control group. This was due to the impact of enrichment programs the experimental group had been given. Enrichment programs provide for in-depth, content-based learning while providing for exploratory learning as well. This makes the learner grasp the concepts learnt as well as increasing the retention capacity.

According to interview responses from learners who were in the experimental group, appropriate enrichment programs make learning funny, exciting, and enjoyable. Based on the performance of learners who were in the experimental group, it is evident that enrichment programs provide a richer and more varied content through strategies that supplement normal class work. Enrichment programs also enable the gifted learner to explore various ways of solving problems as they are normally open-ended, and inquiry-based.

Conclusively, because of the characteristic challenge in executing learning assignments, gifted Science learners need an educational program that offers, in particular, possibilities for advanced thinking, making connections, reasoning, forming concepts, gaining insight, abstracting, making demands with regard to fluency, suppleness, originality, ordering, analyzing, synthesizing, integrating, evaluating critically, and generalizing, and this can be realized through the use of enrichment programs (see Chapter 2, Benefits of enrichment programs).

Through enrichment programs, the subject matter is not made more difficult, but the learners' understanding and their analytical, inductive and deductive abilities are stimulated and enriched. Gifted Science learners' existing patterns of knowledge are expanded because the knowledge they acquire through enrichment programs must be evaluated critically and qualitatively.

Enrichment programs give the gifted Science learner as a researcher the opportunity to identify problems and to solve them by exploring various possibilities for their solution. Enrichment programs if used properly, as evidenced in this research, enable the presentation, not of a larger quantity of similar work, but of subject matter that will increase the learner's power of understanding and encourage them to extend their existing knowledge.

Enrichment programs allow the gifted Science learner to delve more deeply into selected topics putting less emphasis on memorizing, without denying the value of ready knowledge. Enrichment programs provide interesting and stimulating tributaries to the mainstream of school and definitely enhance the gifted learners' understanding thus enhancing their performance in class. This explains why learners who were in the experimental group (those who received enrichment) performed better in both post-tests than those who were in control group and did not receive any enrichment.

However, as highlighted earlier in this research, the limitations were that only forty gifted grade 11 science learners were used in the study. These learners were from three urban schools in the same district, and the majority of their parents were middle-income earners. This makes it difficult to generalize the findings of this study to all gifted grade 11 science learners in the country because of the diverse nature of our schools as well as their different socio-economic backgrounds.

## 5.4 Recommendations

Based on the research findings the followings recommendations are made:

### 5.4.1 Teachers:

- Should differentiate curriculum and instruction to meet the needs and interests of gifted Science learners;
- Create an environment in which the gifted Science learners feel challenged, encouraged, and safe;
- Create a classroom atmosphere that encourages learners to take academic risks and allows them to make mistakes without fear of ridicule or harsh negative critique;
- Provide time on a weekly basis, if at all possible, for individual sessions with gifted Science learners so that they can share their interests, on-going events in their lives, or concerns;
- Provide a range of options for demonstrating learner mastery of curricular objectives, for instance considering a range of options for final product development;
- Maintain regular, ongoing communication with families of gifted Science learners, notifying them of the goals, activities, products, and expectations you have for these learners.

### 5.4.2 Department of Education:

- Establish resource rooms for gifted Science learners in various districts and equip them with an array of different learning-related materials;
- Come up with a curriculum designed to accommodate the gifted learner's advanced cognitive skills;
- Ensure that gifted learners have access to technology, especially various types of software applications, and various interactive/ telecommunications options;
- In-service training for teachers on how to teach gifted Science learners using enrichment programs;

- Increase the number of research projects given to gifted Science learners.

#### 5.4.3 Parents:

- Recognize that gifted learners may experience higher levels of social pressure and anxiety hence need tremendous support;
- Teach gifted learners how to deal with their “uniqueness” at an early age;
- Maintain constant communication with teachers of the gifted learners;
- Provide various toys, books, tasks, internet services, and digital media for the gifted Science learner.

#### 5.4.4 Universities and researchers

- There should be further study on the teaching of gifted Science learners using enrichment programs;
- Faculties of Education should make the study of gifted learners a core module for teacher education;
- Information on enrichment programs should be made readily available to the Department of Education, teachers, and parents`;
- Researched documents on enrichment programs should be easily accessible to the public.

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## **APPENDIX A**

### **Learner assent form**

**TITLE OF STUDY:** The impact of enrichment programs on the performance of gifted Science learners.

This form may have some words that you do not know. Please ask someone to explain these words to you. Take this form home to think about it and talk to your parents before you decide if you want to be in the study.

I am carrying out a study on the impact of enrichment programs on the performance of gifted Science learners. You will be allocated to one of the two groups, either experimental or control, and you will write a total of four one hour long tests each out of fifty.

If you are in the experimental group you will be given enrichment programs and this might take some of your free time. You will also be asked five interview questions towards the end of the study about your experiences and evaluation of the enrichment programs. I will be writing down and taping your responses, but these responses won't be told to your teacher or parent.

You may decide not to answer a question, or write a particular test. Your name will not be mentioned anywhere in the study, or to anyone. Throughout the study you will be referred to using numbers (001 to 040)

You do not need to be in the study. If you choose to be in the study, you may stop at any time. No one will criticize or blame you if you drop out of the study at any point.

If you have any questions about being in this study, you can ask me or ask your parent to call me on 078 546 1420 or my supervisor (Prof A.T. Motlhabane) on 012 429 2840.

If you decide to be in the study then your parent or guardian should also sign this form.

DO NOT SIGN THIS FORM IF YOU HAVE ANY QUESTIONS.

**Consent**

I have read this form. I understand the information about this study. I am willing to be in this study.

-----	-----	-----
Learner's name printed	Signature	Date

-----	-----
Parent signature	Date



## APPENDIX B

### Pre-test 1      Time 1 hour

#### Instructions

1. Leave one line between two sub questions.
2. Number questions correctly according to the numbering system used in this question paper.
3. Show all formulae and substitutions in all calculations.
4. Round off your answers to two decimal places.
5. This test consists of two sections, section A which has multiple choice questions and section B which consists of long questions.

#### SECTION A

QUESTION 1: Each sub question carries two (2) marks.

1.1.23 nitrogen atoms have a mass of.....

- A. 14
- B. 322
- C. 644
- D. 23

1.2. Determine the formula mass of the compound consisting of sodium and oxygen.

- A. 39
- B. 55
- C. 78
- D. 62

(2)

1.3. 1 mole of a substance represents.....

- A. 1g of the substance
- B. The number of atoms in the substance
- C. The volume of 1kg of the substance
- D. The number of particles that is found in 12g of carbon- 12 (2)

1.4. The number of gold atoms that is found in a gold ring with a mass of 30g is.....

- A.  $6.023 \times 10^{23}$
- B.  $9.03 \times 10^{23}$
- C.  $3.56 \times 10^{27}$
- D.  $4.02 \times 10^{24}$

1.5. Consider the following gas reaction that took place under standard conditions:



1.6. A hydrochloric acid solution with a concentration of  $0.1 \text{ mole dm}^{-3}$  consists of....g of hydrochloric acid per litre of water.

