

**AN APPLICATION OF BRAIN-BASED EDUCATION PRINCIPLES WITH ICT AS A COGNITIVE
TOOL: A CASE STUDY OF GRADE 6 DECIMAL INSTRUCTION AT SUNLANDS PRIMARY
SCHOOL**

by

ZELDA JOY LE ROUX

Supervised by

DR. A. MBOGHO

A MINOR DISSERTATION PRESENTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF PHILOSOPHY (IN INFORMATION TECHNOLOGY)

IN THE DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF CAPE TOWN

APRIL 2015

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

“I know the meaning of plagiarism and declare that all of the work in the thesis, save for that which is properly acknowledged, is my own”.

Signed by candidate

Z J LE ROUX

ACKNOWLEDGEMENTS

I want to give thanks to my Heavenly Father for His guidance and grace in this research project, for giving me the following people who supported me in undertaking this study.

Dr. A. Mbogho, Department of Computer Science, University of Cape Town,

Prof. P. Madikizela, Faculty of Psychology, University of the Free State and

Dr. S. Malan, Faculty of Education, University of Stellenbosch, for their guidance, support and academic insight.

Prof. J. Heystek, Faculty of Education, University of Northwest, who motivated me to continue studying.

The Statistics Department of the University of Cape Town, for kindly calculating the statistics for this research project.

Alta van Heerden, Principal of Sunlands Primary School, who kindly made the computer laboratory and other resources available for the duration of the research project.

My colleagues for their support.

Learners of Sunlands Primary School.

My parents for affording me the opportunity to attend university initially, and above all my husband, Johan and sons Emile, Etienne and Juan-Jacques for your patience, love and support in many ways.

I salute you all! You have made this dream of mine possible.

ABSTRACT

The larger population of South African learners do not learn effectively and struggle with low academic achievements currently. This can be attributed to various factors such as frequent changes in the curriculum, underqualified educators, ineffective teaching methods and barriers to learning existing in classrooms today. Learners need extra support, including cognitive support, but in reality the heavy workload of educators may prevent them from giving learners the needed support. If support is given, it is minimal or not effective enough. Computer technologies may afford both educators and learners such opportunities when used as a cognitive tool in activities that provide the needed support.

This research is concerned with the use of computer technology as a cognitive tool to activate learners' cognitive processes, thus enhancing learning, based on Brain Based Education principles. The objective is to lay the foundation in using computer technologies as cognitive tools in educators' teaching practice and instructional design to make teaching and learning more effective, interactive, real world based, giving meaning to what is learnt and to enhance understanding.

A case study research strategy was followed which incorporated an analytical literature study and quantitative research methods, teaching methods and learner activities.

Lesson design, teaching aids and learner activities were developed for a programme in the mathematical concept of decimals. During this programme cognitive education principles were applied to lessons, teaching aids and learner activities. This programme was used during the course of two school terms.

Eighty one learners were chosen from three Grade 6 classes for the population sample of this research study. The three classes formed one Grade 6 group which were divided into two groups, namely a research group and a control group. Both groups were set up to be heterogenic, and were similar in number, gender and academic ability.

Both groups were exposed to an approach of brain-based teaching in collaboration with computer technologies. The research group was taught principles and concepts of decimals with cognitive education based teaching aids (as explained in chapter 5), while the control group covered different Mathematics content according to the school's

curriculum. The reason for the control group covering a different area, was to establish if there would be any significant difference between the decimal pre- and post-test scores of the research group compared to that of the control group. While the research project was done, both groups continued Mathematics classes with their Mathematics teacher as part of their normal school day time table. However, in the Mathematics classroom, the curriculum's focus wasn't on any of the principles and aspects of decimals the research group was exposed to, or measuring volume, capacity, mass, length, distance, money or fraction which the control group was exposed too. Although the control group's area of teaching contained decimal related aspects, the focus thereof was not on the same aspects the research group was exposed to.

Both groups did the same pre-test at the start of the research project as well as the same post-test at the end of the project. Quantitative data were acquired from the pre- and post-test results and were analysed to compare the results of the research group to that of the control group.

The research findings, indicated that there was a significant improvement in learner scores obtained from the research group when computer technologies were used as cognitive tools to activate and enhance learners' cognitive processes. However, there was also an improvement in the scores of the control group as well, but the improvement wasn't as significant as the improvement of the research group.

Although no similar aspects on decimals were done as an intervention with the control group, the approach that has been implemented with the research group implies that it holds promise as a learning tool when ICT is incorporated into a teaching methodology. Therefore, from the research findings in this study it can be suggested that that using computer technologies as a cognitive tool has the potential to activate and enhance learner cognitive processes, thus contributing to more effective learning and academic achievement.

