THE PREVALENCE OF DYSCALCULIA AMONG MATHEMATICS BRIDGING COURSE
STUDENTS AT THE UNITED COLLEGE OF EDUCATION IN BULAWAYO

BY

MERCY JULIET MAVESERE
(B1129229)

SUPERVISOR: DR. D. MAKONDO

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## RELEASE FORM

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SUPERVISOR(S)

PROGRAMME COORDINATOR

EXTERNAL EXAMINER

EXTERNAL EXAMINER

DATE

iv
DECLARATION

I, Mercy Juliet Mavesere declare that this project is my original work and affirm that it has not been submitted to this or any other University in support of any application for a degree or any other qualifications.

Signed.............................................................Date...................................................

Witness........................................................Date......................................................

Supervisor

I,........................................................................declare that I have supervised this thesis and am satisfied that it can be submitted to the faculty of Science Education of Bindura University of Science Education.

Date.......................................................... ..............................................

Signature.............................................................................
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DEDICATION

I dedicate this project to my son Tanaka Leonard Mavesere.
ABSTRACT

This study focused on the prevalence of dyscalculia among the Bridging Course (BC) students at the United College of Education. The escalating number of students who supplement Mathematics at the college prompted the researcher to carry out this study. The study focused on warning signs, forms and behavioural patterns of dyscalculia among the participants identified dyscalculic. The study was carried out among fifty-two of the five hundred BC students who were randomly selected. The researcher used a mixed method through diagnostic tests, interviews and non-participant observations. The findings of the study were that an estimated prevalence of 7.69% of the BC students are prone to dyscalculia. The warning signs of dyscalculia among the students under study were failure to apply facts, rules, formulae and procedures, poor retrieval of addition, subtraction, multiplication and division and failure to reflect upon their thinking. The forms discovered among the BC dyscalculic students were automatisation, linguistic, procedural, metacognitive and attentional difficulties. The behavioural patterns observed among the participants were mathophobia, helplessness, avoidance strategies, use of immature strategies when solving Mathematics problems. The researcher hopes that the findings will be of help to curriculum developers, educationists, adult students struggling to learn mathematics and parents of children with mathematics learning difficulties. The researcher recommends on the use of different senses in the learning of Mathematics in order to learn for understanding. Students should be aware of their strengths and weaknesses in Mathematics and teachers should be aware of each student’s specific difficulties in the learning of Mathematics so as to give appropriate assistance to the learners. This study has looked into dyscalculia, combining both developmental dyscalculia and pseudo-dyscalculia. Anyone who finds this study of interest might look into developmental dyscalculia and pseudo-dyscalculia separately in a different setting altogether, or they may investigate on the intervention strategies which can be applied in developing nations, such as Zimbabwe, where computer games cannot be afforded by most learners on improving their math skills.
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CHAPTER I

1.0 THE PROBLEM AND ITS SETTING

1.1 Introduction

Since 2010, United College of Education (UCE) has embarked on a Bridging Course (BC) programme to assist supplementing Ordinary Level students acquire the required five Ordinary Level passes, including mathematics and English, which are a prerequisite into the Diploma in Teacher Education programme. The BC students are taken through an intensive supplementary programme and then re-sit the Zimbabwe School Examinations Council (ZIMSEC) examinations in June or/and November of the same year (S. Ndou, Human Resources Officer, UCE, personal communication, 23 January 2013). Since the advent of the BC programme at UCE, the highest number of students is enrolled for Mathematics compared to the other five subjects (English, Commerce, Geography, Ndebele and Science) offered by the college for this programme. The table below shows the statistics of the enrolment of BC students for the subjects offered at UCE from 2010 to 2013.

Table 1.1: Statistics of BC students enrolled at UCE for Ordinary Level Mathematics and other subjects from 2010 to 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Examination</th>
<th>Mathematics students</th>
<th>Total number of students in the other five (5) subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>June</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>74</td>
<td>20</td>
</tr>
<tr>
<td>2011</td>
<td>June</td>
<td>53</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>76</td>
<td>44</td>
</tr>
<tr>
<td>2012</td>
<td>June</td>
<td>209</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>168</td>
<td>48</td>
</tr>
<tr>
<td>2013</td>
<td>June</td>
<td>500</td>
<td>113</td>
</tr>
</tbody>
</table>

(Source: D. Marecha, BC coordinator, UCE, personal communication, 24 January, 2013)
This ever increasing number of students who supplement in Mathematics has prompted the researcher to carry out this study. There are cases of students under this programme who have obtained a grade D or worse in Mathematics for more than three sittings (Marecha, D., BC coordinator, UCE, personal communication, 24 January, 2013). Such failure in Ordinary Level Mathematics by the BC students could be attributed to Mathematics difficulties/disabilities. This research, therefore sought to find out whether there are Mathematics BC students at UCE who are prone to mathematics disabilities, namely dyscalculia.

According to Annandale (2012), Butterworth (2004), Geary (2006) and Goldman (2010), dyscalculic people face difficulties in mathematics but performed well in other areas of learning. Approximately nine-tenths of the Mathematics bridging course students at UCE have the other four subjects except for Mathematics. About two per cent of the students even possess good advanced level examination results (Marecha D, BC coordinator, UCE, personal communication, 24 January 2013).

Such a scenario, where the large number of students are supplementing in Mathematics at UCE under the BC programme, has motivated the researcher to carry out this study.

1.2 Definition of key terms

1.2.1 Prevalence refers to occurrence or frequency of something

1.2.2 Mathematics

Pacey (2010:13) defines Mathematics as “the science dealing with quantities, forms, space, etc and their relationship using numbers and symbols, the mathematical operations or processes used in a particular problem, discipline, etc.” Mathematics is, therefore, the manipulation of ideas that happen to be represented in numbers. In line with this definition, the word Mathematics, in this study means a subject which consists of calculations. Its focus is on studying of patterns and relationships between objects or ideas. In this study, Mathematics will be referred to as Math.

1.2.3 Dyscalculia

Adler (2001) and Boosey (n.d.) speak of four types of difficulties in Mathematics, namely, acalculia, dyscalculia, difficulties with Mathematics generally and pseudo-dyscalculia. This study focused on dyscalculia and pseudo-dyscalculia, which, according to Adler (2000), can be similar in appearance.
Pseudo-dyscalculia (secondary dyscalculia) is “a condition which develops in a person due to early experiences of failure in Math and it is caused by emotions. Such students become so convinced that they are not at all good at Math and this is strengthened by each failure they experience in the subject (Adler, 2000 and Doyle, 2010).

Dyscalculia (primary dyscalculia), on the other hand, is referred to by different names by different authors. What seems to be common in the definition of dyscalculia is that it is a condition that affects one from acquiring specific arithmetical skills (Adler, 2009, Annandale, 2013, Butterworth, 2004 and Shalev, 2004). However, the National Centre for Learning Disability (NCLD) (2006para 1) has this to say, “Dyscalculia is a term referring to a wide range of life-long learning disabilities involving math. For the purpose of this study, the term dyscalculia will be used referring to a difficulty in arithmetical skills as suggested by Adler. The term dyscalculia will be used when referring to both pseudo-dyscalculia and developmental dyscalculia since the researcher was not studying the causes of the disability and there is a thin line between the two conditions (Adler,2001).

1.2.4 Bridging Course programme
The University of Technology in Sydney (UTS) (2011para1) defines bridging courses as “short intensive courses designed for high school students entering tertiary study. It is for students who…. may not meet the assumed knowledge requirements.” Thus, in this current study, a bridging course programme is usually a six month programme (January to June and then June to November) in colleges which primarily assists students supplementing Ordinary Level Mathematics, English and other subjects in order to meet the entry requirements for the Diploma in Teacher Education Course.

1.3 Statement of the problem
Most BC students at UCE fail Mathematics at Ordinary Level because they are dyscalculic.

1.4 Aim of the study
The aim of this study was to establish the prevalence of dyscalculia among the BC students at UCE.
1.5 Objectives
The objectives of this study were to;

- identify the warning signs of dyscalculia prevalent among the Mathematics BC students at UCE,
- find the behaviour patterns which can be observed among the dyscalculic Mathematics BC students at UCE,
- establish the forms/subtypes of dyscalculia prevalent among the BC students at UCE, provide insights to Mathematics educators on how dyscalculia can be dealt with in the teaching and learning of Mathematics, and
- suggest intervention strategies to remedy the situation.

1.6 Research sub-questions
The study sought to answer the following sub-questions:

- What are the warning signs of dyscalculia prevalent among the Mathematics BC students at UCE?
- What are the subtypes/forms of dyscalculia prevalent among the BC students at UCE?
- What behaviour patterns are prevalent among the dyscalculic BC students at UCE?

1.7 Hypotheses

- H₀: Dyscalculia does not play a significant role in failing of Mathematics at Ordinary Level at UCE.
- Hₐ: Dyscalculia plays a significant role in failing of Mathematics at Ordinary Level at UCE.

1.8 Significance of the study
The researcher assumes that the following people will find the findings of this study of help to them. Mathematics teachers may be aware of the warning signs of dyscalculia so as to assist students at an earlier stage. Mathematics lecturers in teachers’ colleges may also find the research findings important such that they may equip student teachers with the relevant knowledge and skills concerning dyscalculia. The curriculum developers may as well find the study significant to them such that they may develop remedial packages appropriate for dyscalculic students in both primary and secondary
education. Parents may also be assisted in identifying whether their children have any warning signs of dyscalculia and behaviour patterns of dyscalculic children in order to help such children with the relevant resources and emotional support and also refer them to specialists at an early stage. The findings of the study may as well benefit dyscalculic students on how they can deal with their condition so as to overcome it and pass.

1.9 Assumptions
It is the researcher’s assumption that UCE BC students had written Ordinary Level Mathematics once or more.

1.10 Delimitations of the study
The study was carried out among fifty-two randomly selected participants from the five hundred bridging course students learning mathematics at UCE in Bulawayo.

The study focused on establishing the prevalence of dyscalculia among the mathematics BC students at UCE. The study sought to identify the warning signs of dyscalculia and behavior patterns of dyscalculics among the selected population. It also intended to find out the different forms of dyscalculia among the math BC students at UCE.

1.11 Limitations to the study
The researcher had problems in accessing a standardized test. However, she finally used the Wide Range Achievement Test-2 (WRAT-2) from the United States America used under the Performance Lag Address Programme (PLAP) (2011) which sought to identify students who are performing two years or more behind their peers. It was most appropriate to study all the Math BC students in all colleges in Zimbabwe, but this was found obviously not feasible due to time and financial constraints.
1.12 Summary
This chapter focused on the nature of the problem to be studied. The study focused on the prevalence of dyscalculia among Mathematics BC students at UCE. The researcher was prompted to carry out this study due to the escalating number of students supplementing Mathematics at UCE since 2010 and some of the students keep on failing the subject. The research sought to establish the warning signs, behaviour patterns and the different forms of dyscalculia prevalent among the BC students at UCE. The study was carried out among fifty-two out of the five hundred Mathematics BC students at UCE. The next chapter will give an overview of other related literature to this study, which is based on the sub-questions of the study.
CHAPTER II

2.0 REVIEW OF RELATED LITERATURE

2.1 Introduction
The significance of this chapter is to refer to some literature and some studies carried in different parts of the world concerning dyscalculia. The theoretical framework of the pedagogy of dyscalculia will be discussed. This literature gave the researcher an insight of the gap of knowledge of the subject at hand and on how the current study can be carried out.

2.2 The Theoretical framework on how to teach dyscalculic students

2.2.1 Definition of a theoretical framework
Sinclair (2007:39) defines a theoretical framework as a map or travel plan. “When planning a journey in unfamiliar country, people seek as much knowledge as possible about the best way to travel, using previous experience and the accounts of others who have been on similar trips. ‘Survival advice’ and ‘top tips’ enable them to ascertain the abilities, expectations and equipment that may help them to have a successful journey with good outcomes, to achieve their objectives and return to base safely.” Thus, the theoretical framework of this study assisted the researcher to map the way forward on how to carry out the study and was based on how the student with Mathematics learning difficulties can be assisted to perform his/her best.