- A. 0.1
- B. 36.5
- C. 3.65
- D. 365 (2)

1.7. During the Haber process for the preparation of ammonia, a high yield of ammonia is achieved by using:

- A. A high pressure
- B. A high temperature
- C. Platinum as a catalyst
- D. Vanadium (V) oxide as a catalyst (2)

1.8. Which of the following elements is not required in large quantities by humans?

- A. C
- B. H
- C. O
- D. Cl (2)

1.9. The nutrients needed in large quantities by plants are

- A. N, P, K, O
- B. N, P, K
- C. N, P, O
- D. N, P, D, K. (2)

1.10. The nutrient responsible for strong stems and leafy growth is

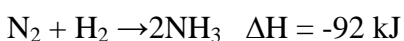
- A. N
- B. P
- C. K
- D. O

(2)

## **SECTION B**

### **QUESTION 2**

When ammonia is prepared in the industry, the following dynamic equilibrium is achieved:



2.1. Why is it called dynamic equilibrium? (3)

2.2. Is the forward reaction endothermic or exothermic? (3)

2.3. Determine the value of  $\Delta H$  per mole of ammonia formed. (3)

2.4. Explain how each of the situations below will affect the equilibrium concentration of ammonia. (3)

2.4.1. The temperature of the system is increased. (3)

2.4.2. More  $\text{H}_2$  is added to the system (3)

2.4.3. A catalyst is added (3)

2.4.4. The pressure in the system is reduced. (3)

2.5. Discuss the need for using artificial fertilizers in the world. (6)

**TOTAL FOR THE TEST = 50 MARKS**

## APPENDIX C

### MEMORANDUM FOR PRE-TEST 1

#### QUESTION 1 (TWO MARKS EACH = 20 MARKS)

- 1.1. B
- 1.2. D
- 1.3. D
- 1.4. B
- 1.5. B
- 1.6. C
- 1.7. B
- 1.8. D
- 1.9. B
- 1.10. A

#### QUESTION 2 (30 Marks)

- 2.1. Both the forward and reverse reactions are taking place, but both occur at the same rate. (3 marks)
- 2.2. Exothermic.  $\Delta H = -92 \text{ kJ}$  indicates a release of energy by the system. (3 marks)
- 2.3.  $-92 \text{ kJ}$  for 2 moles  
 $\Delta H = -46 \text{ kJ}$  per mole. (3 marks)
- 2.4.
  - 2.4.1. Decrease (shift in endothermic direction). (3 marks)
  - 2.4.2. Increase to establish equilibrium. (3 marks)
  - 2.4.3. Stay the same, the rate and production will not be affected at all. (3 marks)
  - 2.4.4. Decrease (4 moles  $\leftarrow$  2 moles to compensate). (3 marks)
- 2.5. There is a rapid increase in the population and this calls for more food. However, the natural nutrients in the soil cannot make food crops grow at the expected rate in order to satisfy the ballooning population, therefore artificial fertilizers are needed. (Any reasonable explanation from the learner is acceptable). (6 marks)

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX D

### Post-test 1      Time 1 hour

#### Instructions

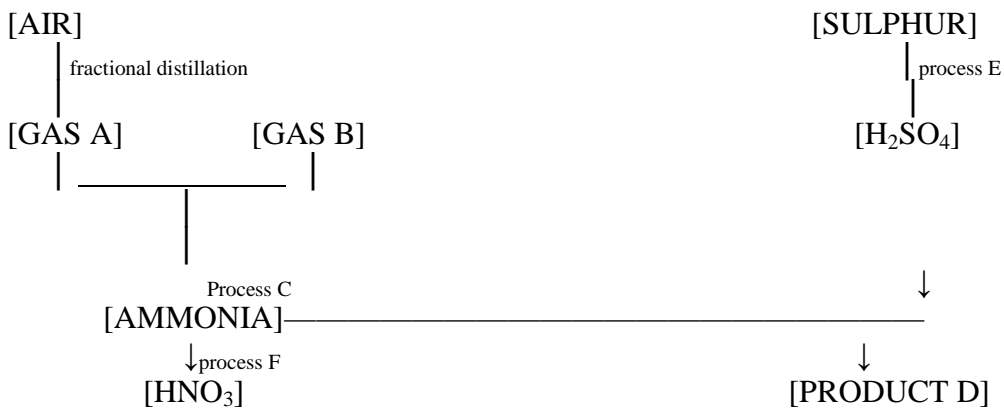
1. Answer each question on a new page
2. Show all calculations, formulae and substitutions where applicable.

#### QUESTION 1

Ammonia is a starting material in the manufacturing of fertilizers.

1.1 Give a reason why farmers add fertilizer to the soil. (1)

1.2 Study the flow diagram shown below:



Write down the:

1.2.1 Name of gas A. (1)

1.2.2. Name of gas B (1)

1.2.3. Name of process C (1)

1.2.4. Formula of product D formed when ammonia reacts with Sulphuric acid (1)

1.2.5. Name of process E (1)

1.2.6. Name of process F (1)

Recently there have been many discussions about the use of organic and inorganic fertilizers.

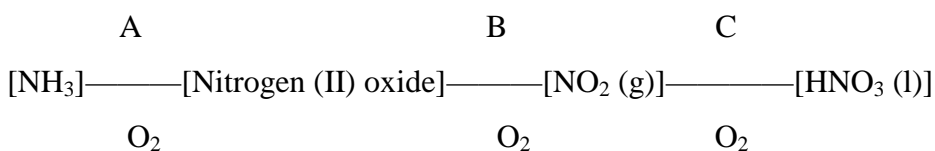
1.3. Write down the names of two organic fertilizers that are sources of primary nutrients for plants. (2)

1.4. State two disadvantages of the use of inorganic fertilizers on the environment. (2)

## QUESTION 2

Nitric acid is used in the preparation of fertilizer. The flow diagram below shows the three steps (A, B and C) in the industrial preparation of nitric acid.

Study the following diagram carefully:



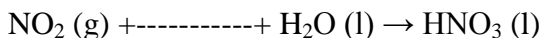
2.1. Write down the following:

2.1.1 Name of this industrial process in the preparation of nitric acid (1)

2.1.2. Balanced equation for step B (3)

2.2.  $\text{NH}_3$  (g) reacts with  $\text{O}_2$  to form two products in step A. One of the products is nitrogen (II) oxide. Write down the name or formula of the other product. (1)

2.3. In step C, water is added to the reaction mixture. This step can be represented by the following incomplete equation:



Fill in the missing reactant and balance the equation. (2)

2.4. 50kg bag of fertilizer is labeled:

3-1-5 (30)

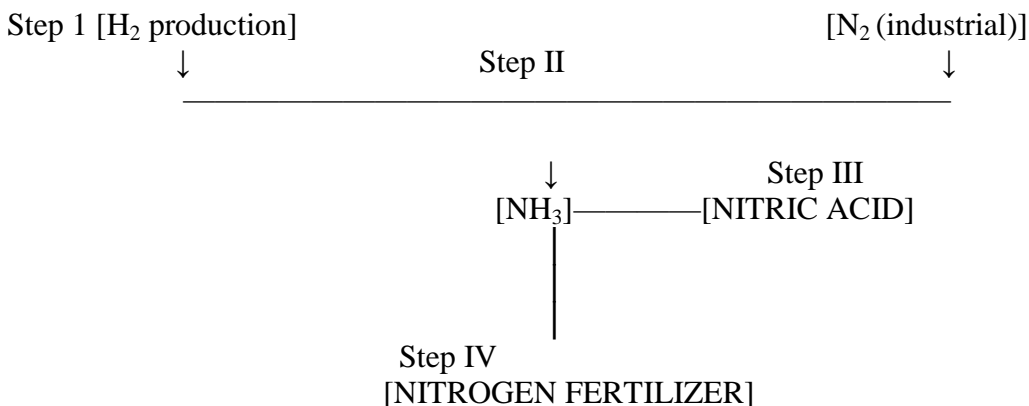
Calculate the mass of nitrogen in this bag of fertilizer. (3)

2.5. Uncontrolled use of fertilizer may cause excess fertilizer to run down into streams and rivers, leading to eutrophication.