Contents

Acknowledgements.	ii
Abstract.	iii
Contents.	v
List of Figures.	x
List of Tables.	x
Keywords.	xii
List of acronyms.	xii
Chapter 1: Orientation and Research Design	01
1.1 Introduction.	01
1.2 Problem Statement.	02
1.3 Rationale for this study.	03
1.4 Significance of this study.	05
1.5 Research Question.	06
1.6 Research Objectives.	06
1.7 Conclusion.	06
Chapter 2: The current situation in South African Education.	08
2.1. Background.	08
2.1.1 Digital absence in the South African classroom.	08
2.1.2 Academic Results in Grades 3, 6 and 12.	10
2.2 Barriers to learning.	10
2.2.1 The lack of attention and motivation.	11
2.2.1.1 Attention.	12
2.2.1.2 Motivation.	12
2.2.2 The lack of optimal use of cognitive brain processes.	13
2.2.3 Ineffective teaching methods.	14
2.3 Conclusion.	15

Contents

Chapter 3: What is learning?	16
3.1 Background.	16
3.2 Learning theories.	16
3.2.1 Behaviourism.	17
3.2.1.1 Implications of a behaviourist approach in the classroom	19
3.2.1.2 Roles of the educator and learner in the behaviourist classroom	21
3.2.2 Constructivism.	23
3.2.2.1 Implications of the constructivist approach in the classroom	25
3.2.2.2 Roles of the educator and learner in the constructivist classroom	27
3.2.2.2.1 Role of an educator in the constructivist classroom	27
3.2.2.2.2 Role of learners in the constructivist classroom	28
3.2.3 Cognitivism.	29
3.2.3.1 Roles of the educator and learner in the cognitivist classroom	31
3.2.3.1.1 Role of the educator in the cognitivist classroom	31
3.2.3.1.2 2 Role of the learner in the cognitivist classroom	33
3.3 Defining learning.	35
3.4 Learning as a cognitive process.	36
3.5 The Learning process.	36
3.5.1 Input.	36
3.5.2 Processing.	36
3.5.3 Output.	37
3.6 Learning styles.	38
3.7 The role of computer-based technologies in learning.	39
3.7.1 The construction of knowledge.	39
3.7.2 Learning in a social context.	42
3.7.3 Collaboration in the learning process.	42
3.8 A comparison of behaviourism, constructivism and cognitivism	42
3.9 Conclusion.	45

Contents

Chapter 4: Cognitive Education.	46
4.1 Background.	46
4.2 What is cognitive education?	47
4.3 Principles on which cognitive education is built.	47
4.3.1 Neuroplasticity.	47
4.3.1.1 Neuroplasticity's role in learning	48
4.3.1.2 Implications of neurotransmitters on learning	49
4.3.2 Strategies that optimise brain functioning	52
4.3.2.1 The triune brain.	52
4.3.2.2 Implications of the triune brain in the computer technology rich classroom.	55
4.3.3 Suggestopedia.	57
4.4 Attention	62
4.4.1 How does attention work?	62
4.4.2 Things that affect attentional focus.	63
4.4.2.1 The effect of motion and change.	63
4.4.2.2 The effect of colour, size and intensity of stimuli.	64
4.4.2.3 The amount of stimuli competing at a given time.	65
4.4.2.4 Visual structure and grouping.	66
4.5 Conclusion.	69
Chapter 5: The use of computer technologies as cognitive tools.	70
5.1 Background.	70
5.2. Using computer technologies as a cognitive tool.	70
5.3 Computer technologies as cognitive tools create cognitive changes	74
5.4 The benefit of using computers as cognitive tools.	76
5.5 Computer Technologies contribute to collaborative learning experiences.	77
5.6 Computer technologies and memory.	77

Contents

5.7 Motivation for using technology to enhance teaching and learning.	78
5.8. Application of cognitive principles with the use of computer technologies and software in the classroom for this study.	84
5.9 Conclusions	89
Chapter 6 - Research design and Execution.	90
6.1 Background.	90
6.2 A quantitative case study	90
6.3 The research question.	92
6.4 The research environment.	92
6.5. Sampling.	93
6.6. Research period.	95
6.7 Instrumentation.	95
6.7.1 Structure of the measuring instruments.	96
6.7.2 Validity and reliability.	102
6.7.3 Ethics	104
6.8 Research procedure	105
6.9 Conclusion	111
Chapter 7: Research findings and interpretation of results.	112
7.1 Background.	112
7.2 Implementation.	112
7.2.1 Data Collection.	113
7.2.2.1 Descriptive statistics of the Research and Control groups.	113
7.3 Research results and Findings.	115
7.3.1 Inferential statistics	115
7.3.1.1 Normality of data	115
7.3.1.2 Variability of data	116
7.3.1.3 Interpretation of data	117
7.4 Conclusion.	122