2.2.2 The importance of Mathematics
In order for one to be good at numeracy it requires a firm base as suggested by Butterworth (cited in Boosey, n.d.). Adler (2000), Geary (2004), Craig (2009) and Goldman (2010c) suggest that mastery of basic arithmetic is crucial to later competence in more complex mathematical operations such as long division, fractions, geometry, calculus and so on. Thus, one needs to be proficient and efficient in Math. Proficiency helps one to retrieve correct answers from long-term memory, whereas efficiency is important as it assists one to join the parts of a problem and come up with the solution before the other parts are forgotten (Goldman, 2010c). Wilson (2012) is of the opinion that dyscalculia limits academic and career possibilities for children and adults as well as affecting everyday life (for example management of finances).
Ansari & Karmiloff-Smith (2002) and Doyle (2010) view mathematical skills as being fundamental to independent living and say that poor numeracy affects educational opportunities, employment opportunities and one’s socio-economic status. In addition to this Butterworth, Varma & Laurillard (2003:1049) refer to a report published by The Basic Skills Agency showing that “poor numeracy is a bigger handicap to getting a job, keeping a job than poor literacy.” Thus, if one has poor numeracy it “can mean the employee will transport the wrong number of goods, or fail to ensure that the correct payment has been received or paid out, and these can cost their company serious money”.

2.2.3 How to teach Mathematics to dyscalculic students

Reid & Hresko (1981) point out that students with learning disabilities lack understanding of their world and how to learn from that world because of the way they are taught. The Mathematics Video Instructional Development Source (MathVIDS) (2013) says that learners facing problems in learning Math spend most of their math time learning and practicing computation procedures at the expense of learning for understanding. Thus, in most instances instructional emphasis for students with Math learning difficulties is often placed on procedural accuracy rather than on conceptual understanding. This calls for learning which helps the dyscalculic student to both understand and master what s/he learns.

According to Lerner (1981:360) the learning of mathematics is based on two contrasting theories, namely, the stimulus-response theory and the hypothesis testing theory. Lerner (1981:363) further suggests that both the stimulus-response approach and the hypothesis-testing theory approach should be applied when teaching dyscalculic learners. The stimulus-response approach is more appropriate for the teaching of mathematics calculation skills, whilst the hypothesis-testing theory is more suitable in the teaching of mathematics reasoning.

The stimulus-response theory was developed by Skinner (Lerner, 1981). Generally the sequence considered in this theory is stimulation, response and reward. The assumption is that structure; over learning, reinforcement and drill are the important elements in the learning of Mathematics (Lerner, 1981:364). In support of this theory, Chinhanu (1997:21) cites Marx saying, “Practice is the basis of the cognition process...knowledge can only be truly attained in man’s relation to his environment.”
Chinhanu adds that concrete material and concrete situations (stimulus) can be used to construct mathematical concepts before they are analyzed. This helps to accommodate late developers. This means that practice, over learning and drill help the dyscalculic learner develop an understanding of Math. Muzawazi and Nkoma (2011:10) emphasize the use of praises; “Praise should be generously given on any signs of change in a positive direction e.g. improved speed in a child who is usually laborious and slow in everything s/he does.”

Lerner (1981) explains the stimulus-response approach as a teacher-centred approach whereby the teacher/instructor determines what is to be learnt and then designs a programme which stimulates the learner to learn the desired knowledge which will then be rewarded by the teacher. In line with this, Waco, Temple and Killeen (2011) allude that dyscalculia can be a lifelong liability if it's misdiagnosed, unrecognized by teachers or not properly treated and thus advocate for specialized teaching that strengthens the processing of numbers using concrete materials, such as beads and counters, supported by game-like software for learners. Butterworth (2004:101) is of the view that it is important not to go on to more advanced concepts until the basics have been mastered. Thus, teachers should make sure that students understand what they're doing before the teachers start drilling number facts. “Going over the same thing again and again gets information from short-term memory into long-term memory,…”

On the other hand, the hypothesis-testing learning was initiated by Suchman (Lerner, 1981) and is a highly active process. This theory has come up with the inquiry method, discovery learning and the problem-solving techniques in the learning of Mathematics. Students are taught in a way that makes them develop cognitive and thinking skills. The student is the source of initiative and structure (Lerner, 1981:362). In support of this theory, Reid and Hresko (1981:310) advocate for the ‘back to basics’ movement which substitutes rote learning with problem solving. They consider Mathematics as “not only a body of knowledge, but also a process of inquiry.” Reid and Hresko (1981:52) assert that for a student to succeed s/he should be able to “make observations, organize information, specialize and generalize, express mathematical ideas and prove conjectures. Problem solving strategies span the content areas and allow children the freedom to explore on their own, without restrictive bonds to adults or others who know the ‘process.’ In addition to this Muzawazi and Nkoma (2011:7) say teachers should use “a child-centred approach and the child determines what needs to be learnt, how it should be learnt and at what
speed or rate.” Muzawazi and Nkoma emphasize the use of all senses, i.e. touch, sight, taste, smell and hearing. They further state that the principle of the new approach to learning Mathematics recognizes “the importance of play, experimentation and a sense of discovery in learning,” and active involvement and perceived successes motivate learners. On the same note, Butterworth (2007:34) suggests that “The nature of mathematics is that you can come to the right answer in many different ways. Encouraging different approaches to the same problem helps students grasp this idea. Using a range of examples is also important because numbers are abstract…. Using numbers in a variety of contexts helps students understand the abstract nature of the number concept.” Thus, the hypothesis-testing theory allows flexibility on how the child learns Mathematics.

**Diagram 2.1: A merge of Skinner’s stimulus-response theory and Suchman’s hypothesis-testing theory in the teaching and learning of mathematics.**

The diagram demonstrates how Skinner’s stimulus response theory and Suchman’s hypothesis-testing theory can be merged in the teaching of mathematics.
2.3 The Prevalence of dyscalculia

2.3.1 Studies in the United Kingdom (UK)

The estimates on the prevalence of dyscalculia are so varied that one cannot really claim to be sure of the actual figure of occurrence. Cases in point are studies carried out by Badian (1983) and Kosc (1974) in the United Kingdom (UK) who put the prevalence at 6% to 7%. The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) cited in Butterworth (2003) put the estimate on the prevalence of dyscalculia at somewhere between 3.4 per cent and 10 per cent. Butterworth (2003:3) further pinpoints that, “between 2 million and 5.8 million people in the UK suffer from a problem that interferes with daily living and academic achievement.”

In other studies in the UK by Butterworth, Varma & Laurillard (2011) and Waco, Temple and Killeen (2011) estimated a prevalence of about 5 to 7% and this was almost the same as what Butterworth (2004) discovered among 6-14 year old children that the estimates were at about 5% to 6% of children of average to superior intelligence but have specific learning deficits in mathematics. Radford (2003) purports that dyscalculia afflicts about one child in 20 in Britain and could make them cases for special treatment.

Still another estimate in the UK is at 3% to 6% of the population (Badian, 1999; Butterworth, 2001; Goldman, 2010c and Wilson, 2012). Goldman believes that this prevalence is uniform across all countries. Wilson (2012 para4) is of the opinion that “The percentage of the population suffering from developmental dyscalculia is difficult to establish, because of the different criteria used for diagnosis.”

Butterworth (2004:3) admits that, “We are not really sure (of the prevalence of dyscalculia). Using discrepancy criteria, estimates vary between 3 percent and 6 percent.”

The Inside Out London (2013), in the Hackney Community College identified the prevalence at 5% to 6% as anticipated by Butterworth (2003). The findings correlated with what the Head of mathematics at Hackney College already knew. He had said that around 1 in 20 students (about 5%) need help with numbers.
2.3.2 Studies in the United States of America (USA)

In his study at Missouri University in the United States of America (USA), Geary (2006) found an estimated prevalence of 3% to 8%. Geary, (2006:648) however, added that “the finding that 3% to 8% of children who have dyscalculia is misleading in some respects. This is because most of these children have specific deficits in one or a few areas, but often perform at grade level or better in other areas.” Christie (2011:5) says that one out of every five people in America is said to be struggling with dyscalculia. “Out of the total number, around three million are children between the ages of 6 and 21.” Christie’s estimate covers adults too, unlike the other estimates which were much concerned with the school-going age only.

2.3.3 Studies in the Middle East

Gross-Tsur, Manor, & Shalev (1996) in Jerusalem put the prevalence at 6% to 7%. Shalev, Auerbach, Manor & Gross-Tsur (2000) conducted a study to confirm the prevalence of 3-6% already published in Jerusalem. They established that dyscalculia is a stable learning disability persisting in about half of the affected children. Rubinsten and Tannock’s (2010) estimate in Israel is at 3.5% to 6.5% of the school-age population.

Doyle (2010) asserts that worldwide studies estimate the prevalence of dyscalculia within the range 3% to 11%. However, she admits that there is no formalized method of the assessment of dyscalculia and the figures depends on how one interprets his or her findings.

These estimates are based on different settings and the researcher intended to find out whether the same situation applied to the population currently under study. The current study focused on people within the age groups of fifteen years up to fifty years. Thus, this study aimed at establishing the prevalence of dyscalculia among Mathematics BC learners at UCE.

2.4 The Diagnosis of dyscalculia

Different researchers use different criteria to diagnose dyscalculia among learners. Craig (2009) and Flinter (1979) observed that dyscalculia is not a difficulty that is commonly diagnosed. To add on to this, Geary (2003) and Shalev (2008) point out that measures that are specifically designed to diagnose Mathematical Learning Disabilities are not available.
Logsdon (2013) suggests that schools can determine if a child has a learning disability in Mathematics by identifying the types of errors each individual child makes. He adds that teachers can also use general types of diagnostic Mathematics assessments, review of students’ work and cognitive assessments. Therefore, in this study the researcher used two tests, interviews and observations in order to diagnose students who are prone to dyscalculia.

NCLD (2006) in the UK recommends on interviewing about a full range of math-related skills and behaviors in order to diagnose for dyscalculia. NCLD add that written tests and an evaluation help in the detection of dyscalculia. Thus, in this current study, the researcher used tests, interviews and observations to evaluate students for learning disabilities.

The other suggestion on how to diagnose dyscalculia is the use of computer-based assessment tools online developed in the UK. There are the ‘Dyscalculia Screener’, which was developed by Butterworth (2003) and the ‘DyscalculiUM’, which is a product of the Mathematics Education Centre at Loughborough University. Whilst the ‘DyscalculiUM’ is typically for adults, the ‘Dyscalculia Screener’ caters for children from 6 to 14 years of age. Inside Out London (2013) used The ‘Dyscalculia Screener’ to Hackney Community College to test for dyscalculia to 31 students aged 14 and 21 and of all abilities. Their findings concurred with Butterworth (2003) that an estimate of 3% to 6% of the London community is dyscalculic.

According to Geary (2003), most researchers rely on standardized achievement tests often in combination with measures of intelligence (IQ). For instance, in their study in the US, Geary (2003) and Geary, Hamson & Hoard (2000), used a standardized test to detect for dyscalculia. Geary (2003:7) considered the individual score of the students in comparison to the whole class so as to classify one to be dyscalculic. For instance, “a score lower than the 20th or 25th percentile on a mathematics achievement test combined with a low-average or higher IQ score are typical criteria for diagnosing MLD(mathematics Learning disability).” Although Butterworth (2011) is of the view that standardized tests are so diverse that the meaning of math achievement may vary between the different tests, Wilson (2012) observed that although methods of diagnosing dyscalculia differ widely, in general they all include an identification of a difficulty in mathematics that affects academic or everyday life. Thus, use
of standardized tests in diagnosing dyscalculia was found by the researcher as the most feasible and appropriate way.

In UK, Wilson, Revkin, Cohen, Cohen, and Dehaene (2006) suggest that assessment of developmental symptoms should examine number sense impairment; both symbolic and non-symbolic tasks (e.g. comparison, estimation or approximate addition of dot arrays). However, this study focused mainly on symbolic tasks.

Geary (1993), in the US, established that the identification of a math difficulty should be considered if one continues to encounter these difficulties at secondary level and beyond, since difficulties with Mathematics in the primary school are not uncommon. Therefore, the researcher wants to establish the math difficulties faced by students who have surpassed both the primary and secondary levels of education.