State one negative impact that eutrophication in water may have on humans. (2)

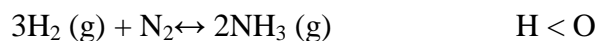
### QUESTION 3

A learner, who is revising for a test on fertilizers, summarizes her notes as follows:



3.1. Write down the name of the industrial process in step 1 used to extract nitrogen gas from the atmosphere. (2)

3.2. The Haber process, indicated in step II, is represented by the following equation:



In this process, high temperatures of approximately 450° are used. Explain in terms of reaction rate, equilibrium and temperature why such a high temperature, and not a lower temperature, is used. (4)

3.3. Write a balanced chemical equation for the reaction that produces the nitrogen fertilizer in step IV. (3)



3.4. The learner decides to educate the community about the possible negative effects of the overuse of nitrogen fertilizers on the environment.

Write down the main arguments that she will raise to convince the community to avoid excess use of nitrogen fertilizers. (4)

3.5. The learner notes that fertilizer with an NPK ratio of 7:1:1 is needed for the growth of maize plants.

3.5.1. State what the term NPK ratio means. (2)

#### QUESTION 4

There is likely to be a gap between food production and demand in several parts of the world by 2020. Demand is influenced by population growth and urbanization, as well as income levels and associated changes in dietary preferences. Fertilizers are very important in the demand for more food. However, over-fertilizing may have disastrous effects on humans and the environment.

4.1. Supply two reasons why the world needs a fertilizer industry. (2)

4.2. State two effects of over-fertilizing on the environment. (2)

Motsie decided to fertilize his vegetable garden. He finds the following information on a 50 kg bag of fertilizer at the nursery:

N: P: K

1:2:3 (30)

4.3. What is the meaning of the (30) on the bag? (1)

4.4. Calculate the % P of the fertilizer in the bag. (2)

- 4.5. What will Motsie observe if his garden has a shortage of phosphorous? (1)
- 4.6. Calculate the mass carrier material present in this bag of fertilizer. (2)
- 4.7. Calculate the mass of P present in this bag of fertilizer. (2)
- 4.8. Which primary nutrient will mainly be gained by the vegetables during a rain and thunderstorm? (1)

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX E

### MEMORANDUM FOR POST-TEST 1

#### QUESTION 1

1.1. Fertilizers are meant to supply soils with the essential nutrient that might be deficient in the soil and vital for plant growth. (1)

1.2.1. Nitrogen gas (1)

1.2.2. Hydrogen gas (1)

1.2.3. Haber process (1)

1.2.4. Ammonium sulphate/  $(\text{NH}_4\text{SO}_4)_2$  (1)

1.2.5. Contact process (1)

1.2.6. Oswald process (1)

1.3. Ammonium sulphate

Ammonium nitrate (2)

1.4. Fertilizers can cause contamination of water if they are overused and washed into water supplies. They also cause eutrophication, algae bloom, and death of aqua animals. (2)

#### QUESTION 2

2.1.1. Oswald process (1)

2.1.2.  $2\text{NO (g)} + \text{O}_2 \text{ (g)} \leftrightarrow 2\text{NO}_2 \text{ (g)}$  (3)

2.2. Water (1)

2.3.  $\text{NO}_2 \text{ (g)} + \text{NO} + \text{H}_2\text{O (l)} \rightarrow \text{HNO}_3 \text{ (l)}$  (2)

2.4.  $\frac{3}{9} \times 30 = 10 \text{ kg}$  (3)

2.5. Eutrophication

Algae bloom

Water contamination

Death of aqua animals and plants (2)

QUESTION 3

3.1. Fractional distillation (2)

3.2. More effective collisions, faster production of the fertilizer, produce large quantities over a short period, forward reaction is favored. (4)

3.3.  $\text{HNO}_3 (\text{aq}) + \text{NH}_3 (\text{g}) \rightarrow \text{NH}_4\text{NO}_3 (\text{aq})$  (3)

3.4. Eutrophication, algae bloom, harmful to people, and aqua animals and plants. (4)

3.5. Nitrogen: Phosphorous: Potassium (2)

QUESTION 4

4.1. The world's population is growing every second hence more food should be grown to cater for the increasing population.

The soil is fast losing its fertility hence additional nutrients are needed to make up for the lost ones. (2)

4.2. Eutrophication

Soil erosion

Soil acidity (2)

4.3. The amount of fertilizer in the bag. (1)

4.4  $\frac{2}{6} \times 30 = 10$  (2)

4.5. The roots won't develop properly

The plants won't flower properly. (1)

4.6.  $50 - 30 = 20$  kg (2)

4.7.  $\frac{2}{6} \times 30 = 10$  (2)

4.8. Nitrogen (1)

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX F

### PRE-TEST 2

#### Instructions

This test consists of two sections, Section A which is one-word items and multiple choice questions, and Section B which has long questions.

#### Section A

##### QUESTION 1: ONE-WORD ITEMS

Give one word or term for each of the following descriptions. Write only the word or term next to the question number.

1.1. The type of bond between two atoms where both bonding electrons are donated by one of the atoms. (1)

1.2. A type of covalent bond formed between two atoms when electrons are not equally shared by the two atoms. (1)

1.3. A chemical reaction that shows a decrease in oxidation number. (1)

1.4. A physical quantity that represents the average kinetic energy of the molecules of a gas. (1)

1.5. Compounds consisting of carbon and hydrogen atoms only. (1)

##### QUESTION 2 MULTIPLE CHOICE QUESTIONS

Four options are given as possible answers to the following questions. Each question has only one correct answer. Write only the letter (A-D) next to the question number.

Which one of the following can behave as an ampholyte?

- A.  $\text{HSO}_4^-$
  - B.  $\text{SO}_4^{2-}$
  - C.  $\text{H}_3\text{PO}_4$
  - D.  $\text{OH}^-$
- (2)

2.1. An oxidizing agent is a substance.....

- A. That is experiencing oxidation
  - B. That reduces other substances
  - C. That is reduced
  - D. That releases electrons.
- (2)

2.2. Cracking is an example of.....

- A. An addition reaction
  - B. An elimination reaction
  - C. A substitution reaction
  - D. A dehydration reaction
- (2)

2.3. Which one of the following does not involve the transfer of electrons?

- A. Redox reaction
  - B. Formation of ionic bonds
  - C. Electrochemical reactions
  - D. Formation of covalent bonds
- (2)

2.4. Which one of the following chemical bonds will be the strongest?

- A. C-C
  - B. C-O
  - C. C-F
  - D. C-N
- (2)

2.5. A standard solution is a solution....

- A. With a concentration of 1 mole per cubic decimeter

- B. Where all of the solids are not dissolved in the solvent  
C. Of which the concentration is known  
D. Which is neutral (2)

2.6. Which of the following compounds does not have multiple bonds?

- A.  $\text{N}_2$   
B.  $\text{O}_2$   
C.  $\text{H}_2\text{O}$   
D.  $\text{HCN}$  (2)

2.7. Consider the four sulphur-containing compounds shown below:

I  $\text{H}_2\text{S}$

II  $\text{SO}_2$

III  $\text{H}_2\text{SO}_4$

IV  $\text{H}_2\text{SO}_3$  (2)

In which of the above compounds does sulphur have the same oxidation number?