Contents

Chapter 8: Summary of findings, limitations and recommendations.	123
8.1 Background.	123
8.2 Summary of findings related to research question.	123
8.2.1 Summary of the literature study findings.	123
8.2.2 Summary of the quantitative research findings.	125
8.3 Limitations of the study.	125
8.4 Conclusions.	126
8.5 Recommendations	128
9. References.	129
10. Appendix	146
1. Teaching slides.	146
2. Learner workbook slides.	151
3. Pre-test.	156
4. Post-test.	162
5. Test results.	172

Contents

List of figures

1. Figure 4.1.	Neurons.	49
2. Figure 4.2	A synapse.	49
3. Figure 4.3	How neurons communicate.	50
4. Figure 4.4	The triune brain.	53
5. Figure 4.5	iMindMap.	60
6. Figure 4.6	An unstructured instruction.	66
7. Figure 4.7	A structured instruction.	67
8. Figure 4.8	A non-segmented pattern.	67
9. Figure 4.9	A segmented pattern.	67
10. Figure 4.10	Drop-down lists.	68
11. Figure 5.1	Use of coloured font.	86
12. Figure 5.2.	Graphics for visual display	86
13. Figure 5.3.	Visual structure and Figure and Ground.	87
14. Figure 6.1	An example from Section A in the pre-test.	98
15. Figure 6.2	An example of the answer and formula sheet.	98
16. Figure 6.3	An example of a coloured spreadsheet cell.	99
17. Figure 6.4	An example of the answer and formula sheet in the post-test.	99
18. Figure 6.5	An example of the triangle and scroll down list in the post-test.	100
19. Figure 6.6	Graphics added appeal and novelty.	100
20. Figure 6.7.	Giving meaning by displaying a ruler.	100
21. Figure 6.8.	Giving meaning with reality.	100
22. Figure 6.9.	Coloured font used to draw learners' attention to words.	101
23. Figure 6.10.	Coloured concepts.	101
24. Figure 6.11.	Segmented information giving structure.	102
25. Figure 6.12.	Visual structure to separate given information from answers.	102
26. Figure 6.13.	2013 School Calendar	110
27. Figure 7.1.	Distribution of normality – Research group.	115
28. Figure 7.2.	Distribution of normality – Control group.	116
29. Figure 7.3	Distribution of variability - Research and Control groups.	116

30. Figure 7.4	Distribution of variability - Grade 6 classes.	118
31. Figure 7.5	Pre and post difference between the research and control groups.	119

List of tables

1.	Table 3.1 A comparison of learning theories	45
2.	Table 6.1 Representation of groups	89
3.	Table 6.2 Gender Representation	91
4.	Table 6.3 The distribution of age among the research and control groups	91
5.	Table 7.1 Representation of groups	109
6.	Table 7.2 Gender Representation	110
7.	Table 7.3 The distribution of age among the research and control groups	110
8.	Table 7.4 Analysis of pre-test data.	114
9.	Table 7.5 Distribution of data as given by the UCT Dept. of Statistics	115
10.	Table 7.6 Analysis of pre- vs post-test data.	115
11.	Table 7.7 Analysis of post-test data.	117
12.	Table 7.8 Analysis of pre- vs post-test data for each learner.	117

KEYWORDS

Cognitive education, cognitive processes, cognitive tool, computer technology, digital media, educators, learners, learner needs and learning.

LIST OF ACRONYMS

ANA – Annual National Assessments

CAPS – Curriculum and Assessment Policy Statement

DBE – Department of Basic Education

DOE – Department of Education

GUI – Graphic user interface

ICT – Information and Communications Technology

NCS – National Curriculum Statement

NCSNET – National Commission on Special Needs in Education and Training

NCESS – National Committee for Education Support Services in South Africa

PED – Provincial Education Departments

Chapter 1

Orientation and Research Design

1.1 Introduction

Schools in South Africa today face an increasing demand in their attempts to ensure successful learning in the classroom. Educators are faced with a plethora of tasks, ranging from teaching, assessments, administration to coaching extra-mural activities. Often educators complain about the workload preventing them from fulfilling their main purpose and resulting in poor student performance. Furthermore, information presented in the learning environment isn't always done in a manner leading to maximising learning, resulting in a negative impact on learning outcomes (Nicholson, Nicholson and Valacich, 2007: 01). Traditional teaching approaches are "quickly losing their ability to challenge, motivate and engage students in ways that are compatible with their digital lives in a techno-centric society" (Edwards, 2012: 80). Very often the needs learners may have are not taken into consideration in lesson planning regarding optimising cognitive processes and the dominant learning styles they may have. All these factors may lead to shallow processing of information. Integrating computer technology into educators' teaching practices and learner activities may offer relief to educational challenges present in the South African educational context.