Gross-Tsur, Manor, & Shalev (1996), Shalev (2008) and Shalev, Auerbach, Manor & Gross-Tsur (2000), in their different studies in Jerusalem, used standardized tests to evaluate the students who had math learning problems. Shalev et al established that dyscalculia is a stable learning disability persisting in about half of the affected children. On the other end, Shalev (2008) and Shalev & von Aster (2008) emphasize that, how best to obtain and validate the criteria and measures necessary to diagnose dyscalculia is still a matter of controversy since the diagnostic instruments used are varied. However, Shalev suggests on the use of a test which taps knowledge on arithmetic facts and procedures, and also basic number-processing skills. She further suggests that if such a wide ranging test is not available, then more than one test should be used. Thus in this study, although a standardized test was available the researcher used a second test so as to validate the findings.

Some types of standardized tests used in assessing dyscalculic people in the United Kingdom are the Wechler Individual Achievement Test (WIAT-II UK), the Test of Mathematical Abilities-Second Edition (TOMA-2), the Wide Range Achievement Test 4 (WRAT), the Mathematics competency Test and the Neuropsychological Test Battery (Doyle, 2010 and Von Aster, 2001). Alloway, Rajendran & Archibald (2009) used the Automated Working Memory Assessment (AWMA) in his study with 200
children aged 5 years. If one looks at such varied type of tests one wonders how dyscalculia can be of
definite forms whatsoever. This makes it difficult to answer Wilson’s (2012) questions which read,
“Which tests should be used to show difficulty in mathematics, and where should the cut-off point be?
How should other factors be ruled out, and which other factors should be ruled out?” In addition to this,
Mussolin (2010:82) purports that, “A major concern in research on mathematical disabilities is the
heterogeneity in criteria and tests for assigning children to the category.” Thus, the criteria used to
diagnose dyscalculia are so varied, but the researcher of this study used a WRAT-2 to diagnose students
with dyscalculia among her sample of fifty-two BC students at UCE in Bulawayo.

Koumoula, Tsironi, Stamouli, Bardani, Siapati, Annika, Kafantaris, Charalambidou, Dellatolas and Von
Aster (2004) tested a sample population of 240 children in Greece using the Neuropsychological Test
Battery for Number Processing and Calculation in Children. Koumoula et al’s criteria for dyscalculiawas
a score of less than 1.5 standard deviation from the mean and they identified an estimate of 6.3% of the
sample. Von Aster and Shalev (2007) used a similar criteria and obtained an incidence of 6% among a
sample population of 337 Swiss children. These assessments were carried out among children, whereas
the current study focused on adult learners. In this current study, the researcher used the Wide Range
Achievement Test-2, which was developed in the United States of America and was used by Siegel &
Ryan (1989) to diagnose students with dyscalculia (Mussolin, 2010). The researcher then considered
students with a score of less than 1.5 standard deviations below the mean as dyscalculic.

Ayo, Kelechi and Abiodun (2013) carried out a correlational survey study in Ibadan, Nigeria among 477
primary school pupils within the age range of eight to twelve and in Grades 4 and 5. It was on
examining the prevalence of dyslexia and dyscalculia among persons with academic deficits in
mathematics in Ibadan metropolis public primary schools. They used the Mathematical Abilities Test
(MAT). They discovered that dyscalculia was not peculiar to any gender and concluded that persons
with academic deficits in mathematics should be screened for dyscalculia. Also, they should be taught
according to a carefully developed Individualized Education Plan.

It seems studies on dyscalculia were carried out in other countries such as the United States of America
(USA), the United Kingdom (UK), Greece, Jerusalem, Nigeria, to mention but a few. It seems little; if
any, studies on this issue have been carried out in Zimbabwe, and none has been conducted among mathematics BC students at UCE who are the prime focus of this study.

### 2.5 The Warning signs of dyscalculia in adults

Ember (2004) and Kenyon (2000) advise teachers and parents to take note of the different warning signs of dyscalculia so as to realize students with mathematics disabilities in their classes. In this study the signs of dyscalculia were determined by the way students present their written work in mathematics. The written documents assisted the researcher identify the thinking patterns among students. Thus, the warning signs of dyscalculia were observed through writing the standardized test and the other test. The researcher was only concerned about the warning signs of dyscalculia which were related with the items in the tests. This section; therefore, will describe some of the signs of dyscalculia which are related to the current study.

#### 2.5.1 Difficulties in acquiring arithmetical skills

To begin with, Butterworth (2001) define dyscalculia as a condition a child is born with that affects the ability to acquire the usual arithmetical skills. Butterworth, Varma & Laurillard (2011), Boosey (n.d.), Butterworth (2003), Doyle (2010), Goldman (2010c), Landerl, Bevan & Butterworth (2004), Logsdon (2013), Kenyon (2000) and Shirey (2013) add that dyscalculics operate at or above average in other subjects but demonstrate difficulties in math particularly in anything associated with number. In relation to this, the NCLD (2006:3) observes that “if basic math facts are not mastered, many teenagers and adults with dyscalculia may have trouble moving on to more advanced math applications.” NCLD (2006) suggests that since mathematics disabilities are varied, the signs and symptoms that a person may exhibit are varied as well.

In her case study in UK on a dyscalculic adult, Doyle (2010:6) narrated one of the dyscalculics’ personal and detailed description of the dyscalculic experience as,

“For as long as I can remember, numbers have not been my friend. Words are easy as there can be only so many permutations of letters to make sense. Words do not suddenly divide, fractionalise, have remainders or turn into complete gibberish because if they do, they are gibberish. Even treating
numbers like words don’t work because they make even less sense. Of course numbers have sequences and patterns but I can’t see them. Numbers are slippery.

The above contention clearly shows that dyscalculics encounter severe difficulties in working with numbers.

Teachers and parents often identify signs of dyscalculia in an achievement test (The Australian Teacher, 2011). Because these students have no sense of number (Hamilton-Newman, 2010), they tend to get low scores in achievement tests. Some of the causes of low performance are described below.

2.5.2 Difficulties in understanding math vocabulary

Henderson in Ireland (2012) state that some dyscalculic students struggle to read and understand the vocabulary of math questions, and; therefore they do not understand what they are asked to do. For example, add, increase, plus, total are different words which describe the same action. Interpretation of math symbols is another attribute which shows the inability of dyscalculic students to understand the math language (Annandale, 2012, Doyle, 2010 and NCLD, 2006). For instance, one may confuse the greater than and the smaller than signs which results in incorrect answers. The math vocabulary inhibits dyscalculic students from comprehending mathematical word problems, trouble using a calculator, doing operations backward and making mistakes when reading, writing, or recalling numbers (Genden, 2010).

2.5.3 Difficulties in remembering math facts and procedures

Ember (2004), Mazzocco, Feigenson and Halberda (2011), Henderson (2012) and Price (2013) posit that poor memory is another source of mathematics disabilities. Poor memory results in students facing difficulty remembering mathematics facts, concepts, rules, formulas, sequences, and procedures (Kenyon, 2000). Wilson, Revkin1, Cohen, Cohen & Dehaene (2006) add that if teachers want to test students’ capacity on memory, “performance in simple arithmetical calculation such as subtraction and division would be a more sensitive measure, as addition and multiplication is more open to compensatory strategies such as adding or counting on, and memorization of facts and sequences.” Butterworth, Varma & Laurillard in London (2011) and Henderson in Ireland (2012) point out that math is very sequential and for one to complete a math task s/he must follow a strict sequence. A case in point is the division of mixed numbers as a process which requires following a strict sequence. Thus,
one should be able to convert mixed numbers to improper fractions, and then remember to invert the divisor. One should also be good at division and multiplication so as to determine the answer. In agreement with this, Geary (2003) suggests that poor working memory resources affect execution of calculation procedures and learning arithmetical facts.

2.5.4 Inability to calculate accurately
Apart from poor mastery of number facts and inability to calculate fluently, Mabbott and Bisanz (2008) claim that dyscalculics have slow ability to use backup procedures. In addition to this, Koontz and Berch (1996) found that dyscalculic children under-perform on both ‘forward and backward digit span’ tasks. In line with this, dyscalculic students experience difficulties with orientation and direction and this can lead to confusion of math symbols (Annandale, 2011; Ember, 2004; Henderson, 2012; Reid & Hresko, 1981 and Tajar & Sharifi, 2011). This leads to not remembering the order of operations they must follow to solve a mathematics problem. Logdson (2013para4) adds that “Because they (dyscalculic learners) do not understand mathematics concepts, they do not remember and cannot build on them to master more complex problems.”

Logdson’s (2013) finding is in contrast to The London Broadcasting Company (2011) which says dyscalculics don't reverse the order of numbers when reading them. Butterworth (2001) in London, purports that, "Typically, dyscalculics don't have problems with the order of symbols, but anything with numbers could cause anxiety or even panic," thus, the researcher intends to establish whether dyscalculic students at UCE confuse the order of digits.

2.5.5 Other signs and symptoms of dyscalculia
Pacey (2010) describes the signs of dyscalculia precisely as tending to be inaccurate, to lose their place in a column of numbers or lengthy calculations. She also suggests that dyscalculic students become easily confused about which column to start (left for division or right for addition), or to identify the relationship between rows; for example, in subtraction, which one should be taken from the other; the top or bottom row. They also tend to forget and change the type of operation they are carrying out, tend to lay their work poorly and form the digits carelessly, so they are more than usually likely to lose their place or be working out the wrong numbers of the sum altogether. Ember (2004), Reid & Hresko (1981)
add that dyscalculic students may have trouble in lining up numbers on paper. They can easily forget the
times tables repeatedly throughout their school career. For all these mean they tend to come up with the
wrong answers. The researcher intends to look for all the above signs and symptoms of dyscalculia.

In line with this, Kaufmann (2002) carried out a case study in Austria on an adolescent who exhibited
outstanding difficulties in retrieving arithmetic facts which were pronounced on multiplication and
division problems. The researcher seeks to establish whether BC students at UCE also face difficulties in
retrieving arithmetic facts, which is a warning sign of dyscalculia.

NCLD (2006) and Gernett (cited in Kenyon, 2000) describe the signs and symptoms of dyscalculia in
teenagers and adults as difficulties in learning mathematics concepts beyond the basic facts, for
instance, facing troubles in counting and calculating rapidly, using counting strategies which are slow,
facing difficulties in learning mathematics vocabulary, trouble with mental mathematics, difficulties in
finding different approaches to one problem and poor ability to estimate costs or measures. The NCLD
adds that if any of the problems stated above persists over time then the learner is prone to dyscalculia.

Doyle (2010) carried out a number of case studies among dyscalculic students at The Eureka Centre
hosted by the University of Loughborough. The Eureka Centre is specifically for students who are not
confident with Mathematics and statistics. She conducted the study over three consecutive years; 2008,
2009 and 2010, among different participants. One of the dyscalculic students confessed that the
condition affected his/her academic potential primarily in math. Another student admitted that, apart
from mathematics where the effect is severe, it also impacts on any subject that involves counting. The
other student expressed the difficulties s/he faced when working with numbers and the negative thrust
the difficulties have on his entire life. The student could follow math methods step by step but needed to
practice over and over again. The student found it extremely difficult to calculate and learn
multiplication tables, common sequences, telephone numbers and anything to do with number.

Chan, Au & Tang (2013), in their study in Hong Kong, used an experimental method comparing normal
children, and developmental dyscalculic children. The purpose of the study was to identify the different
reasons why the Chinese children struggled with math. They tested on symbolic and non-symbolic tasks.
Their observations were that children with developmental dyscalculia perform poorly in non-symbolic
tasks but not in symbolic tasks. Chan et al. suggested that developmental dyscalculia is a distinct deficit in non-symbolic processing.

In another related longitudinal study carried out in Jerusalem to one hundred and forty dyscalculic pupils at the ages 10-11 and then 13-14, Shalev, Manor & Gross-Tsur (2001) observed that the pupils’ performance was poor in arithmetic work. When they re-examined their participants at 16-17 (when the participants were finishing high school), Shalev and colleagues observed that 51% of the dyscalculic students could not multiply 7 by 8, 71% could not solve 37 x 24, 49% could not solve 45 x 3 and 69% could still not add fractions. Shalev and colleagues’ study further revealed that the errors of students with developmental dyscalculia typically include inattention to the mathematical operators, use of wrong signs, forgetting to carry over and misplacement of digits. Thus, the aim of this current study is to establish whether BC learners at UCE encounter persistent problems similar to those observed by Shavel and colleagues.

The aforementioned difficulties in the learning of math were observed on populations different from the one under study. Therefore, in this study the researcher looked for any of these signs and symptoms of dyscalculia among the BC learners at UCE to determine forms of dyscalculia in the context of Zimbabwe.