- A. I and II only  
B. I and III only  
C. II and IV only  
D. II and III only (2)

2.8. The molar mass for hydrous copper (II) sulphate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , is:

- A.  $249,5 \text{ g mol}^{-1}$   
B. 249,5  
C. 159,5



D.  $159,5 \text{ g.mol}^{-1}$  (2)

2.10. In a standard Cu-Zn electrochemical cell the electrolyte at the anode consists of:

- A.  $0.1 \text{ mole dm}^{-3}$  of  $\text{Cu}^{2+}$  ions
- B.  $1.0 \text{ mole dm}^{-3}$  of  $\text{Zn}^{2+}$  ions
- C.  $0.1 \text{ mole dm}^{-3}$  of solution of  $\text{Zn}^{2+}$  ions
- D.  $1.0 \text{ mole dm}^{-3}$  of  $\text{Cu}^{2+}$  ions (2)

## SECTION B

### Instructions

The formulae and substitutions must be shown in all calculations.

Leave one line between two sub questions.

### QUESTION 3

A learner sets up a standard electrochemical cell by using the following half-cells:

$\text{Pt (s), O}_2/\text{H}^+, \text{H}_2\text{O}_2 \text{ (aq)}$  and  $\text{Cu}^{2+} \text{ (aq)}/\text{Cu (s)}$  A potassium chloride solution is used in the salt bridge.

3.1 Which electrode is the cathode? Explain your answer.

3.2 Write down the oxidation half- reaction equation.

3.3 Write down the reduction half- reaction equation.

3.4 Determine the emf of this cell.

3.5 The concentration of which ion will increase in the  $\text{O}_2/\text{H}_2\text{O}_2$  half-cell, while the cell is in operation? (5 marks each).

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX G

### MEMORANDUM FOR PRETEST 2

#### SECTION A

QUESTION 1 (One mark each)

1.1. Dative covalent

1.2. Polar bond

1.3. Redox

1.4. Temperature

1.5. Hydrocarbon

QUESTION 2 (Two marks each)

2.1. A

2.2. C

2.3. B

2.4. D

2.5. C

2.6. A

2.7. C

2.8. C

2.9. A

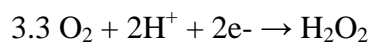
2.10. D

#### SECTION B

QUESTION 3

3.1 Pt, O<sub>2</sub> (g) H<sup>+</sup>/ H<sub>2</sub>O<sub>2</sub>

3.2 Cu → Cu<sup>2+</sup> + 2e<sup>-</sup>



3.4  $E^\theta_{\text{cell}} = E^\theta_{\text{cathode}} - E^\theta_{\text{anode}}$

$$= 0.68 - 0.34$$

$$= 0.34 \text{ V}$$

3.5  $\text{K}^+$  [ $\text{H}^+$  ions are removed, see 3.3, electrolytes are negative.  $\text{K}^+$  moves in to neutralize electrolytes].

(5 marks each)

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX H

### Post-test 2

#### Instructions

This test consists of four long questions with sub questions.

Answer each question on a new page.

#### QUESTION 1

The potential difference of a galvanic cell, measured experimentally by learners, is compared with its potential difference calculated at standard conditions.

The voltmeter measures an initial reading of 0.3V and Cu and Pb are used as electrodes, with  $\text{Cu}^{2+}(\text{aq})$  and  $\text{Pb}^{2+}(\text{aq})$  as electrolytes.

- 1.1 Write down the energy conversion that takes place in this cell. (1)
- 1.2. State one function of the salt bridge. (1)
- 1.3. Write down the half-cell reaction that takes place at the anode. (2)
- 1.4. In which direction do electrons flow in the external circuit when this cell delivers a current? (1)
- 1.5. Write down the balanced net (overall) cell reaction. (3)
- 1.6. Is the cell reaction exothermic or endothermic? (1)
- 1.7. Use the Table of Standard Reduction Potentials to calculate the initial potential difference (emf) of this cell at standard conditions. (4)

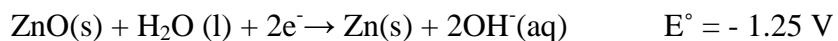
## QUESTION 2

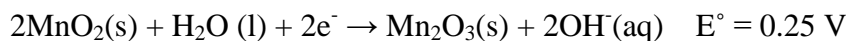
The main products of the chlor-alkali industry are chlorine, sodium hydroxide, and hydrogen. The simplest industrial method for the preparation of these chemicals is the electrolysis of brine. Most chlor-alkali plants make use of the membrane cells.

- 2.1. Define the term *electrolytic cell*. (2)
- 2.2. Write down the names or formulae of the ions present in brine. (2)
- 2.3. Write down the half- reaction that occurs at the anode. (2)
- 2.4. Write down the half-reaction that occurs at the cathode. (2)
- 2.5. The membrane is made from a special plastic, a fluorocarbon polymer. What is the function of the membrane? (2)
- 2.6. Give a reason why chlorine is used in drinking water. (1)

## QUESTION 3

Alkali dry cells are also used in wrist watches. The half-reactions involved when such cells function and their respective standard potentials are given below:





3.1. Write down the:

3.1.1. Half-reaction that takes place at the anode. (2)

3.1.2. Half-reaction that takes place at the cathode. (2)

3.1.3. Balanced net (overall) cell notation that takes place in this cell. (2)

3.2. The cell is labeled as 1.5 V; 1 000 mA.h.

Calculate the:

3.2.1. Maximum charge that can be delivered by the cell. (3)

#### QUESTION 4

Batteries consist of one or more galvanic cells. A galvanic cell is a combination of two half-cells. John wants to determine which one of Option A or Option B, shown below, can be used to assemble a galvanic cell with the highest potential difference.

Option	Combination of half-cells
A	Ag(s) in AgNO <sub>3</sub> (aq) and Ni in Ni(NO <sub>3</sub> ) <sub>2</sub> (aq)

B	Mg (s) in $\text{Mg}(\text{NO}_3)_2$ (aq) and Ag in $\text{AgNO}_3(\text{aq})$
---	--------------------------------------------------------------------------------

4.1. Write down a balanced chemical equation, excluding spectator electrons, for the net (overall) cell notation for the galvanic cell in Option B. (3)

4.2. Calculate the initial potential difference that can be obtained under standard conditions for the galvanic cell in Option B. (4)

4.3. State two standard conditions that John must adhere to during the experiment; to ensure the measured potential difference is the same as the calculated potential difference. (2)

4.4. Write down the cell notation (symbolic notation) for the galvanic cell in Option A. (4)

4.5. Without any calculations, determine which one of Option A or Option B should result in the galvanic cell with the highest potential difference. Refer to the relative strengths of the two reducing agents involved, as well as the relative strengths of the two oxidizing agents involved, to explain your answer. (4)

**TOTAL MARKS FOR THE TEST = 50**

## APPENDIX I

### MEMORANDUM FOR POST-TEST 2

#### QUESTION 1

1.1. Chemical energy to electrical energy. (1)

1.2. Completes the circuit

OR

Maintains electrical neutrality (1)