Research suggests that computer technologies and digital media can support learning and can particularly be useful in developing higher thinking skills such as critical thinking, analysis, scientific enquiry, interpreting and organising information (Jonassen, 1994: 02; Rochelle, Pea, Hoadley, Gordon and Means, 2000: 67). Additionally, computer technologies may contribute to a more meaningful processing of information in the learning process. However, having computer technologies available in a classroom does not ensure their effective use. The use thereof as an effective learning tool is more likely to take place when embedded in a broader education reform movement that includes improvements in educator training, planning of lessons and activities, identifying goals, curriculum, student

assessment, and a school's capacity for change (Rochelle *et al.*, 2000: 76; Kotze, 2013: 4,5).

1.2 Problem Statement

Many schools in South Africa are equipped with computer laboratories, and in some instances classes are equipped with a computer, a projector and other technologies. As previously mentioned having this technology in a classroom does not ensure its effective use. There are a few factors contributing towards its ineffective use, namely:

- a) Each learner and classroom environment is unique as learners have different cognitive and pedagogical needs (Cilliers, 2005: 2-6);
- b) Educators are not adequately trained to use computer technology effectively (Wenglinsky, 1998: 10);
- c) Computers are used as a conveyor of knowledge instead of a constructor of knowledge (Jonassen, 1994: 01).
- d) The structure and resources of traditional classrooms often provide poor support for learning and cognition as they lack the necessary computer technology that can be used for effective teaching and learning. (Rochelle, *et al.*, 2000:79);
- e) Computer technology isn't integrated into regular classroom instruction in the learning environment (Bauer and Kenton, 2005: 519-546);
- f) The specific student population, software design, student grouping and level of access to technology found in a school (Schacter, 1990: 05).

Effective use of computer technology in the classroom has the potential to make a significant impact on education (Noeth and Boris, 2004: 7-13). Teaching with computer technologies as a cognitive tool, may lead to the facilitation of a deeper and more meaningful learning process by allowing learners to make use of their cognitive processes to learn more effectively (Salomon, Perkins and Globerson, 1991: 2-8, Pea, 1985: 168; Jonassen, 1994: 02). The question arises, "Can the use of the computer technology, software and various digital and multimedia tools be beneficial to cognitive processes and the learning potential of learners?"

1.3 Rationale for this study

Education in South African has experienced many changes since 1994, more particularly in the curriculum and as a result of a move to outcomes-based practices by educators. Poor achievement levels of South African learners in basic numeracy and literacy has been a matter of concern (Department of Basic Education, 2011a: 18-35; DBE 2012: 22-63; DBE 2013: 7-38). According to Cilliers (2005: 7-12) a contributing factor to poor learner achievement is the fact that learners are not making use of their cognitive abilities to learn successfully.

Poor achievement levels may also indicate that learners still struggle with an inability to learn effectively. Learners learn in different styles and paces, but, educators expect them to achieve learning outcomes with traditional teaching methods where all are treated the same way with a singular teaching method (Kramer, 1999: 4, 13). Although the underlying principles of OBE are to change one's educational practices to accommodate learners' learning styles and needs, many educators still practise teaching in a traditional class setting with traditional 'chalk and talk' as the main pedagogy. This could be due to resistance to change and insufficient training in implementing new policies which require a change in teaching methods (Swanepoel, 2009: 465, 472).

Along with the mentioned change in South African Education, the use of computer based technology has increased. More classrooms are equipped with computer technologies and digital media with funding received from private companies and organisations such as Khanya and the National Education Department (Smith and Hardman, 2014: 22, 23). Though schools have the opportunity to use these technologies, one will still find that the majority of educators and learners do not use them to their fullest potential to enhance teaching and learning in the classroom, resulting in little or no impact (Ndlovo and Lawrence, 2012: 01). This can be attributed to a barrier in the minds of educators through constrained thinking about the use of computer technology in education and educators not comfortable with its use in the classroom (National Science and Technology Forum, 2014: 03). Educators may also perceive computer technology as "just another tool" which contributes to a limited view of its use in the classroom (Hokansen and Hooper, 2000:

547). Alternatively, if computer technology can be viewed as a tool for enhancing cognitive processes, our understanding of how it can benefit and transform the learning process could be changed (Hokansen and Hooper, 2000: 541,547-550).