Therefore the researcher intends to find out whether such situations also exist among the BC student at UCE.

2.6 The subtypes of dyscalculia
NCLD (2007) assert that disabilities involving math can be so different, and the effects they have on a person's development can be just as different. For instance, a person who has trouble processing language will face different challenges in math than a person who has difficulty with visual-spatial relationships. Another person with trouble remembering facts and keeping a sequence of steps in order will have yet a different set of math-related challenges to overcome. Different authors provide different subtypes of dyscalculia. However, NCLD observe that the features of the different subtypes of dyscalculia seem to be the same but given different names by different researchers.
A study conducted by Zhang (2007) in China based on the subtypes of developmental dyscalculia in pupils from Grades 1-4. His sample was made up of 54 children from 3 different schools. He discovered that there were four subtypes of developmental dyscalculia in pupils from Grades 1-4, namely, auditory, visual, analogue and audio-analog. He also observed that these children’s deficits were varied in number processing and calculation abilities.

2.6.1 Automatisation difficulties
This form of difficulty is given different names by different authors. For example, it is termed automatisation difficulties by Adler (2001), mathematical difficulties by Annandale (2011), semantic memory subtype by Geary (2007) and memory difficulties by Christie (2011), MathVIDS (2013) and Rosselli, Matute, Pinto & Ardila (2006). They all describe this subtype as the inability to retrieve simple math facts. According to Adler, automatisation difficulties are characterized by the student often requiring a long time to carry out even simple arithmetic tasks. Adler (2001), Butterworth (2004) and Geary (2007) point out that students with this problem often count on their fingers until far into the upper levels of education. Geary (2007) adds that students with semantic memory problems have a high error rate on the facts retrieved. Annandale (2011) and MathVIDS (2013) observed that such students, apart from failure to carry out simple addition, subtraction, multiplication and division, they face difficulties in solving multi-step problems.

In an experimental study conducted by Geary (2004) at the University of Missouri, US, he discovered that children with mathematical learning disabilities show persistent deficits in some areas of arithmetic and counting knowledge. Many of these children have an immature understanding of certain counting principles and, with respect to arithmetic, use problem-solving procedures that are more commonly used by younger, typically achieving children. They also frequently commit procedural errors. Geary also observed that procedural skills involving simple arithmetic improve over the course of the elementary school years, and thus, the early deficit may not be due to a permanent cognitive disability, but difficulties of retrieving basic arithmetic facts is a deficit that often does not improve.

In another setting, Butterworth (2003) also carried out a case study in London on Charles, a 31-year old dyscalculic who had attained a degree in psychology. Charles confessed that he had struggled to enter
into university for he had failed ‘GCSE’ math, a prerequisite for entry. Butterworth discovered that Charles was hardworking and intelligent but he had a severe handicap of poor number skills. Butterworth observed that Charles used his fingers when adding or multiplying and he was unable to do written arithmetic problems such as 37-19. Charles also used his fingers to tell whether 9 was bigger or smaller than 3.

2.6.2 Linguistic difficulties

Another subtype of dyscalculia is the language processing problem. Flinter (1979), Kenyon (2000), Montis (2000), NCLD, (2006) and Shirey, 2013). Adler (2000) and Annandale (2012) refer to it as linguistic difficulties. People with such a difficulty find it hard to get a grasp of the vocabulary of math, which makes it difficult to build on math knowledge. Linguistic difficulties can manifest themselves in difficulties in understanding numbers as concepts (NCLD, 2006). Annandale (2011) describes linguistic difficulties as failing to understand mathematical terms and convert from narrative to algebraic form. Emerson (2009) puts it as “Such difficulty means that the world of numbers is sufficiently foreign that learning the ‘language of Mathematics’ in itself becomes akin to learning a foreign language.” Dowker (2009:7) adds that, “Language difficulties can affect children’s ability to understand and make use of instruction, and their ability to encode and represent mathematical information. It also affects their ability to reflect on their own difficulties and work out useful strategies…”. It is the intention of this study to find out BC students at UCE fail to understand the mathematical language as observed by other researchers.

2.6.3 Visual spatial difficulties

The other form of dyscalculia is visuospatial, which Geary (2007) describes as difficulties in spatially representing numerical and other forms of mathematical information and relationships, frequent misinterpretation or misunderstanding of spatially represented information. Christie (2011), Dowker (2009), NCLD (2006) and Shirey (2013) observed that visual spatial processing difficulties make it hard for dyscalculic students to visualize patterns, different parts of a mathematics problem or identify critical information needed to solve equations and more complex problems. Adler (2000p9) asserts that “Dyscalculia may also be based on problems in visual perception that lead to facing difficulties at tasks involving logical thinking as well as in carrying out computations.”
Genden (2010 para 5) describes visual difficulties as difficulties, which involve visual perceptual problems, reversals and substitutions e.g. 3/E or +/x, problems copying from a sheet, board, calculator or screen, problems copying from line to line, losing the place in multi-step calculations substituting names that begin with the same letter, e.g. integer/integral, diagram/diameter, problems following steps in a mathematical process, problems keeping track of what is being asked, problems remembering what different signs/symbols mean and problems remembering formulae or theorems.

Trott at Loughborough University (2009) and Annandale in South Africa (2011) refer to this subtype of dyscalculia as perceptual subtype whereby the person encounters difficulties in recognizing and understand symbols and other groups of numbers.

2.6.4 Metacognitive difficulties

Another subtype of dyscalculia is metacognition (MathVIDS, 2013), which is described as the inability of dyscalculic students to monitor their learning, that is, evaluating and employing strategies when need be, knowing whether a strategy is successful and making changes when needed. In connection to this Adler (2001:11) talks of planning difficulties which comprise failure to “carry out computations effectively, that is, one may have difficulties in following a clear strategy in solving arithmetic problems, losing track of one is at, sticking to strategies that are dysfunctional and fail to work out, or giving up on strategies that are correct and becoming passive.” MathVIDS (2013 para 11) allude that, “Because math is problem solving, students who are not metacognitively adept will have great difficulty being successful with mathematics. These students need to be explicitly taught how to be metacognitive learners.” Geary’s (2004) procedural subtype seems to be related to the metacognitive or planning subtype. He explains it as when the learner frequently use “developmentally immature procedures (i.e., the use of procedures that are more commonly used by younger, typically achieving children), frequent errors in the execution of procedures, poor understanding of the concepts underlying procedural use and difficulties sequencing the multiple steps in complex procedures.” The current study sought to establish whether the BC students found dyscalculic any metacognitive difficulties.
2.6.5 Attentional difficulties

Annandale (2011) and MathVIDS (2013) include attentional subtype, which consists of failing to copy figures correctly and observe figures correctly (Annandale, 2011). MathVIDS purport that students with attention problems might have missed important piece of information when learning a concept which makes it difficult to implement the problem solving just learnt. They gave an example of long division; “students may miss the "subtract" step in the "divide, multiply, subtract, bring down" long division process. Without subtracting in the proper place, the student will be unable to solve long division problems accurately.” Thus, math requires a great deal of attention, particularly when multi-steps are involved in the problem solving process.

Rosenberger cited in Goldman (2010b) conducted an experimental study among 102 children in London, using a written test and a questionnaire. He intended to find whether there is a relationship between low achievement in math and attentional deficits. Seventy-two children qualified as dyscalculic, and thirty qualified as dyslexic. The groups were highly comparable in overall scholastic aptitude; in fact, only the arithmetic score could distinguish the two groups. He found out that the factor of inattention was higher among the dyscalculics than that of dyslexias. He then concluded that specific underachievement in math is a result of inattention and automatisation of number facts becomes difficult from early grades. Christie (2011), Lerner (1981), Montis (2000) and Xu (2005) posit that each learner is unique; therefore, the form(s) of dyscalculia in each learner is unique to that particular learner. In line with this, Kenyon (2000) pinpoints that “Mathematics learning disabilities do not often occur with clarity and simplicity. Rather they can be a combination of difficulties which may include language processing problems, visual spatial confusion, memory and sequencing difficulties.” Wilson (2012) sees the different varieties of the subtypes of dyscalculia being caused by the different tests used by the researcher in diagnosing dyscalculia. Thus, the purpose of this study is to find out whether BC students identified as dyscalculic, face difficulties in specific areas of Mathematics.

2.7 The behaviour patterns of dyscalculic students

In this study, the researcher made a distinction between warning signs and behaviour patterns of dyscalculia although they seem to be treated the same by a number of authors (Annandale, 2012 in South Africa; Butterworth, 2004 in UK; Butterworth, Varma& Laurillard, 2011 in UK; Geary, 2004 in
USA; Logsdon, 2013). In this study, behaviour patterns of dyscalculic students are more aligned to behavioural tendencies which can be easily identified during the learning process.

2.7.1 Lack of confidence

Butterworth (2001), Henderson (2012) and MathVIDS (2013) state one of the behaviours displayed by dyscalculic students as lack of confidence when dealing with math, which is caused by their inability to operate math problems. MathVIDS (2013) says, “Students who experience continuous failure in math expect to fail. Their lack of confidence compels them to rely on assistance from others to complete tasks such as worksheets.” Lack of confidence among dyscalculic students make the students passive, to the extent that they fail to connect what they already know with what they are confronted with so as to quickly come up with an answer. For example, if they know that 6x4=24, they then struggle to get 6x5 rather than simply adding a 6 to 24 to get 30. On the same note, Boosey (n.d.) believes that just because they lack confidence, dyscalculic students practice avoidance strategies often manifesting in behavior issues and helplessness. She gives an example of avoiding “group/partner work and if put in the situation they will rely totally on others for answers.” To add onto this, Butterworth (2001) states that dyscalculic students present their work untidily, or one may consider presentation of work more important than the calculations. Ember (2004) alludes that lack of confidence results in fear of mathematics, hence failure of math. He adds that these students may believe they cannot do math at all.

It is the purpose of this study to establish such patterns of behaviour do exist among the BC students at UCE.

2.7.2 Mathophobia

Chinn (2008), Pacey (2010) and MathVIDS (2013) identified that anxiety about handling numbers breeds among students with math learning difficulties because of failure to work with numbers meaningfully. Wilson (2012para 3) defines math anxiety as “the feeling of tension and fear that some children and adults experience, and which is often specifically associated with mathematical activity.” Butterworth, Varma & Laurillard (2011), in their study, observed that dyscalculic learners exhibit dislike of or anxiety towards math, or avoidance behaviours. Geary (2006) is of the opinion that dyscalculia is very likely to eventually result in frustration, avoidance and potentially excess anxiety when having to solve math problems. He adds that any such anxiety will be in addition to the underlying cognitive deficit.
and will almost certainly make the learning of mathematics even more difficult. However, Geary (2006) and Wilson (2012) admit that very little research has been done on the association between math anxiety and dyscalculia. At the other end, Butterworth carried out a focus group study with dyscalculic children and discovered that dyscalculia may increase the chances of anxiety. In addition to this, Ma and Xu's (2004) findings on dyscalculic learners suggest that children with dyscalculia may find daily math lessons “a source of huge anxiety, as they try to understand what their mates find obvious.”

Boosey (n.d.) conducted individual case studies at St. Alban High school in the UK, on 6 pupils who had been initially identified dyscalculic. She collected data from the history of the learning of each pupil to date, made summative assessments, individual Education Plans, conducted interviews and gave them a short informal test. All the 6 identified pupils said math was their least favourite subject and 5 of them found math the most difficult. None of the 6 had ever played card games. Of the 6 identified, one was confident in knowing the times tables, the other 5 claimed that they were confident in some (2, 5 and 10). The results clearly show math anxiety among the 6 pupils.

In the US, Rubinsten and Tannock (2008) conducted an experimental survey among 12 dyscalculic and 11 non-dyscalculic children to investigate on the effects of math anxiety on numerical processing in children with dyscalculia. The children were to complete an arithmetic equation with false or true responses. Rubinsten and Tannock observed that students with dyscalculia responded faster to equations that were preceded by both math-related and negative primes. The results showed the researchers that there is a direct link between emotions, arithmetic and low achievement in math. Thus, in this study, the researcher intended to identify whether the identified dyscalculic students suffer from mathophobia.