1.3.  $\text{Pb} \rightarrow \text{Pb}^{2+} + 2\text{e}^-$  (2)

1.4. Pb to Cu (1)

1.5.  $\text{Pb} + \text{Cu}^{2+} \rightarrow \text{Pb}^{2+} + \text{Cu}$  (3)

1.6. Exothermic (1)

1.6.  $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$

$$= 0.34 - (-0.13)$$

$$= 0.47 \text{ V} \quad (4)$$

#### QUESTION 2

2.1. The cell in which a chemical compound is broken down with the aid of an electric circuit.

(2)

2.2.  $\text{Na}^+$  and  $\text{Cl}^-$

Sodium ion and chloride ion (2)

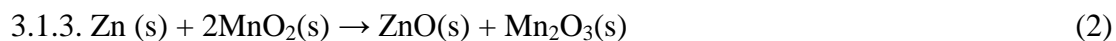
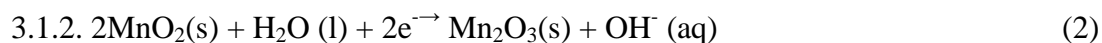
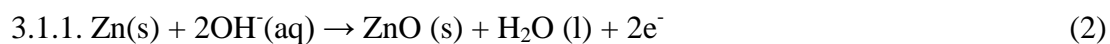




2.5. The membrane separates the anode and the cathode and allows only the positive ions through from the anode to the cathode (semi-permeable/ ion- selective) (2)

2.6. The disinfectant kills bacteria to improve health conditions. (1)

### QUESTION 3



$$3.2.1. 1000\text{A.h.} = 1000 \times 10^{-3} \times 3600$$

$$= 3600 \text{ C} \quad (3)$$

### QUESTION 4



$$4.2. E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

$$= 0.80 - (-2.36)$$

$$= 3.16\text{V}$$

(4)

4.3. Temperature 25°C

Concentration of solution 1 mol.dm<sup>-3</sup> (2)

4.4. Ni / Ni<sup>2+</sup> // Ag<sup>+</sup> / Ag (4)

4.4. Option B

Mg has a stronger reducing ability than Ni, indicating its readiness to donate electrons. On the other hand it (Mg) has a weaker oxidizing ability, meaning it doesn't accept electrons as readily as Ni. (4)

**TOTAL FOR TEST = 50 MARKS**

## APPENDIX J

### RUBRIC FOR RESEARCH PROJECT

<b>Abstract</b>	No abstract included or not appropriate <b>0 - 1</b>	Research concept stated clearly. Conclusion present <b>2 – 3 marks</b>	Findings are summarized. Fewer than 2000 words. Conclusion present <b>4 marks</b>	Research concept clear. Findings summarized. Conclusion present. Fewer than 2000 words. <b>5 marks</b>	Abstract of very high standard and quality, lacking nothing. <b>6 marks</b>
Title page	No title page <b>0</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>
Introduction	Not included, inappropriate <b>0 - 1</b>	Research question is given, argument sequence is mapped out. <b>2 – 3 marks</b>	Research question is given, clear, argument sequence is mapped out. <b>4 – 5 marks</b>	Research question clearly answered, clear why research is being carried out, argument sequence mapped out	

				well. <b>6 – 8 marks</b>	
<b>Report</b>	No report included, included but inappropriate, plagiarism. <b>0 – 2 marks</b>	Findings in own words, terms and concepts correctly used, resources cited. <b>3 – 6 marks</b>	Findings in own words, concepts clearly explained, resources used are cited, guiding questions answered fully. <b>7 – 10 marks</b>	Findings in own words, concepts explained in scientific terms, resources correctly cited, guiding questions thoroughly answered. <b>11 – 14 marks</b>	Findings in own words, concepts explained in scientific terms, appropriate diagrams and/ or pictures, guiding questions thoroughly answered. <b>15 – 25 marks</b>

**TOTAL FOR RESEARCH PROJECT = 40 MARKS**

## APPENDIX K

### RESEARCH PROJECT

Carry out a research project on the manufacture, use, and disadvantages of any two artificial fertilizers in South Africa. You need to pay attention to all the chemical processes involved in the manufacture of the fertilizers chosen. In your research project, also look at the following processes:

- Haber process,
- Contact process,
- Ostwald process, and
- Eutrophication.

Make use of the attached rubric to help you write your research project. Among other things, include a title page, abstract, contents page, conclusion, bibliography, as well as pictures and/ diagrams.

**TOTAL FOR RESEARCH PROJECT = 40 MARKS**

## APPENDIX L

### INTERVIEW QUESTIONS

#### QUESTION 1:

What were the most beneficial aspects of the enrichment programs you were given?

#### QUESTION 2

How did participating in the enrichment programs affect you?

#### QUESTION 3

Were the enrichment programs given to you appropriate for your level?

#### QUESTION 4

Basing on your recent experience, do you think enrichment programs should be given to all learners?

#### QUESTION 5

What were the most difficult aspects of the enrichment program?

## APPENDIX M

### TRANSCRIPTS OF INTERVIEWS

#### QUESTION 1

What were the most beneficial aspects of the enrichment programs?

Learner 002

“Well, truly speaking everything given to me [laughs]. But the most beneficial ones was going to Sasol plant on the field trip as well as watching DVDs. These made me understand the work better”.

Learner 011

“Sasol. It was fantastic seeing the actual production of fertilizers as well as doing the research. That made me score high marks in the [post] tests”.

Learner 005

“I found all activities highly beneficial as they challenged me [pause] yes and also made me work extra hard”.

Learner 009

“Being able to work on my own and carrying out researches was awesome [pause] as well as the extra lessons I attended at the Varsity. The guys were good and I can recall everything taught to me”.

Learner 027

“Basically the DVDs and the field trip made me understand the work clearly and also gave me the opportunity to go an extra mile”.

Learner 006

“Watching DVDs taking the place of the ordinary teacher and bringing in different teaching styles to the class, was quite beneficial to me”.

Learner 016

“I enjoyed going on the field trip as well as attending extra classes. That broke the monotonous daily routine [pause]. But seriously this opened my mind and made me understand better”.

Learner 028

“All programs were beneficial and actually funny [pause] in fact DVDs, extra classes and the trip to Sasol plant were the best. They kept me motivated and on my toes to learn extra”.

Learner 021

“I found all enrichment programs useful as they brought to class the much needed and missed flavor of variety”.

Learner 030

“Umm I could say all activities were highly beneficial as they taught me stuff I won’t forget and they [activities] made me score high marks in the [post] tests”.

Learner 033

“All stuff I learnt through the enrichment is in my head now. The programs helped me master the concepts well and permanently [laughs]”.



Learner 036

“[sigh] I would give my vote to the field trip to Sasol where I saw the actual production of fertilizers and also the extra classes at the varsity where I was taught by experts, this boosted my self-esteem and confidence and strived to do better every day”.

Learner 038

“When DVDs took the place of the teacher and the field trip presented reality to me, this made me understand the work better and permanently [pause] I wish this could be done over and over”.

Learner 040

“All activities [long pause] yes all activities were beneficial to me”.

Learner 008

“In my opinion all activities were beneficial as they made me understand the concepts well o an extent that I won’t forget them [laughs].”

Learner 018

“Watching DVDs and visiting the Sasol firm. Can we do that again soon [claps hands]”.