Cognitive education is a new teaching paradigm introduced into the South African education environment through OBE to give learners the opportunity to learn in a manner that best suits them (Kramer, 1999: 04-21). However, the insufficient training of educators and their lack in competency to implement new policies as mentioned previously may imply that learning in some classrooms is not taking place efficiently due to educators still using “traditional” or known teaching methods (Ndlovo and Lawrence, 2012: 05).

Changing educational practices and approaches to accommodate learners’ needs can be done with a holistic approach in which educators integrate cognitive education and the use of computer technology in the classroom. This has the potential to contribute to the activation of learners’ cognitive processes towards facilitating deeper and more meaningful learning processes and raising learner achievement overall (Rochelle *et al.* 2000: 76-93; Nicholson *et al.*, 2007: 3; Mayer and Moreno, n.d.: 1).

The rationale, therefore, for this research study is that the developed brain-based cognitive approach combined with the revision afterwards, has the potential to improve knowledge of aspects and principles of decimals if compared with learners who are not exposed to the same content. However, it is important to note that those not exposed (the control group) to these specific decimals have been exposed to decimals from grade 4 already and hence would have some knowledge pertaining to decimals. The rationale is to show that this approach would make a significant difference in the research group if it is used in addition to the existing knowledge of decimals that learners have been exposed to since grade 4 in comparison to learners that just rely on their previous and existing knowledge.

A further rationale for this study is also to embark on an in-depth literature study regarding aspects pertaining to the current situation in South African Education, Learning,

Cognitive Education and the use of computer technologies as computer tools.

1.4 Significance of this study.

The new National Curriculum and Assessment Policy Statement for Grades R to 12 supports a cognitive focus on teaching and learning cognitive processes. Ideally, cognitive education methodologies and the application of computer technologies should congregate in the classroom, but in reality, the integration process thereof is taking place at a slow tempo in the South African context (De Souza and Van Eeden, 2009: 18-19). A possible reason could be the lack of educator training regarding the integration of ICT in the curriculum (De Souza and Van Eeden, 2009: 19).

This case study draws theoretically on the works of Vygotsky (1978: 19-120), Feuerstein (1991: 68-134) and McLean (1990: 15-18), more specifically on the concept that tools (in this case computer software) have the potential to have a positive impact on cognitive processes. It is envisaged that this research study may help discover the extent to which computer technologies and software may be successfully and beneficially integrated into teaching and learning in the classroom. It is furthermore envisaged that this study will make a contribution to the body of knowledge related to Education as well as Information Technology with a particular emphasis on how computer technologies, can be used as a cognitive tool to enhance the learning process.

Computer technologies are rapidly being introduced in the South African education system and there is a need for the effective integration and use thereof in teaching and learning. With the use of computer technologies as cognitive tools, educators face a challenge in the use thereof and may require a mind shift to change their teaching methods so that teaching and learning could be more effective in the classroom. Therefore, this study is significant as it suggests how computer technologies and software can be used for effective teaching and the enhancement of learning in the South African classroom. This study aims by means of an in-depth case study to show what the impact of computer technologies and other digital media on the cognitive processes of learners towards enhanced learning may be.

1.5 Research Question

As previously mentioned this research study may help discover the extent to which computer technologies and software may be successfully and beneficially integrated into teaching and learning in the ICT classroom. With this in mind, the research will attempt to answer the following research question: “Does the use of ICT as a cognitive tool to teach decimal concepts by means of a developed brain based cognitive approach have the potential to lead to improved learner results compared to learners not exposed to the intervention?”

1.6 Research Objectives

The primary objective of this study is to determine whether the use of ICT by applying cognitive education principles have the potential to improve learner performance when teaching decimals. The secondary objectives are to research the current state of education and to explore the literature for a suitable theoretical grounding of this work. The secondary objectives are clarified below.

A. Researching the current state of education:

1. To investigate the current level of learning effectiveness in South African schools.
2. To identify and describe barriers that prevents learners from learning effectively in a classroom.

B. Literature survey:

1. To define learning and describe the learning process.
2. To define various learning theories;
3. To define cognitive education and the principles of the theory.

1.7 Conclusion

This chapter aimed at introducing a background of the South African education system, noting that current teaching strategies are impacting learning negatively. Therefore there is a demand for new teaching and learning strategies which may include the efficient use of computer technologies in the classroom.

Chapter 2 will discuss factors contributing to ineffective teaching and learning methods more broadly, giving insight to challenges the South African education system, educators and learners are facing on a daily basis.