### 2.7.3 Slowness and use of immature strategies

The other characteristic displayed by dyscalculic learners is slowness in math. Butterworth (2004), Butterworth, Varma & Laurillard (2011) and Ember (2004), Price (2013) and ScienceDaily (2011) observed that dyscalculic students are significantly slower on addition, subtraction, and multiplication than their peers for they depend much more on immature strategies, such as counting on their fingers, or verbal counting (Flinter, 1979 and Geary, 2004) to solve problems. “The dyscalculic learners tend to commit more errors as they might miscount when using these immature strategies,” (Geary and Hoard,
On the same note, Annandale (2011) considers dyscalculic students as slow and inaccurate in their calculations. However, Geary (2006:3) has this to say, “Generally, one can fail to diagnose dyscalculia when only accuracy is considered, since percent correct will not reveal whether the subject is using immature strategies like counting in addition.” This means that some dyscalculic learners can be very proficient as they work with numbers but they take a long time to finish a task because of the procedural strategies they will be using. Therefore, this researcher found it necessary to observe the BC students as they learnt and wrote tests so as to identify factors such as use of immature strategies.

Dyscalculia in adult learners was observed by Trott and Drew (2011) in their ethnographic case study to higher education learners within the age range 20 to 50 at Loughborough University, London. The learners had been identified dyscalculic at childhood. Trott and Drew established that the dyscalculic students’ problems such as counting using fingers, lacking number sense of numerosity above 1000 and failing to divide persisted up to higher education. This study sought to find out whether there were BC students at UCE facing similar problems purported above.

Although Muzawazi and Nkoma’s (2011) study did not focus on dyscalculia per se, they observed that there were pupils in both primary and secondary education who struggle with math. Muzawazi and Nkoma (2011), in their study among primary and secondary school pupils at Sakubva Primary School and Dangamvura High School in Mutare, observed that in Zimbabwean education system, high teacher pupil ratio makes it difficult to individualise the learning process fully, so some pupils suffer from math difficulties. This research; therefore, intended to find out if the same situation obtains in adults who are learning Ordinary Level mathematics at UCE.

2.7.4 Other behaviours

Other characteristics of dyscalculia include failure to complete a math task in a noisy classroom which can be done by their normal peers with a minimal distraction (Goldman, 2010c). The NCLD (2006) adds that dyscalculic learners may be vulnerable where teachers follow an interactive whole-class method of teaching. They also feel frustrated and embarrassed when asked a very simple question in public. Therefore, the study aims at finding out whether BC students have the same characteristics when learning mathematics.
All these studies were carried out among children, teens or adults in countries, such as the US, the UK and such other countries. This study was carried out among math BC students in Bulawayo, Zimbabwe so as to establish whether the behaviour patterns observed among different subjects in different settings apply to this group as well.

2.9 Summary
This chapter gave an overview of literature which is in line with the current study. This study is based on the theories of Skinner (1968), the stimulus-response theory and that of Suchman (1960), the hypothesis-testing theory. Thus the appropriate methodology for teaching the dyscalculic student is to combine both the teacher-centred and the student-centred approaches. The prevalence of dyscalculia is estimated between 3% to 11%, according to different studies carried out in different countries. The warning signs of dyscalculia manifest themselves in failing to carry out simple arithmetic operations, failure to apply the proper rules, procedures and formulae, not understanding the language of math, failure to solve problems which involve multiple steps. The behavioral tendencies of dyscalculic people is use of immature strategies when solving mathematical problems, suffering from math anxiety, relying on others when working in groups, helplessness and such like behaviours. There are varying subtypes of dyscalculia, such as procedural, automatisation, linguistic and visual-spatial difficulties.
CHAPTER III

3.0 RESEARCH DESIGN

3.1 Introduction
According to Kerlinger (1986:279), “A research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems.” This chapter, therefore, described the plan or programme of this research. The study was both qualitative and quantitative. The researcher used a standardized test and two other tests to validate the findings. Observations and interviews were also carried out in order to identify the characteristics of dyscalculia common among the math BC students at UCE.

3.2 Methodology
The study used a mixed approach. Spratt, Walker and Robinson (2004:14) assert that, “Primarily qualitative research seeks to understand and interpret the meaning of situations or events from the perspectives of the people involved and as understood by them.” Cresswell (2007) describes the major characteristic of qualitative research as gathering close information by actually talking directly to people and seeing them behave and act within their context. He adds that, in qualitative research, the researcher is the key instrument in collecting data through examining documents, observing behaviours, or interviewing participants. In this current study, the qualitative method enabled the researcher to observe characteristics of dyscalculia displayed by the math BC students at UCE. It also helped the researcher to establish the actual difficulties the students face when solving mathematical problems. Direct observations whilst the students were learning and writing tests enabled the researcher to study the phenomena in their natural setting, whilst interviews enabled the researcher to dig deeper into problems faced by the students as they learn mathematics.

Spratt, Walker & Robinson(2004) explain quantitative research as putting emphasis on measurement when collecting and analysing data. Spratt,Walker and Robinson put it as, “Quantitative research is defined, not just by its use of numerical measures but also that it generally follows a natural science model of the research process measurement to establish objective knowledge (that is, knowledge that exists independently of the views and values of the people involved),”(2004:13). Thus, quantitative
methodologies, in the form of diagnostic tests, assisted the researcher to establish the prevalence of the warning signs and the different forms of dyscalculia among the BC students at UCE.

3.3 Population

Nachmias and Nachmias (1996) view a population as the aggregate of all cases that conform to some designated set of specifications. In the same vein, Babbie (2005:144) defines a population as “…..the theoretically specified aggregation of study elements.” This means that the population refers to the sum of all the elements under study. In this case, the population of the study was all the BC students who were learning math at UCE in January to June of 2013. Thus, the population of the study was the five hundred (500) mathematics BC students at UCE in Bulawayo.

3.4 Sampling

Bailey (1987) defines a sample as a sub-set of the total population. He adds that a sample should be as representative as is possible of the population from which it is drawn. According to Adler (2001), dyscalculia cuts across all ranges of student abilities; therefore a sample of fifty-six students was selected through simple random sampling. There were seven classes for the mathematics BC programme at UCE. The researcher put small papers with either a ‘yes’ or a ‘no’ in seven different small boxes (i.e. a box for each of the seven classes). Each box had eight papers with a ‘yes’. The researcher herself went around the classes letting all the students in each and every class to pick a card from their box. The eight students who picked a ‘yes’ in each class were selected for the sample to be studied. However, for ethical considerations, students who were not willing to participate were allowed to withdraw. Fortunately, initially, all those who picked a ‘yes’ were very much willing to participate. However, after taking the standardized test, four of the participants dropped out, which dropped the sample to fifty-two. A total of fifty-two (52) from the five hundred BC students made up the sample. This made up a sample of more than 10% of the population which the researcher considers as a suitable representation of the mathematics BC students at UCE.

3.5 Data collection procedures

A survey was carried out among the selected sample. Diagnostic tests, observations and interviews were the instruments used in order to provide the researcher with valid and reliable data. Instruments were
triangulated as a way of validating the research findings. Details on how each of the instruments was used are given below.

3.5.1 Diagnostic tests

According to Gay (1976:86), a test is “…a means of measuring the knowledge, skill, feeling, intelligence, or aptitude of an individual or group.” He further qualified a test as a data collection instrument which produces numerical scores which can be used to identify, classify, or evaluate test takers. In this study, the researcher found it appropriate to use tests since she intended to establish dyscalculic students among the BC students at UCE. Tests were seen as the best instruments in collecting the required data because they could clearly mirror the types of errors made by the students under study. It is from the pattern of errors that the researcher could identify the warning signs and subtypes of dyscalculia prevalent in the students under study.

The researcher managed to source a standardized test, the Wide Range Achievement Test-2 (WRAT-2), which was developed in the United States Of America (USA). The purpose of the test was to help teachers to establish the level of performance of each learner in Mathematics and their level of learning. Webster (n.d.) defines a standardised test as “a test (as of intelligence, achievement or personality) whose reliability has been established by obtaining an average score of a significantly large number of individuals for use as a standard of comparison.” The WRAT-2 also was used for secondary school pupils in Manicaland Province by Muzawazi and Nkoma (2011) under the Performance Lag Address Programme (PLAP). Considering that mathematics is a universal subject (Perkins & Flores, 2002), the researcher found the WRAT-2 from USA a suitable assessment tool since she failed to source any locally developed standardized test. According to Nag & Snowling (2012) standardized tests require theoretical expertise and large numbers of personnel such that many middle and low income countries are “nowhere near developing such tests.” Zimbabwe, being among those countries referred to by Nag and Snowling, the researcher could not get any standardized test from local psychologists and educationists. Gay (1976:86) says the advantage of standardized tests is that the items are well constructed in order to meet the required criteria. He adds objectivity as another advantage of these tests. He further alludes that the criteria for administering, scoring and interpreting the test is well defined. The researcher; therefore, considered the test very relevant since dyscalculic learners can be identified if
the person’s performance in a standardized test is two years or more less than that of their peers (Shalev, 2004 and DSM-IV, 2000).

Nag and Snowling (2012) and Adler (2001) suggest that, it is possible for teachers to devise short age-appropriate tasks to tap basic arithmetic facts; simple addition and subtraction, to identify students who are dyscalculic. The researcher, therefore, set an additional test as a way of validating the research findings. This is in agreement with Geary (1990), Geary, Brown & Samaranayake (1991) and Geary, Hamson & Hoard (2000) who say an achievement test can only be reliable and valid if the student persists scoring low in other achievement tests. The items in the teacher-made test were parallel to those in the standardized test so as to establish areas of difficulties in math for each student. A pilot test was conducted to members of the BC students at Hillside Teachers College in Bulawayo pursuing the same programme so as to test for the validity and reliability of the parallel test. The pilot study made the researcher aware of some ambiguous questions, which were then fine-tuned. It also informed the researcher what to type of she might expect from her participants.

This means that, in this study, students were given one standardized test and a teacher-devised test (parallel to the standardized test) during the same week. The participants were put in a single room for writing the tests. The researcher administered the two tests on two different days, that is, on a Monday and a Wednesday of the same week from ten o’clock in the morning to twelve noon. These days were chosen because that is when the mathematics BC students have their one-and-a-half hour lessons at two o’clock. The seating arrangement for the students was so spacious that no one could copy from the other. After writing each test, the researcher collected the answer scripts herself to ensure hundred percent feedback from the participants.

3.5.2 Observations
Four non-participant observations, with the assistance of video recordings, were made as the students learnt and interacted with their teachers. Non-participant observation is whereby the observer stands aloof (Cohen, Manion & Morrison, 2011). Thus the researcher was not participating in the learning process.
Although observations are time consuming, especially during the planning stage and may lead to personal bias if the observer does not agree with what s/he observes (White, 2000), the researcher found it the most appropriate way of collecting behaviour patterns of dyscalculic students as they learn. According to White (2000), observational research has the advantages that the researcher can do it by him/herself and it does not need expensive technology. In this study the researcher used her laptop to video record the proceedings by herself. White further suggests that observational research always works since there is always something to observe. At first when this researcher got into the first classroom she could not tell what she was exactly observing since what was taking place in the classroom was far from what the researcher had planned for; the lesson was all about the lecture method. Later on, playing the video on her own, the researcher could pick up some behavioural tendencies from the targeted participant. Thus, the researcher collected first hand information in its natural setting and this made it easier to interpret the data (Cohen, Manion & Morrison, 2011 and Nachmias & Nachmias, 1996). Nachmias & Nachmias (1996) and Cohen, Manion & Morrison (2011) add that observations can reveal behaviour patterns which the informants may not be aware of and are unable to fully describe. This means that observations have an advantage of being naturalistic.

Since the students were aware that they were being observed and video recorded, they seemed shy to participate at the beginning, but they later on relaxed as the lessons progressed. The observations were focused on the four participants who had shown some signs of dyscalculia in the standardized test and one other subsequent test. The observations assisted the researcher identify the behaviour patterns (such as slowness when calculating, use of fingers as an aid for computations, being frustrated when called, avoidance strategies and such like behaviours) displayed by dyscalculic students when learning math.

3.5.3 Interviews

According to Wilson (2012) dyscalculia can be tested in students by interviewing them about a full range of mathematics related skills and behaviours. Cohen, Manion & Morrison (2011) define an interview as a two-person conversation initiated by the interviewer for the specific purpose of obtaining relevant information about the research. In this study, the researcher used interviews in order to obtain information on how the interviewee got specific answers in the tests they wrote and also to gather information on how the student calculates and feels about math. This is in agreement with White’s
view that “face-to-face interviews can clear up any misunderstandings.” The researcher carried out semi-structured interviews through the use of an interview schedule which allowed a guided discussion in the process. The interviews were based on the observations made from the marked tests. Interviews were also used as a way of determining some behaviour patterns of the participants considered dyscalculic. The interview consisted of oral mathematics questions as well, such as multiplication bonds. All the interviews were tape recorded so as to help the researcher to replay the interviews and analyse accurate proceedings.