Learner 029

“Everything [pause] Yeah, just everything was great.”

Learner 013

“Going on the trip [field] was highly beneficial as I was able to actually see the real production of fertilizers. This way I won’t forget what I learnt”.

Learner 017

“[Laughs] all activities were of great benefit and they made me comprehend the matter taught. They [enrichment programs] helped me comprehend the concepts such that I won’t forget them”.

Learner 039

“Watching DVDs kept me motivated and attentive [pause] Also the extra work was quite challenging [sighs] A bit hectic”.

## **QUESTION 2**

How did participating in the enrichment programs affect you?

Learner 002

“Participating in the programs made me realize I had great potential which was untapped thereby being underutilized. I felt highly challenged to perform better and felt special”.

Learner 005

“I felt honored [long pause] Being chosen boosted my self-confidence and self-esteem”.

Learner 021

“It was like, yeah, being called upon to produce first class work, like you always say. I was challenged academically and enjoyed it”.

Learner 008

“For the first time I made use of my free time though at times I wanted to give up because the work stretched me. Seriously I realized I could be my own teacher and score better marks [laughs].

Learner 009

“I was made to work extra hard as I felt I wasn’t doing well enough. This boosted my confidence and self-concept greatly”.

Learner 011

“I felt honored though I couldn’t face my peers who were not par of the group [pause]. On a lighter note the activities made me feel special and worthy”.

Learner 016

“For once in my school career I was able to do my school work seriously as it challenged me.... This was different from the everyday easy work I was used to”.

Learner 033

“Being given such quality work made me feel proud motivated and focused on my school work”.

Learner 017

“The challenge tapped some hidden potential in me and I felt the urge to put on my thinking cap [laughs]. I felt like I was now a varsity student”.

Learner 013

“I proved I could work on my own and produce good results [pause] my self-esteem and Self-confidence was boosted [pause]. I felt special being in the group”.

Learner 006

“Watching DVDs instead of watching the teacher was funny and motivating. I played them over and over again thereby repeating the lessons to myself, in my room, at my own time and pace [long pause] I was able to comprehend every single thing”.

Learner 036

“I am a proud person so being part of this elite group made me more proud [laughs]. On a serious note I felt like the salt of the earth in the classroom as I had to explain the work to my peers who were not part of the group”.

Learner 038

“[Sighs] I felt the time had come for me to prove my worthy and show the world that I am up for greater challenges”.

Learner 028

“It made me realize I had energy and brains I didn’t know existed [laughs] It took me to greater academic heights”.

Learner 018

“In short I felt highly challenged and honored to be given such an opportunity as it proved that for once I was being taken seriously. I felt the urge to work hard and score higher marks.”

Learner 039

“I felt great and raring to go because the activities were of the level I always wanted and was thrilled to be in the position to prove my ability”.

Learner 027

“I felt stupid [laughs] I am kidding. I felt being taken to task to score higher marks than those who weren’t given the opportunity to be part of the group”.

Learner 029

“The programs [enrichment] made me feel worthy for a start. I got the urge to work extra hard and prove my worthy”.

Learner 030

“This boosted my self-esteem and self-concept”.

Learner 040

“The field trip and being taught by scientists made me confident and change my career choice. It also made me excel”.

### **QUESTION 3**

Were the enrichment programs appropriate for your level? How?

Learner 017

“Yes, they were. They challenged me and were quite varied”.

Learner 030

“Definitely [pause]. Though some of the questions seemed quite challenging”.

Learner 036

“The perfect level”, “No being held back by rest of the class, and no easy questions which we normally answer without scratching our heads.”

Learner 002

“Absolutely [pause] they were different from the daily activities in our text books which we answer without scratching our heads”

Learner 028

“My assessment of the programs is that they were of appropriate level to those kids of high ability only not to those whose ability is low”.

Learner 029

“No [pause] they were too easy and boring to do. They [enrichment programs] need to be more challenging”.

Learner 009

“All activities were of the correct level as they were not like the baby stuff we normally get in class [laughs and pause]. All work should be of such level”.

Learner 033

“Yes the activities were of suitable level as I had to think twice before I wrote the answers. The field trip, extra lessons as well as the DVDs were all perfect”.

Learner 011

“In my opinion the activities given were of appropriate level as they were not push-overs. They needed one to think properly, work hard and read extensively”.

Learner 013

“Yes [pause], absolutely. All activities were of appropriate level according to my evaluation”.

Learner 005

“These were the perfect level as they made me think and work hard. Bravo! [Laughs]

Learner 021

Yep, they made me put my thinking cap on. For the first time I felt being stretched academically. I loved it”

Learner 016

“[pause] umm I think so since they were not easy nor difficulty. So yeah they were of the appropriate level”.

Learner 008

“Definitely. They [enrichment programs] made me work harder and read widely for answers to given questions”.

Learner 018

“The level and quantity was superb [pause] but more research projects are needed”.

Learner 039

“All activities in my opinion were suitable and right for my academic ability as they kept me motivated to do better and score higher grades”.

Learner 027

“Yes [sigh] precisely [pause] they were of the right level”.

Learner 038

“They were the right level [pause], difficult, challenging but above all academically beneficial”.

Learner 040

“Perfect level, unlike daily class activities which are boring and too easy I didn’t finish them as fast as I do with daily class work.”

Learner 006

“Yeah, they were perfect level and kept me on my toes”.

#### **QUESTION 4**

Do you think enrichment programs should be given to all learners? Why?

Learner 005

“Definitely! Enrichment programs add to where the teacher has left and therefore should be given to all learners as we all need to excel in our studies”.

Learner 006

“ I think so because all learners have a right to the best education and enrichment programs contribute to this type of education [pause] yes they should be given to all learners in the school”.



Learner 008

“South Africa needs people in the science field as well as science teachers and this goal can be realized through making use of enrichment programs [pause] so yes they should be given to all learners”.

Learner 013

“No [pause] I suggest they are given only to learners of high ability so that they are not frustrated by the difficult work”.

Learner 016

“I agree 100%. It’s unfair to give them to only a few learners since I discovered these help one to excel in their school work”.

Learner 017

“I agree [pause] but I suggest they [enrichment programs] be differed according to ability so that the dudes won’t be frustrated by some work if their brains are not very sharp”.

Learner 009

“Yes, these add variety to the daily routine. They [enrichment programs] keep the class focused, busy, challenged, and motivated [pause]. No one will misbehave in my opinion”.

Learner 018

“I totally agree but...eh....why not put the learners into ability groups so that learners are given programs appropriate to their levels [pause] this is less stressing and frustrating”.

Learner 021

“That will be awesome because enrichment programs make you get very high marks therefore the whole class will get good grades. I totally agree [pause] lets have them in full swing”.

Learner 027

“No I disagree. These programs should only be given to the academically-able learners because the other ones will be frustrated and quit the activities”.

Learner 029

“You want some kids to drop out of school? [Laughs].These programs are highly challenging and should only be given to the high flyers otherwise schools will be left with very few kids [laughs]

Learner 011

“Definitely. This will make everyone score high marks because the teaching methods are different and more challenging, plus interesting work is given”.

Learner 028

“Umm [pause]. I don’t think so because some of the activities might be too difficult for the kids and end up frustrating them”.

Learner 030

“Yes what I noticed is that these programs continue from where the teacher and the books leave. So it’s important we are all given enrichment as it really helps”.