Chapter 2

The current situation in South African Education

2.1. Background

In chapter 1 it was discussed that information presented in the classroom isn't always done in a manner leading to and enhancing the learning process, thus impacting learning outcomes negatively (Ndlovo and Lawrence, 2012: 1-2). It was also mentioned that learner needs are not met. Indications are that many learners are not learning efficiently resulting in low academic achievement (Department of Basic Education, 2012: 06). This emphasises greater demand for new teaching and learning strategies to be implemented in the South African classroom.

The aim of chapter 2 is to describe the current South African Education situation in terms of a description of the digital absence in the classroom, academic results as portrayed by the Annual National Assessments (ANA), barriers to learning and the current reality as reflected by the National Commission on Special Needs Education and Training investigation.

2.1.1 Digital absence in the South African classroom.

Although the Department of Basic Education has turned to modern technology in some schools country wide to strengthen teaching and learning and to redress past inequalities in South African Schools, the intervention has made little or no progress regardless of the availability of these technologies in the classrooms (Ndlovo and Lawrence, 2012: 1). The term "digital absence" therefore, is used in this study to refer to the learning void created by educators' in not making use of ICT to enhance teaching and learning in the classrooms. Ironically today's children move and communicate with each other in a digitally rich world (Sprengr, 2010: 3-4). With the rapid development of ICT, adolescents and youth in South Africa are the primary adopters of mobile technology with 72% of 15 – 24 year olds having

a cell phone (UNICEF, 2013: 4). Where children have no difficulty embracing technology due to growing up with it in its various forms, one may find educators shying away from embracing and using computers in the classroom (Ndlovo and Lawrence, 2012: 5).

One would wonder what the reasons for educators are in shying away from using computer technology in the classroom. This may be due to the fact that some educators are 'afraid' of using computer technology, because they have little experience, training or are not fully exposed to it (Ndlovo and Lawrence, 2012: 5; Pan African Research Agenda, 2012: 251). Findings of the Pan African Research Agenda (2012: 251) at South African schools indicated that the majority of educators struggle to move beyond using information and computer technology to compile lesson plans, tasks and tests for learners. Their use of ICT is not at a level where they can use new tools such as computer software other technologies to enhance learning (Ndlovo and Lawrence, 2012: 5). Therefore, the assumption can be made that they are not embracing and maximising the potential of computers especially for enhancing the actual teaching and learning of their subjects (Pan African Research Agenda, 2012: 251).

Furthermore, as another factor causing the 'digital absence', the Pan African Research Agenda (2012: 252) found in their research that although some schools are equipped with computer laboratories, they aren't used due to a lack of expertise among staff, restrictions imposed by the Education Department, a far too high a ratio of learners to computers, or a lack of classroom space.

Various new technologies did not bring about the change in South Africa as was anticipated (Ndlovo and Lawrence, 2012: 1). Edwards (2012: 50, 51) argued that "by the time computers were readily available, educators had already been exposed to a number of new technologies that either failed to deliver what had been promised or appeared to pose too much of a threat to the status quo to be easily absorbed" into the classroom. This may have led to educators being wary of using computer technology as part of their teaching practices in the classroom.

2.1.2 Academic Results in Grades 3, 6 and 12

International and regional studies have indicated that South African learners tend to achieve below acceptable levels in reading, writing and counting (DBE, 2012: 06).

Although the improvement of the quality and levels of education outcomes in South Africa is a top priority for the Department of Basic Education (DBE, 2011b: 3), results from the Annual National Assessments (DBE, 2011a: 19-35; DBE, 2012: 22-23; DBE, 2013: 37-72) from 2011 to 2013 have suggested that learners battle to achieve even the basic outcomes set out for Language and Mathematics. National averages for Language in Grades 1 to 3 ranged from 35 to 59% and those of Grades 6 to 9 ranged from 28 to 48%. National averages for Mathematics ranged from 13 to 68%.

Although an improvement was indicated from 2011 to 2013, ANA results showed a remarkable decrease in performance both in Languages and Mathematics as learners progressed to higher grades (DBE, 2011a: 19-35; DBE, 2012: 22-23; DBE, 2013: 37-72). Less than 57% of learners obtained 50% or higher in the assessments, with the result that 43% of learners failed (DBE, 2012: 23-38). Reasons given by the DBE for low achievement among learners ranged from socio-economic and demographic to historical realities (DBE 2012: 68) which seem to be valid reasons, but the question arises if digital poverty in South African classrooms also contributed to these low levels of achievement among learners.