3.6 Data analysis
Data were quantitatively and qualitatively analysed. Quantitative data were got from the two tests, whilst qualitative information was analyzed from the tests, interviews and observations.

3.6.1 Qualitative data analysis
The behavioural tendencies of dyscalculic students observed by the researcher through interviews and non-participant observations, with the assistance of video recordings, were thematically described. The researcher used the narrative approach where possible so as to give a clear picture of what transpired during the interviews and observations in connection with the behavioural tendencies of the dyscalculic students.

3.6.2 Quantitative data analysis
The tests were thematically analysed in order to find the signs of dyscalculia and the different forms of dyscalculia prevalent among the BC students learning mathematics at UCE. The prevalence of each of the learning difficulties was tabulated. The mean on the performance of the whole sample was calculated and the standard deviation of each of the scores was obtained. Students with 1.5 standard deviations below the mean were considered dyscalculic as suggested by Doyle (2010) Koumola et al (2004). The prevalence of the different warning signs of dyscalculia from each test was obtained from the four students who qualified to be dyscalculic. The averaged prevalence of each warning sign was then expressed in percentage. The different forms of dyscalculia prevalent among the four students were tabulated per individual. This was then presented on a column graph. The prevalence of the subtypes of dyscalculia for the four students were then combined to get a general picture of the subtypes of
dyscalculia among the students under study. The averaged total of each subtype was expressed in percentage. A pie chart was then drawn to help in clarifying the prevalence of each of the subtypes of dyscalculia.

3.7 Summary

The study used a mixed method so as to get a deeper understanding of the subjects under study. The data were collected using interviews, observations and document analysis. The participants wrote three tests including a standardized test. Qualitative data was analyzed using the thematic approach. Graphs were drawn to represent quantitative data. The prevalence of different subtypes of dyscalculia was calculated. Students who were prone to dyscalculia were determined according to the criteria of 1.5 standard deviations below the mean as initiated by literature.

Chapter 4 gives the results of the findings from the diagnostic tests, non-participant observations and interviews. The first part of the chapter will focus on the prevalence of dyscalculia among the BC students at UCE. The other findings were based on the research sub-questions of the study.
CHAPTER IV

4.0 DATAPRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter focuses on the observations made by the researcher about the tendencies of dyscalculia among the BC students at UCE. The data will be presented according to the research sub-questions and hypotheses of the study. Data were collected using two tests in order to address the prevalence of dyscalculia, its warning signs and the different forms of dyscalculia among the BC students at UCE. The behavioural tendencies of the students when learning math in this study were captured through observations and interviews, and during the writing of the tests. The first part of the chapter described the criterion used by the researcher in identifying the students who might be dyscalculic and the prevalence of dyscalculia among the BC students at UCE.

4.2 The prevalence of dyscalculia among the BC students at UCE

Students were given 2 tests, one of which was a WRAT 2 standardized test developed in USA and used in the PLAP by Muzawazi & Nkoma (2011) in Manicaland Province in Zimbabwe. The second test was developed by the researcher herself following the same format as the WRAT 2. Students provided the working and the answers to the tests on the test scripts. Both test answer scripts for one participant were given the same coding. This helped the researcher to find the general performance of each participant, so as to validate the findings of the study. After marking both tests, the researcher, with the assistance of the Microsoft excel package, calculated the z-score of the averaged score for each participant.

To diagnose one as dyscalculic, the researcher considered those students with a deviation of less than or equal to 1.5 below the mean as developed by Koumoula et al. (2004) and Geary (2003) who suggest that most researchers compare individual scores to the performance of the whole class so as to classify one to be dyscalculic.

Using that criterion the researcher discovered that 4 out of 52 students, namely, Students B14, B16, B23 and B54, were prone to dyscalculia. This gives a percentage of 7.69, which is consistent with Doyle (2010) who puts the prevalence estimate between 3% and 11%, Butterworth (2007) who estimated a
prevalence of 3% to 8% and (DSM-IV) cited in Butterworth (2003) who put the estimate at somewhere between 3.4 per cent and 10 per cent. In view of the above, Table 2 below gives statistical data of the participants who met the criterion for the diagnosis of dyscalculia.

Table 4.1: Research participants who were considered dyscalculic

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Average</th>
<th>Class mean</th>
<th>Standard Deviation</th>
<th>z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 14</td>
<td>26%</td>
<td>29%</td>
<td>27.5%</td>
<td>52.08%</td>
<td>12.62</td>
<td>-1.95</td>
</tr>
<tr>
<td>B 16</td>
<td>30%</td>
<td>37%</td>
<td>33.5%</td>
<td>52.08%</td>
<td>12.62</td>
<td>-1.53</td>
</tr>
<tr>
<td>B 23</td>
<td>35%</td>
<td>31%</td>
<td>33%</td>
<td>52.08%</td>
<td>12.62</td>
<td>-1.51</td>
</tr>
<tr>
<td>B 54</td>
<td>29%</td>
<td>35%</td>
<td>32%</td>
<td>52.08%</td>
<td>12.62</td>
<td>-1.60</td>
</tr>
</tbody>
</table>

Using the results obtained in the diagnosis of dyscalculia, the researcher proceeds to make an analysis of her observations. The analysis will be based on the warning signs, behaviour patterns and different forms of dyscalculia identified among the four participants who are prospective candidates of dyscalculia.

4.3 The warning signs of dyscalculia among the BC students at UCE

During marking of the scripts, the researcher coded each type of difficulty a participant faced. She then focused on the papers of the four with the lowest z-scores since they met the criterion used by the researcher in identifying signs of dyscalculic students. The table below is a summary of the difficulties faced by the four participants.
Table 4.2: Summary of the warning signs of dyscalculia observed from the students’ test scripts.

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Test 1 (out of 54)</th>
<th>Test 2 (out of 52)</th>
<th>Averaged total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B14</td>
<td>B16</td>
<td>B23</td>
<td>B54</td>
</tr>
<tr>
<td>Change of signs</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subtraction of whole numbers</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Inattention</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Converting mixed numbers to improper fractions</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Addition of whole numbers</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Multiplication of whole numbers</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Failure to reflect upon own thinking</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Division of whole numbers</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Failure to understand what is asked for</td>
<td>2</td>
<td>11</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Failure to apply the correct rule, formula, or procedure</td>
<td>3</td>
<td>12</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Items left unanswered</td>
<td>29</td>
<td>11</td>
<td>12</td>
<td>23</td>
</tr>
</tbody>
</table>
The table consists of the prominent difficulties faced by the bottom four participants. The difficulties are arranged in ascending order. This means that the participants had less problems in change of signs. Subtraction, inattention, misalignment of numbers when computing and failure to converting fractions are second in the rank with a percentage rating of difficulty of 0.9%. Failure to apply the rules, formulae and procedures of mathematics proved to be the highest challenge at 17.9%.

To get the percentage of each difficulty, the researcher calculated the averaged score of each difficulty against the averaged total number of items. Thus, Paper 1 had 54 questions and Paper 2 had 52, and the averaged possible score of items was 53. Then, the percentage of each difficulty was determined by the formula $\frac{\text{the average frequency of each difficulty} \times 100}{53 \times 4}$.

(NCLD) (2006) and Garnett (cited in Kenyon, 2000) describe the signs and symptoms of dyscalculia in teenagers and adults as difficulties in learning mathematics concepts beyond the basic facts. This statement was proved to be true when two candidates, namely, B54 and B14 gave their answers for $9 \times 7$ as 56 and 72, respectively. Still, B54 failed to add 8 to 59 as well as to subtract 38 from 84. This shows that B54 faces many difficulties in learning basic arithmetic facts. Three of the four participants could not multiply 809 by 47. B14 worked it out as:

\[
\begin{array}{c}
809 \\
\times 47 \\
\hline
35,652
\end{array}
\]

Thus, the wrong answer was arrived at because of poor retrieval of multiplication facts when the student said $9 \times 7 = 72$. Shalev, Manor & Gross-Tsur (2001) also observed that at the age of 16-17 years, 71% of their dyscalculic participants could not multiply 39 by 24.
Student B14 added 229; 5048; 63 and 1381 and got 1021. She added it as,

\[ \begin{array}{c}
229 \\
5048 \\
63 \\
+ 1381 \\
\hline
1021 \\
\end{array} \]

Thus, she added digits which do not have the same value together. This was a result of misalignment of numbers as observed by Reid & Hresko (1981) when they say dyscalculic put numbers on paper. This student failed to reflect upon her silly seen that 5000 + 1000 is far much ahead of 1021. The got 12; this revealed inability to connect math problems to real life situations. The student attempted to convert mixed numbers to improper fractions but did it wrongly. The participant solved the problem as;

\[ \frac{21 + 3}{2} = \frac{26}{2} = 12. \]

\[ \text{Ans} = 12 \]

instead of just adding the whole numbers on their own and then add a \( \frac{1}{2} \) to a \( \frac{1}{2} \). This whole process was marred with errors, so a wrong answer was produced. This is one of the many cases students fail to reflect upon their thinking processes. Such a finding concurs with what Butterworth, Varma and Laurrillard (2011), Doyle (2010), Emerson (2009) and Pacey (2011) observed when they say that students with dyscalculia follow lengthy procedures when solving mathematical problems, consequently they get wrong answers.

It seems division is more problematic to the four participants as indicated on the table. Addition and subtraction consist of only 0.9% each, multiplication; 3.8%, whilst division comprises 8%,
which is a way above other computational skills. This finding is in line with what Wilson et al (2006) observed when they say if teachers want to test students' capacity on memory, performance in simple arithmetical calculation such as subtraction and division would be a more sensitive measure, as addition and multiplication is more open to compensatory strategies such as adding or counting on, and memorization of facts and sequences.

Division seemed to be problematic to the participants. On $\frac{9}{4527}$, all the four students got 53 rather than 503. Someone with an aptitude of math could have multiplied 53 by 9 to find out whether they would get 4527 (Adler, 2010). The students in question divided 9 into 45 and got a 5 and then divided 9 into 27 and got a 3. Such an error revealed that students do not reflect upon their thinking and they may not be linking what they get with reality. This finding agrees with MathVIDS (2013) when they say students with attention problems might have missed important piece of information when learning a concept which makes it difficult to implement the problem solving just learnt. They give an example of long division; "students may miss the "subtract" step in the "divide, multiply, subtract, bring down" long division process. Without subtracting in the proper place, the student will be unable to solve long division problems accurately." However, Geary (2004) suggests that procedural skills improve over the course of the elementary school years, but these students have way passed the childhood age, but they seem to make many procedural errors.

Another example is when Student B23 subtracted 349 from 928 as;

\[
\begin{align*}
928 & \\
-\ 349 & \\
\hline
\text{Ans} & = 581
\end{align*}
\]

Thus, the student subtracted 8 from 9 and got a one and then subtracted 4 from 12 and got an eight, which resulted on a wrong answer altogether. The student applied what is convenient to him though it was procedurally wrong. This finding is in line with what Pacey (2011) observed
when she says dyscalculic students fail to identify the relationship between rows; for example, in subtraction, which one should be taken from the other; the top or bottom row.

Students seemed to encounter difficulties in understanding the mathematical language in a number of cases. For example, the problem 'Subtract $7\frac{2}{3}$ from $10\frac{1}{4}$' was presented as '$7\frac{2}{3} - 10\frac{1}{4}$'. On the same question, B14 simplified it as

\[ \begin{align*}
\text{Ans:} & \quad \frac{28}{10} \\
\frac{28}{10} - \frac{40}{10} & = \frac{12}{10} \\
& = 1\frac{2}{5}
\end{align*} \]

She divided 3 into 23 and got 63.1 and 4 into 41, he obtained a 10, and then subtracted the two. Another problem of interpreting what was required was observed in the problem which required students to find the mean of the four given numbers; B23 arranged the numbers in order of their magnitude and then encircled the number which was in the middle. Thus, the student confused median for mean. Only one of the four attempted to answer $\log_{10} 5\sqrt{5}$. The problem of not understanding the language of math was also discovered by Annandale (2012), the Dyslexia Association of Ireland (2012), Doyle (2011) and the NCLD (2006). The math vocabulary inhibits dyscalculic students from comprehending mathematical word problems, trouble using a calculator, doing operations backward and making mistakes when reading, writing, or recalling numbers (Genden, 2010).