Learner 033

“Absolutely.....that will be great because what I discovered is that these programs motivate, challenge, and make you be focused on your school work giving you the quest to perform better”.

Learner 039

“I agree because I saw how beneficial these programs are as well as the fact that they break the daily monotony found in our schools [pause] yes everyone should be given enrichment according to their level”.

Learner 036

“No, no, no. Some dudes will drop out of school [laughs]. Some of the activities can be really challenging. So it’s a no from me”.

Learner 038

“I agree. It will make learning funny and enjoyable. It will also improve the grade average”.

Learner 040

“Everyone needs to be involved, yes, [pause] but more programs should be given to those who are capable so that people’s egos won’t be bruised”.

Learner 002

“I agree 100%. We need different learning styles in class. This will keep us motivated and willing to learn”.

## QUESTION 5

What were the most difficult aspects of the whole program?

Learner 017

“Carrying out a research project on my own [pause] we always used to do them in groups. This was really difficulty and challenging”.

Learner 002

“I couldn’t think of a straight forward way of coming up with a good research project. Researches should be given more often please sir [claps hands].

Learner 005

“Research project [pause] I will carryout more projects of my own [sigh] I only realized it now that I need more practice in that area”.

Learner 006

“All activities went well except one....research project. Schools should give us more research projects as enrichment”.

Learner 008

“[Sigh] research project sir. This was my third research project in my whole school career’ let’s have more please”.

Learner 013

“Is it possible for the Department of Education to give us more research projects? [Pause] or maybe our schools can step in there”.

Learner 016

“The only challenge I faced was to come up with an acceptable research project. More would be appreciated sir”.

Learner 021

“I didn’t face any challenges at all. All activities were manageable and not difficult to tackle at all”.

Learner 027

“Research projects need more time than you gave us. We need about 4 to 8 weeks for a single project. The time frame given to us made us work throughout the night”.

Learner 030

“Research projects [long pause]. At first I didn’t have a clue what was happening and where to get the information. We need to have more of these [pause]. Definitely”

Learner 033

“The one and only challenge I faced was gathering sufficient information for the research project...I was tempted to use the literature I collected on the field trip. That’s the challenge I faced”.

Learner 036

“I need to keep on carrying out research projects on my own because I discovered this is a grey area. That’s the only difficult activity I encountered in this program”.

Learner 038

“Ummm...yes...just research project...but I got it right though I need to polish that area”.

Learner 039

“Sir [laughs] we need you to give us more research projects if possible. This area caught me off-guard but I will come right”.

Learner 028

“I felt stupid doing the research project [laughs]. It was the second research project I have done in my school career”.

Learner 040

“I didn’t experience any difficulties at all. All activities were manageable and to my level”.

Learner 011

“Umm....I didn’t encounter any difficulties at all. All was perfect”.

Learner 009

“Finding information, [pause], reading it and then writing a research project was cumbersome [pause]. More researches are needed please”.

Learner 018

“Synthesizing information for the research project wasn’t a joke [laughs]. Ha-a-a, I will carry out more researches on my own. I now know how to do so”.

Learner 029

“How do you present a research project? [Long laugh]. Schools should give learners as many research projects as possible. Surely these help [learners] understand concepts better”.

## APPENDIX N

### LETTER OF PERMISSION FROM THE PRINCIPAL

To Whom It May Concern:

I am a student at the University of South Africa. At present, I am enrolled for a Masters degree in Education specializing in Natural Science Education.

To fulfill the requirements of this degree, I need to carryout a research. I am carrying out a research on the impact of enrichment programs on gifted Science learners in grade eleven (11) and would therefore need co-operation of your learners and educators. I would like to carry out my research at your institution and I would be prepared to share the requirements for my research project with you and, if you would like me to, I will give you feedback on the research I would have carried out.

Thank you very much for helping me research my goal- it is valuable to me as an educator to be able to take responsibility for my own professional development and to contribute to the development of various aspects of the cognitive life of the gifted learners in South African schools.

You are welcome to contact my supervisor, Dr A.T. Motlhabane through telephone on 012 429 2840 or email him at [motlhat@unisa.ac.za](mailto:motlhat@unisa.ac.za).

Yours faithfully

ERASMOS CHARAMBA

UNISA STUDENT NUMBER 48166413

---

PRINCIPALS SIGNATURE

---

DATE

## **APPENDIX O**

### **SAMPLES OF LEARNERS' WORK AND SIGNED LETTERS OF PERMISSION FROM PRINCIPALS**



## Index 002

Page 1° Fertilizer in  
General

Page 2° Nitrogen-based  
fertilizers <sup>1</sup>/<sub>3</sub> Requirements  
and function ✓

Page 3° Plant Content  
<sup>1</sup>/<sub>3</sub> Vegetative Growth

P. T. U

Page 4 : Dosage / Quantity

Effects of fertilizers

Page 5 : Advantages of

ammonium nitrate.

Page 5 : Ammonium Sulphate

Page 6 : Advantages and

Disadvantages of Ammonium  
Sulphate.

Page 6 : Use of Ammonium Nitrate.

Page 7 : Mixed Fertilizers

Page 8 : Pictures of  
the fertilizers

Page 9 : References

## Fertilizers in General ?

Fertilizers are generally thought of as plant food. Actually most of the plant's food is made through the process of photosynthesis.

Through photosynthesis the plants remove carbon dioxide from the atmosphere, combines it with water and captures the carbon, hydrogen and oxygen atoms used to build the plant.

It is through this process that the plant manufactures glucose, which is then used as an energy supply as well as providing the essential building blocks of the plant skeleton.

Other atoms and molecules are also needed and some may be short supply because photosynthesis occurs everyday (unless dormant) and the other molecules must be scavenged through the root system.

These other nutrients such as nitrogen, phosphorus, sulfur, potassium and a host of other nutrients must be found in the soil and then removed from soil by the plants root system.

Supplying nitrogen to plant systems usually induces a flush of growth whether it is redwoods or algae. This is one of the reasons why algae begins to grow in lakes when excessive nitrogen is released to the water through fertilizer use at home as well as agricultural runoff.



# Nitrogen-based fertilizers

Nitrogen is one of the macronutrients required for proper plant nutrition and growth.

Nitrogen becomes part of many organic compounds within the plant cell. Somewhere between 1 and 5% of the total dry weight of a leaf can be accounted for by nitrogen.

The plant takes up nitrogen from the soil in two forms nitrate ( $\text{NO}_3^-$ ) and ammonium ( $\text{NH}_4^+$ ). Nitrogen plays an important role in many of the basic molecules of the plant cell such as amino acids used in making proteins, nucleotides used in making DNA.

Nitrogen is present in so many compounds that one begins to understand why it is that a lack of nitrogen will lead to growth deficiency symptoms.

## Requivement and function

Nitrogen also known as an essential major element, can be found in both inorganic and organic forms in plants. It is usually found in combination with carbon (C), hydrogen (H), oxygen (O), which are brought into the cell through photosynthesis. Although inorganic nitrogen can accumulate in the nitrate form ( $\text{NO}_3^-$ ), organic nitrogen, that is



nitrogen in combination with hydrogens ( $\text{NH}_4^+$ ), predominates in the cell due to the high concentration of super large molecules known as proteins.

## Plant Content !

Nitrogen consists of 1.50 % to 6.00 % of dry weight of many crops. Usually the amount required in most plants for optimal metabolism, also called the sufficiency value, is from 2.5 to 3.5 percent measured in leaf the tissue.