2.2 Barriers to learning

Barriers to learning can be located within different contexts such as the learner himself, centres of learning, the education system as well as a social, economic and political context (Department of Education, 1997: 11). Barriers to learning are defined by Bennet (2003: 303) as “a significant impairment of intellectual functioning” suffered by learners. These barriers may be observable in different ways and become visible when learners are having learning difficulties; however, when these barriers occur they require different intervention strategies to remove and resolve (De Jager, 2006: 1-6). A key to preventing barriers from occurring is meeting needs among learners (De Jager, 2006: 18-19). Such needs can be met by using computer technologies and software which may help learners

to use strategies to bypass and work around their learning difficulties (MacArthur, 1999: 169-189; Smith and McCulloch, 2014: para. 5-19).

The National Commission on Special Needs in Education and Training (NCSNET) and the National Committee for Education Support Services in South Africa (NCESS) investigated and reported on special needs and support services in education and training in South Africa (DOE, 1997: 11-17). They found the following factors contributing towards barriers to learning in South Africa:

- a) Socio-economic factors such as poverty and access to basic services;
- b) Violence;
- c) Discrimination;
- d) Attitudes;
- e) An inflexible curriculum not meeting diverse learning needs;
- f) Inadequacy of educator training;
- g) Lack of parental involvement;
- h) Inadequate support services to schools;
- i) Language and communication challenges;
- j) Disabilities or impairments that require specific support.

Learning barriers often create demotivation (De Jager, 2006: 01). Learners often experience learning barriers, due to needs not being met (De Jager, 2006: 03). In order for learning to take place, barriers have to be removed (De Jager, 2006: 01-06).

2.2.1 The lack of attention and motivation.

Attention, motivation and successful learning are linked as attention may influence motivation positively, but, the opposite is also true, as deficits in attention influences motivation negatively (Jensen 2005: 103). Among the factors that can obstruct attention considerably is threat as perceived by the reptilian complex in the triune brain, which causes the cerebrum to downshift, preventing the cortex to operate (Cilliers, 2003; 39; Jensen 2005: 16, 36; Sprenger, 2010: 33-34). Attention is also determined by the importance of information (Jensen 2005: 16). When information is deemed as important

enough, attention will be paid to the new information learned and it will be routed via the hippocampus to the cortex for storage (Jensen 2005: 16).

2.2.1.2 Attention

Attention can be described as behavioural and cognitive processes where there is selective focus on a part of the milieu while other things are ignored (Anderson 2004: 519). It is a cognitive process that allows learners to control irrelevant stimuli (Sprenger, 2005: 15). Attention is “necessary to hold information in working memory and to efficiently move information to long-term memory, that is, to learn it” (Wickens and McCarley, 2008: 01). It is tied closely to other domains of cognitive psychology, such as memory and learning, and is “an act of directing one’s thoughts”, but also the act of “taking notice” (Hornby, Cowie and Gimson, 1983: 50).

Educators often have to compete for learner attention when teaching (Billington and DiTomaso, 2003: 91-104). Learners are inundated with sensory stimulation throughout their school day (Sprenger, 2005: 14). If one considers the average number of learners in a classroom at Sunlands Primary School, any one learner has to filter out thirty or more other learners as well as other visual and noise distractions. Furthermore, some learners have learning difficulties while others have disorders such as ADD/ADHD, Tourette syndrome, Dyslexia and Asperger’s Syndrome (a form of autism) which make it difficult for them to pay attention to activities and teaching in the classroom (Levine, 2002: 82-89; Jensen, 2005: 36). Other factors such as glucose levels, threat response and information not being meaningful also impact attention in the classroom (Jensen, 2005: 36; McNay, McCarty and Gold: 2001: 325-337; Ornstein, 1993: 134). The lack of attention will impact learning negatively and where academic achievement is compromised intervention is needed (Ornstein, 1993: 135).

2.2.1.3 Motivation

Jensen (2005: 102) regards motivation as an “arousal” or “drive” where arousal suggests direction towards a goal and drive doing something to achieve the goal. Motivation drives behaviour towards certain goals, leads to increased effort and energy, increases the

initiation of activities as well as the persistence thereof and affects cognitive processes (Ormrod, 2008: 384-386).

The lack of motivation is based on a range of factors. The factors are as follows:

- a) Learners' inability to do a task due to not understanding the task (Wright, 2001: no page no);
- b) Learners' inability to use cognitive strategies correctly and constantly (Cilliers, 2010: 07);
- c) Learners lack essential skills that would enable them to do a task (Wright, 2001: no page no);
- d) Learners' perceive a task as too much effort (Wright, 2001: no page no);
- e) There is no engagement taking place in the classroom (Sprenger, 2010: 46-52);
- f) There are no pay-offs or rewards in store (Jackson, 2001: 15; Wright, 2001: no page no);
- g) A lack of confidence and a fear of failure (Jackson, 2001: 67, 68).