Another observation made is that BC students are not aware of the rules of math in solving multi-step problems. This is revealed by having all the four students failing to simplify $18 - 3 \times 11 + 50\div2$ and $4\frac{1}{8} \times 8 - 6 \times 3 \div 5$. Similar observations were made by Annandale (2012), Butterworth (2007), Goldman (2010c), NCLD (2006) and Trott and Drew (n.d.) when they say students with dyscalculia find it difficult to apply the correct rules, formulae and procedures in solving problems that require multi-step procedures. The problem on the determination of simple interest seemed to be something very new to the participants. One of the questions on that concept read ‘Find the simple interest on $12000 at 6% per annum for 70 days.’ B16 worked it as
instead of using the formula: \( \text{Interest} = \frac{PRT}{100} \). Such a working clearly shows that the student did not understand what was required by the question at all.

Goldman (2010c) alludes that;

*When a nonimpaired student is confronted with a straightforward arithmetic problem such as \( 5 + 11 + 37 \), the student can quickly identify the steps needed to solve the equation and move on to the next item on the worksheet. When a mathematically disabled student is confronted with the same problem, even after having learned and understood the fundamentals of counting and addition, each of the steps necessary to compute the answer takes up significantly more effort to complete. By the time the student moves on to the next item on the assignment, he has already expended a considerable amount of mental energy - significantly more than the first student has - and has likely taken more time to complete each problem. After the first three or four items, his or her energy store is perhaps depleted, and the rest of the worksheet is riddled with errors because the student has no mental energy left to tackle the subsequent calculations (para 11).*

This assertion seems to apply to students under study. A case in point is Student B23 who got all the first twelve problems of Test 1 correct. From there on he started to make a lot of silly mistakes, such as, exchanging digits in an answer; thus, he wrote 7621 instead of 6721. She failed to get any of the last fourteen problems correct and B14 left 29 and 21 items unanswered in Papers 1 and 2, respectively. The researcher collected from the participants during interviews that the student was too tired to work any more and he found the problems beyond his capacity.

Summarily, the researcher observed that among the BC students, there are some warning signs of dyscalculia, such as, failure to retrieve arithmetical computations easily, failure to apply
mathematical rules, formulae and procedures where appropriate, failure to interpret what a question wants and loss of concentration when responding to math problems, which results in making too many errors. Such observations were in agreement with literature cited above. Because of these observations, the researcher can safely say the above stated warning signs of dyscalculia exist among math BC students at UCE as already hypothesized.

### 4.4 The subtypes of dyscalculia observed among the BC students at UCE

According to Adler (2001:8), dyscalculia indicates “specific or special learning difficulties in mathematics. Students with specific difficulties do not have problems with all mathematics. Usually, though, their ability across the whole subject suffers,…Students with specific learning difficulties in mathematics obviously differ from those who display more general learning difficulties.” Therefore, the researcher wanted to find out whether the four students suffer from specific difficulties in math.

The researcher put the different difficulties she observed from the students’ scripts into five major groups, namely, automatisation/memory, language/linguistic, procedural, metacognition/planning and attentional difficulties. The researcher discovered that visuospatial difficulties are included in all the five categories. The researcher found it difficult to categorise some of the difficulties into either the linguistic or the procedural difficulty. For instance, in order to express 0.075 as a common fraction, B16 just put the answer as 7/5. This makes it difficult to say whether the student did not understand the question or that the student did not know how to go about it.
The graph below is a summary of the subtypes of dyscalculia which were observed among the BC students at UCE.

![Graph 1: Summary of the subtypes of dyscalculia per individual student](image)

**Fig: 4.1**

On this section, the research will discuss each of the four participants separately so as to establish the prevalence of the subtypes for different individuals.

B14 faced more challenges in language, procedural and memory difficulties as compared to the other three students. This is why the student left most of the problems unattended to. The student failed to add, divide and multiply numbers with more than one digit. For instance, on 890 x 4.7, the student worked it as, 35600+5380 = 40980. Firstly, the student did not understand where to put the 0 as a place holder when multiplying. Secondly, when the student multiplied 7 by 9, she got 48, and lastly the addition of the two numbers was wrong. An example of linguistic difficulty is when she gave the answer 5 centimetres as the number of centimetres in $1\frac{1}{2}$ metres. This was revealed during the interview. This was also noted by the NCLD (2006) and Garnett (cited in Kenyon, 2000) when they say that dyscalculic people have poor ability to estimate costs or measures. This student’s difficulties are more pronounced in linguistic skills. The student did not face any attentional difficulties, that is, on all the questions she attempted there were no silly mistakes, such as copying the wrong digit or exchanging the sign. Thus, B14 can be said to be dyscalculic mainly in the language, procedural and automatisation skills when solving mathematical problems.

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On the other hand, B16 suffers from the application of rules, formulae and procedures most. For instance when dividing 5 into 215, s/he worked it out as:

\[
\begin{array}{c}
5 \mid 215 \\
\underline{121} \\
\underline{5} \\
245
\end{array}
\]

Ans 121

and on Factorise \( r^2 + 25 - 10r \), the student solved it as:

\[
\begin{align*}
\frac{r^2 + 25 - 10r}{(r-5)(r+5)} + 25 \\
\frac{-10r}{15}
\end{align*}
\]

Ans 15

The two examples clearly show that the student did not know how to go about the problems. Linguistic difficulties were also discovered. People with such a difficulty find it hard to get a grasp of the vocabulary of math, which makes it difficult to build on math knowledge. This was also noted by Adler (2009), Annandale (2012), Kenyon (2000), NCLD (2006) and Shirey (2013).

As once observed by the researcher, it was very difficult to differentiate linguistic from procedural difficulties. An example is when responding to ‘If \( a = 7 \) and \( b = 3 \), what is the value of \( a^2 + 3b? \)’, Students B16 and B23 gave the answer as:

\[
\begin{align*}
\frac{a^2 + 3b}{7 + 3} & = \frac{49 + 9}{10} \\
& \approx \frac{58}{10} \\
& = 5.8 \\
\text{Ans} & \approx 8.2
\end{align*}
\]

Thus, the students could not interpret 3b, which was because of failing to understand the math language or not knowing what is to be done. Inattention was observed when B16 ignored the denominator after correctly adding or subtracting fractions. However, B16 had problems in all
areas of mathematics, but the difficulties are more pronounced in procedural and language deficits.

Although less frequently, B23 has more computational and linguistic difficulties than in the other subtypes of dyscalculia. On ‘1÷24’, the student gave the answer as $3\frac{28}{24}$. Such an answer makes one wonder whether the student had carefully thought about the question. On adding $4\frac{1}{3}$ to 3, the student obtained a 41, thus, s/he divided the denominator 3 into the whole number 3 and then wrote down the 4 and the 1 left after dividing, as the final answer. The student in question seems to have more of attentional difficulties than the other three. A good example is when s/he left out a 9 on simplifying $9+5048+36+4785$; his answer was 9869 instead of 9878. According to the findings, the student seems to have difficulties in all areas, but mostly in language processing and automatisation.

The last student, B54’s most difficulties involved metacognition, which is described by Adler (2001) Annandale (2012), Doyle (2010) and Geary (2004) as when dyscalculic students find math difficult because they fail to monitor their own thinking. For example, the student gave the answer for $95 \times 0.3$ as $28.5$, which shows that the student did not reflect upon thinking since money is expressed in dollars and cents. This same answer was not only given by these four students, but also by twenty-two other students from the entire group. Thus, both the able and those with learning difficulties failed to monitor their own thinking.

Overall, the BC students at UCE face different challenges in the learning of math, but language processing appears to be most problematic to all the students identified as dyscalculic. The table below is a summary of subtypes of dyscalculia among the BC students at UCE.

<table>
<thead>
<tr>
<th>Subtypes of dyscalculia</th>
<th>B16</th>
<th>B14</th>
<th>B23</th>
<th>B54</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic</td>
<td>10</td>
<td>18</td>
<td>12</td>
<td>11</td>
<td>52</td>
<td>25</td>
</tr>
<tr>
<td>Automatisation</td>
<td>7</td>
<td>15</td>
<td>9</td>
<td>10</td>
<td>41</td>
<td>19</td>
</tr>
<tr>
<td>Procedural</td>
<td>12</td>
<td>15</td>
<td>6</td>
<td>6</td>
<td>39</td>
<td>18</td>
</tr>
<tr>
<td>Metacognition</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>11</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>Attentional</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4.3: Summary on the prevalence of the subtypes of dyscalculia among the participants identified dyscalculic
Table 4.3 above shows that most students face linguistic difficulties as compared to other subtypes of dyscalculia. It should be noted that 25% of the questions were not answered by the students. The observation made by the researcher is that dyscalculic students leave questions unanswered when they fail to interpret the question. A case in point is the question ‘2 - _= ¼’. None of these four students attempted to answer it although it was among the first five questions. The graph below illustrates the prevalence of the subtypes of dyscalculia. For the graph to give a full picture of the difficulties the students face, the portion for unanswered questions has been included.

![Pie chart: The prevalence of subtypes of dyscalculia and the unanswered questions among the participants identified dyscalculic](image)

Fig: 4.2

4.4 The behaviour patterns prevalent among the dyscalculic students at UCE
The behaviour patterns of dyscalculic students were identified through observations and interviews. The researcher carried out four observations on the participants in their natural settings, that is, while they were learning in class. She interviewed four of them separately. Both the observations and the interviews were video recorded so as to make an analysis of the
observations later. However, little was observed in some classes from lesson observation since the BC students are on a crash programme. A programme which should normally last two years in normal schools is covered within four months in the BC programme, that is, from end of January to early June. Because of this, the lecture method is usually the order of the day. However, from the few observations carried out by the researcher some trends of dyscalculia were noted.

When the researcher administered the two tests, students exhibited a lot of anxiety. Anxiety was revealed when the students were asked to write the second test. The researcher had problems to lure those who had found the first test too tough for them to write the second one. Some students were even afraid of meeting the researcher in order not to be given another test. Out of the 56 students who wrote the first test, four of them did not come back to sit for the second test, which reduced the sample to 52. Thus, students were practicing avoidance strategies because of mathophobia, which was caused by the unpleasant experience they got from the first test. This observation concurs with earlier observations noted by Butterworth, Varma & Laurillard (2011) and Geary (2006) when they observed that dyscalculic learners exhibit dislike of or anxiety towards math, or avoidance behaviours.

In the didactic situation, another observation made was that Student B16 did not want to go to the chalkboard to demonstrate a certain point. The conversation below was between her and the teacher:

Teacher: How do we get the equation of a line when given these two points, (0;0) and (-1;2)?
B16 (not real name) come and work it out on the board.
B16: Iii, zvapaboardhandidi kana kumbozvinzwa, handisikuda. (I don’t want to go to the board at any cost) (voice raised and with eyes wide open).
Teacher: Alright, B16. Anyone to help her?

This observation concurs with the NCLD’s (2006) finding that dyscalculic learners may be vulnerable where teachers follow an interactive whole-class method of teaching. They also feel frustrated and embarrassed when asked a very simple question in public. Helplessness was also evidenced when Student B14 was tasked by her teacher to work out a problem on the chalkboard. The student was stuck with a chalk and a book in her hands, not
knowing what to write. When asked to work in groups, the same student was just seated on her own doing nothing at all. When the researcher probed her, she flatly shrugged in utter boredom and frustration. These observations match with what Boosey (n.d.) observed when she says that just because they lack confidence, dyscalculic students practice avoidance strategies often manifesting in behavior issues and helplessness. She gives an example of avoiding “group/partner work and if put in the situation they will rely totally on others for answers,” (p3).

In another class, the researcher observed Student B54 failing to get the correct value of $\frac{65\sin 59^\circ}{\sin 65^\circ}$ from a calculator. The teacher had to demonstrate over and over again when he observed that the student was totally confused. The trouble of using a calculator by dyscalculic students was also observed by Genden (2010).