A lower range of 1.8 to 2.2 percent is commonly found in most fruit crops. The highest concentration of nitrogen is found in the new leaves, and the nitrogen values generally decrease with the increasing age of the tissue or tree.

## Vegetative Growth

Tree vigor is generally measured by amount of shoot growth or gain in trunk circumference per unit time, usually one year or growing season.

Cropping potential of young trees is directly related to canopy development.

## Dosage Effects

If levels of nitrogen are low, summer or post harvest applications of nitrogen may be beneficial

- \* Inadequate nitrogens: Limits flowers development and increases the tendency towards biennial cropping.

- \* Excessive Nitrogen: Can delay flowering of young trees. In trees of bearing age, excessive nitrogen may also stimulate development of excessive shoot growth leading to reduced flowering and fruit set.

## Ammonium Nitrate (34-00-00)

This means that 34% of the weight of bag will be nitrogen and there will be no phosphorus (P) or potassium (K) in this fertilizer.

- \* Ammonium nitrate is a water-soluble form of nitrogen
- \* It moves easily into the soil with rainfall or irrigation. It follows then that it can easily be lost if too much rain occurs after applying it to the soil.
- \* The ammoniac form of the nitrogen has the ability to lower the soil pH



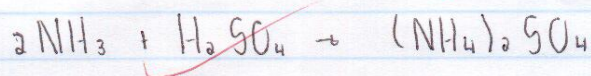
## Advantages of Ammonium Nitrate

- \* It's essential in the agricultural business since farmers want to make sure that the production levels are high but the quality needs to be in the highest levels too.
- \* During seasons like summer, it is very applicable to use since it ~~evaporates~~ much slowly than the other types.
- \* Storage of this fertilizer is ~~easy~~ easy

## Ammonium Sulphate

Ammonium sulphate is made by synthetic ammonia with sulphuric acid.

*write the states*



A mixture of ammonia gas and water vapour is introduced into a reactor that contains a saturated solution of ammonium sulphate and about 2 and 4% of free sulphuric acid at 60°C. Concentrated sulphuric acid is added to keep the solution acidic, and to retain its levels of free acid



## Advantages of ammonium nitrate

- \* It's inexpensive
- \* High in (N) nitrogen (82%)
- \* Easy to handle with right equipment

## Disadvantages of Ammonium Sulphate

- \* Create high levels of acidity in soil
- \* It is low in nitrogen content relative to ammonium nitrate, which elevates transportation costs.

## Uses of Ammonium Sulphate

Ammonium Sulphate is used on a small scale in the preparation of other ammonium salts, especially ammonium persulfate.

Ammonium Sulphate has also been used in flame retardant compositions acting much like diammonium phosphate

## Reference !

1. Rogers Reserve maes

research ✓

2. Wikipedia free

encyclopedia // Ammonium

Sulphate

3. e-How.com ✓

4. WWW.eduxite.com / Kbase /

advantage 3 disadvantages

002

# APPENDIX J

## RUBRIC FOR RESEARCH PROJECT

<b>Abstract</b>	No abstract included or not appropriate <b>0 - 1</b>	Research concept stated clearly. Conclusion present <b>2 - 3 marks</b>	Findings are summarized. Fewer than 2000 words. Conclusion present <b>4 marks</b>	Research concept clear. Findings summarized. Conclusion present. Fewer than 2000 words. <b>5 marks</b>	Abstract of very high standard and quality, lacking nothing. <b>6 marks</b>
<b>Title page</b>	No title page <b>0</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>	Title, author's name, date present. <b>1 mark</b>
<b>Introduction</b>	Not included, inappropriate <b>0 - 1</b>	Research question is given, argument sequence is mapped out. <b>2 - 3 marks</b>	Research question is given, clear, argument sequence is mapped out. <b>4 - 5 marks</b>	Research question clearly answered, clear why research is being carried out, argument sequence	

20/40

## **APPENDIX P**

### **SIGNED LETTERS OF PERMISSION FROM PRINCIPALS AND DISTRICT OFFICE**



LETTER OF PERMISSION FROM THE DEPARTMENT OF EDUCATION (DISTRICT OFFICE)

To whom it may concern:

I am a student at the University of South Africa. At present I am enrolled for a Master's degree in Education specialising in Natural Science Education.

To fulfil the requirements of this degree, I need to carry out a research. I am carrying out a research on the impact of enrichment programs on the performance of gifted Science learners in grade eleven (11) and would therefore need co-operation of your learners, principals and teachers in the district. I would be prepared to share the requirements for my research project with you and, if you would like me to, I will give you feedback on the research I would have carried out.

Thank you very much for helping me reach my goal- it is valuable to me as a teacher to be able to take responsibility for my own professional development and to contribute to the development of various aspects of the cognitive life of the gifted learners in South Africa.

You are welcome to contact my supervisor, Dr. A.T. Motlhabane through telephone on 012 429 2840 or email him at [motlhat@unisa.ac.za](mailto:motlhat@unisa.ac.za).

Yours faithfully

ERASMOS CHARAMBA

UNISA STUDENT NUMBER 481 66413



LETTER OF PERMISSION FROM THE PRINCIPAL

To Whom It May Concern:

I am a student at the University of South Africa. At present, I am enrolled for a Masters degree in Education specializing in Natural Science Education.

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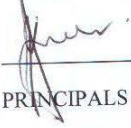
Thank you very much for helping me research my goal- it is valuable to me as an educator to be able to take responsibility for my own professional development and to contribute to the development of various aspects of the cognitive life of the gifted students in South African schools.

You are welcome to contact my supervisor, Dr A.T. Motlhabane through telephone on 012 429 2840 or email him at [motlhat@unisa.ac.za](mailto:motlhat@unisa.ac.za).

Yours faithfully

  
ERASMOS CHARAMBA

UNISA STUDENT NUMBER 48166413

  
PRINCIPALS SIGNATURE

  
DATE

VAAL CHRISTIAN SCHOOL  
PO. BOX 2435  
VEREENIGING 1930  
TEL: 016 457 2010/1  
FAX: 016 457 2013

LETTER OF PERMISSION FROM THE PRINCIPAL

To Whom It May Concern:

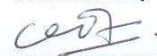
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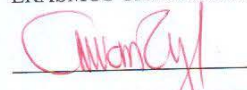
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Yours faithfully

  
ERASMOS CHARAMBA

  
PRINCIPALS SIGNATURE

UNISA STUDENT NUMBER 48166413

7/09/2013

DATE



## **APPENDIX Q**

### **LANGUAGE CLEARANCE CERTIFICATE**



25 Maple Crescent  
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3610

Phone 031 - 7075912  
0823757722  
Fax 031 - 7110458  
E-mail:  
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***Dr Saths Govender***

---

18 OCTOBER 2013

THE EXAMINING PANEL

### LANGUAGE CLEARANCE CERTIFICATE

This serves to inform that I have read the final version of the dissertation titled:

'The impact of enrichment programmes on the performance of gifted Science learners'  
by Erasmios Charamba.

To the best of my knowledge, all the proposed amendments have been effected and the work is free of spelling and grammatical errors. I am of the view that the quality of language used meets generally accepted academic standards.

Yours faithfully



DR S. GOVENDER  
B Paed. (Arts), B.A. (Hons), B Ed.  
Cambridge Certificate for English Medium Teachers  
MPA, D Admin.