The other observation made by the researcher was slowness among the BC students identified dyscalculic. A case in point is when the researcher asked a simple multiplication question during the interview; different responses given were:

**Interview 1**

*Interviewer:* What is the answer for $7 \times 6$?

*Interviewee:* It’s, hmmm... 42. *(got the answer after tapping on the desk with her pen for several times)*

*Interviewer:* Why were you tapping the table?

*Interviewee:* I know $7 \times 2$, so I was saying $14 + 7 = 21, 21 + 7 = 28, 28 + \ldots \ldots 35 + 7 = 42$.

**Interview 2**

*Interviewer:* What is the answer for $9 \times 7$?

*Interviewee:* 52

*Interviewer:* How did you get 52?

*Interviewee:* Ah, let me see *(started counting using his fingers)*, 63.

According to Goldman (2010c), dyscalculic students should be aware of their strengths and weaknesses in math so as to get assistance in the special area(s) the student is poor at. Unfortunately, Student B23 (the one interviewed above) seemed not aware of his weaknesses and seemed over-confident of his abilities in mathematical skills.
Interview 3

Interviewer: What is the answer for 9 x 7?
Interviewee: (staring upwards for some seconds and then counting using fingers) 63.

Interviewer: Why do you count your fingers?
Interviewee: It’s difficult to get the answers for larger numbers from the head. Thus, for the students to answer even a simple question, they take a lot of time using different strategies. The researcher also observed use of fingers or making strokes on a piece of paper, then counting them, or just staring upwards or in front for some minutes very common among the students. Two the students were audibly counting their fingers when they were writing the test. This was consistent with Geary’s (2004) observations that dyscalculic students can be heard verbally counting when computing numbers. The aforementioned examples showed the researcher that most students are not good at automatisation. Thus, such observations are in line with Butterworth (2004), Butterworth, Varma & Laurillard (2011) and Ember (2004), Price (2013) and ScienceDaily (2011) when they say one characteristic of dyscalculia is slowness due to the use of immature strategies like using their fingers when adding, subtracting, multiplying and dividing. However, in the current study, finger counting and such like strategies were common across the sample. Geary (2006) found out that some students can score very good marks in a test but using immature strategies, and in this study, one student who obtained an average mark of 58% was observed by the researcher during writing both tests making strokes on a paper to come up with the answers.

In short, the researcher established that students showed math anxiety by using avoidance strategies, such as refusing to demonstrate on the board, not participating in group work, avoiding the researcher, raising of the voice when asked a question and the like. Use of immature strategies, such as counting fingers, making strokes on paper when multiplying or verbally counting were also noted among the sample through interviews and direct observations.
4.5 Summary

The study revealed that among the BC students there are several warning signs of dyscalculia. The most prevalent being failure to understand what is required, followed by failure to apply the rule, formula or procedure to a problem. The major behaviour pattern of dyscalculic learners observed by the researcher in this study is high mathophobia, which manifests itself in being rude when asked to participate, avoiding group work, avoiding the researcher in fear of tests. Use of immature strategies was common among the identified participants since most of them used their fingers, glared upwards or audibly counted when solving a computational problem. Linguistic difficulties, procedural difficulties, automatisation difficulties, metacognitive difficulties and attentional difficulties were the subtypes of dyscalculia identified among the participants. An estimated prevalence of 7.69% was obtained by the researcher using the criteria of a standard deviation of less than or equal to 1.5 considering the averaged mark of each individual of the two tests. However, the students need further assessment which is to be carried out by a psychologist, a medical doctor and a neurologist. The other observation made was that students leave questions they find difficult unattended.

In the next chapter, the researcher made a summary of the whole study and drew up her own conclusions and recommendations of the study.
CHAPTER V

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction
In this chapter the researcher made a summary of what the study was all about and the findings made concerning the prevalence of dyscalculia among the BC students doing math at UCE. The researcher drew her own conclusions based on the results obtained in this study. Recommendations for further studies and for the educational practices will be made in line with the teaching of math.

5.2 Summary
The study aimed at investigating the prevalence of dyscalculia among the mathematics bridging course students at UCE. The researcher was prompted to carry out this study because of the escalating enrolment of math BC students at UCE. The study was carried out among a randomly selected sample of fifty-two participants out of the five hundred math BC students enrolled for 2013 June. Initially the sample comprised 56 participants but the other 4 dropped out on the way. The study used a mixed method paradigm in order to validate the findings. The researcher used a WRAT 2 standardized test from the USA used by PLAP and another test which was parallel to the standardized test. These tests were analysed so as to identify the difficulties BC students face when learning math. The difficulties were classified and presented on a table. The researcher observed that the difficulties faced by the learners were in agreement with the warning signs of dyscalculia from a wide range of literature. Interviews and observations assisted the researcher to identify the characteristics of dyscalculia displayed by the BC students under study. The researcher captured some videos during interviews and observations and this was poorly done since the researcher lacked expertise in using the laptop to record data. The researcher observed that students suffer from high math anxiety which was revealed through avoidance strategies, such as being rude, not participating in group-work and such like behaviours. The subtypes of dyscalculia identified comprised automatisation difficulties, linguistic difficulties, procedural difficulties and metacognitive difficulties. Another observation made was that students leave questions they find difficult unanswered. The researcher found a prevalence estimate of 7.69%, which is consistent with other researcher’s findings.
5.3 Conclusions
From the observations made, the researcher concluded that:

5.3.1 The signs and symptoms of dyscalculia include failure to apply facts, rules, formulae and procedures. Students also fail to interpret what is required by a mathematical problem. Because of this difficulty, students leave some questions unanswered. The other sign of dyscalculia is poor retrieval of addition, subtraction, multiplication and division. This problem causes students to perform poorly in their tests since their work will be marred with errors. Students do not reflect upon their thinking as well. This is revealed by some answers which are from reality in some instances. Similar signs and symptoms of dyscalculia were also noted by Adler (2001), Butterworth (2001), Pacey (2010, Shalev (2004) and many other researchers.

5.3.2 The subtypes of dyscalculia are automatisation, linguistic, procedural, metacognitive and attentional difficulties as noted by Adler (2001), Annandale (2012), Butterworth (2003) and many other researchers.

5.3.3 The behavior patterns of dyscalculia students include mathophobia (which is shown through practicing avoidance strategies), slowness, helplessness, use of immature strategies when solving Math problems, feeling embarrassed when asked to participate in public and difficulties in using the calculator. Such behavior patterns were also observed researchers, such as Annandale (2012), Henderson (2012), Geary (2006) and many others.

5.3.4 There are students who fail Math repeatedly because of their dyscalculic conditions. In this study, the researcher identified that 7.69% of the UCE BC students fail Math because of their dyscalculic condition. This finding is in line with Doyle (2010) and DSM-IV (cited in Butterworth, 2003). This finding concurs with the hypothesis of the study, which says dyscalculia plays a significant role in failing of Mathematics at Ordinary Level at UCE.

5.4 Recommendations
The researcher makes the following recommendations:
It is high time Zimbabwean teachers learnt about dyscalculia and be equipped on how to assist their pupils with the specific learning difficulties. More has to be done in the teaching of math.
Carnellor (2004:5) states that “for many adults…mathematics generates unease and insecurity. ….These feelings probably originate from their own classroom experiences where mathematics consisted of drill, rules, and recipes, instead of understanding and application. ” In the same vein, Mac an Bhaird (2008) in Israel observes that teachers give students too much pressure in order to achieve the highest possible points in math through rote-learning and little understanding of math. Thus, teachers should teach math for understanding so that students will be able to apply the learnt skills in real life situations. In the teaching and learning process, teachers should put effort to identify students with mathematical learning difficulties in their classes so as to give them the appropriate assistance. Adler (2000:14) says, “Mathematical exercises of the wrong sort could make a child with dyscalculia worse.” Thus, teachers should be equipped with the appropriate methodologies for handling the dyscalculic learner in the classroom. Muzawazi and Nkoma (2011:17) recommend that teachers should evaluate their methodologies and improve on record keeping so as to monitor the progress of each pupil. Mazawazi and Nkoma suggest that teachers need to increase the number of activities, media and time for the children in order for all pupils to gain from the learning of math.

Siegler (1988) warns that dyscalculia develops gradually if untreated at an earlier stage. Butterworth, Varma & Laurillard (2011) agree that effective early intervention may help to reduce the later impact on poor numeracy skills. This is in line with Butterworth (1986)’s view that although developmental dyscalculia is an innate condition, it can be treated. According to Arsic, Eminovic, Stankovic, Jankovic, & Despotovic (2012), Ayo, Kelechi & Abiodun (2013), Lerner (1981), Butterworth & Dehaene (2000), learners suffering from mathematical disability typically require additional remediation and time spent on mathematics-related problems. Wilson and Dehaene (1999), in New Zealand, have developed an adaptive computer game called ‘The Number Race’ which is designed especially to help students with dyscalculia to practice mathematical skills. Mpofu, Watson and Chan (1999) observed that dyscalculic adults also need special treatment in relation to their disability at work places.

In addition to this, Attwood (2011para13) suggests that,ö

Having found the problem, the solution is to use the multi-sensory method to overcome it, and then to return to the tests to see if any other area of maths gives a problem. The process can be repeated until all the basic maths (up to and including percentages, areas, decimals and
fractions) are understood, at which point the child can return to mainstream lessons. In this way the issue of whether the child is dyscalculic, or has simply failed to understand some basic maths earlier on in his/her education, is by-passed. Formal testing is therefore unnecessary, and we move quickly to a solution.

Thus, the researcher suggests an early diagnosis of math difficulties, rather than dyscalculia per se, will help the teacher to give individual help to the student, which is in line with the student’s area of difficulty. “Early diagnosis coupled with appropriate support and teaching strategies will eliminate the escalation of avoidance that is evident in pupils for whom math is a real fear,” (Kaufmann & von Aster, 2012). This means that a thorough and early evaluation is of necessity to identify the area(s) of weakness so as to receive the appropriate treatment for the subtype of dyscalculia one has. Kaufmann & von Aster (2012) are of the view that some positive action must be introduced to ensure that the daily math lesson is appropriate for almost all pupils and that they make progress and gain positively from the lesson. Teachers should desist from using the lecture method when teaching math and adopt and adapt child-centred approaches whereby students are actively involved in the learning process.

For BC teachers, the researcher recommends for individualized learning and breaking down of concepts so as for the supplementing students to understand. The NCLD (2007) is of the idea that it is necessary to explain ideas and problems clearly and encourage students to ask questions as they work. This means that teachers should not rush with the students but each concept should be clearly explained while students are allowed to ask questions for more clarity. In addition to this, teachers should provide supervised practice to prevent students from practicing misconceptions and "misrules" (Kenyon, 2013).

Kaufmann & von Aster (2012) reviewed publications on dyscalculia from multiple disciplines, that is, medicine, psychology, neuroscience and education. They found out that many children and adolescents with dyscalculia have cognitive dysfunction and intervention strategies employed were directed to specific problems. They concluded that a thorough and early evaluation is of necessity to identify the area(s) of weakness so as to receive the appropriate treatment for the subtype of dyscalculia one has.
Curriculum designers should as well design the appropriate curriculum for all types of learners. The curriculum designers should prepare learning materials specifically for the student with learning difficulties.

Furthermore, although the results of the study cannot be generalized to the entire Zimbabwean society, the researcher is of the opinion that the education system should take into consideration adult learners who suffer from math learning difficulties and find appropriate ways of assisting them.

This study has looked into dyscalculia, combining both developmental dyscalculia and pseudo-dyscalculia. Anyone who finds this study of interest might look into developmental dyscalculia and pseudo-dyscalculia separately in a different setting altogether, or they may investigate on the intervention strategies which can be applied in developing nations, such as Zimbabwe, where computer games cannot be afforded by most learners on improving their math skills. One may also look into the different types of dyscalculia as suggested by Adler (2001). The researcher urges all math educators to study more about dyscalculic students in order to help them in any way one can.

5.5 Summary
In this chapter, the researcher made a summary of her study. She used a standardized test to diagnose students who are prone to dyscalculia. Observations and interviews were also done so as to establish behaviour patterns among the dyscalculic students among her fifty-two participants. She observed that the dyscalculic students used inappropriate rules, procedures and formulae, failing to understand what the question required and such like. She as well established that dyscalculic students suffered from mathophobia, used immature strategies when computing and other different patterns. The researcher recommended that all stakeholders in education should consider the dyscalculic learners in order help them in their learning.
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APPENDICES

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