Jackson (2001: 16) notes that learners are simply not motivated by what they find in school. They don't see the value in what educators are trying to teach them. When no value is seen in what is taught, they will not be motivated to invest their time and energy into the learning process (Jackson, 2011:16). "Without motivation, there is little chance for continual cognitive learning" (Ornstein, 1993: 134). Therefore, to motivate learners educators have to "prove" to them that the learning task has value (Sprenger, 2005: 18). This can be done by making the task desirable (Sprenger, 2005: 18).

2.2.2 The lack of optimal use of cognitive brain processes.

Educators face many challenges to optimise learners' cognitive potential and to enable learning to take place successfully. Learners don't demonstrate their relatively unlimited brain potential. Previous research has led to important findings as to why learners are often not engaging cognitive brain processes in the classroom. Cilliers lists them as follows:

- a. "The average learner uses a small percentage of his/her brain potential" (Cilliers, 2005: 07). This phenomenon can be attributed to stress experienced by the learner,

- the affective domain where motivation for learning is low, negative attitudes, perceptions and values. Furthermore learners do not make use of their own unique learning styles that may contribute towards effective learning;
- b. “Functions of the right brain hemisphere are under-utilised” (Cilliers, 2005: 07). Traditional teaching methods tend to make learners only utilise the left brain for academic activities, with the result that the right brain hemisphere is under-utilized. The right brain hemisphere is used for rhythm, movement, images, imagination, colour, music, and recognition. When it is not used it goes into a resting state. Plainly stated, it switches off;
 - c. “The role of the sub-conscious brain is also underutilised as the conscious brain are mostly used” (Cilliers, 2005: 08). The sub-conscious brain is largely receptive towards suggestions. Suggestions lead to a certain result and the sub-conscious brain’s function is to find a way to make it happen. Educators do not make use of positive suggestions to motivate learners. Very often negative suggestions and nasty remarks are made. This leads to learners not believing in themselves and the potential they have, thus contributing to low academic performance;
 - d. “The influence of the triune brain has been underestimated and not enough attention is given to the brain’s influence in a classroom situation” (Cilliers, 2005: 09). Very often, due to educators not knowing about the power of the triune brain, non-effective learning environments are created which contribute to the downshifting of the brain which prevents effective learning taking place;
 - e. “Educators do not stimulate as many of the cortical brain lobes as possible which relate directly to learning during the teaching process to facilitate transfer, therefore optimal learning can’t take place” (Cilliers, 2005: 13).

2.2.3 Ineffective teaching methods.

Often due to inadequate training some educators use teaching styles which may not meet the needs of learners in the classroom (DOE, 1997:14). A teacher may teach according to his dominant learning style which in effect will not accommodate learners using different learning styles or at a pace that may limit the creativity and involvement of learners with high levels of competence (LeFever, 2004: 28; Kinsella 1995: 170-194). Although much

more emphasis is placed on cognitive education principles in the move towards outcomes based education, educators still may lack in knowledge regarding cognitive teaching principles or find it difficult to adapt their teaching methods to accommodate cognitive principles in their teaching strategies (Kramer, 1999: 04-21; Ndlovo and Lawrence, 2012: 05).

2.3 Conclusion

The implication of the current South African reality as described in this chapter is that a need exists for new approaches to teaching and learning. Such new approaches need to enable learners to learn more effectively, thus achieving greater academic success. Although many factors that may hinder learning are discussed, this research study aims to address barriers in learning regarding the lack of attention, lack of optimal use of cognitive brain processes and ineffective teaching methods.

Bearing in mind that the research question of this study is: “Does the use of ICT as a cognitive tool to teach decimal concepts by means of a developed brain based cognitive approach have the potential to lead to improved learner results compared to learners not exposed to the intervention?”, the following chapter will systematically define learning and describe the processes thereof to provide a framework for evaluating whether the use of computer technologies as cognitive tools can be used as a possible inclusive approach to learning in the South African classroom.

Chapter 3

What is learning?

3.1 Background.

In chapter 2 the current South African Education reality was reflected upon and it was indicated that many learners are not learning effectively resulting in low academic success. Reasons contributing to this include a digital absence in South African classrooms, socio-economic factors and barriers to learning. The question arises as to how an enhanced learning process can be facilitated to contribute towards higher academic achievement.

The aim of chapter 3 is to focus on learning theories, what learning is, the processes involved in the learning process and how computer technologies can change how and what children learn in the classroom.

3.2 Learning theories

Today's world is the epicentre of important scientific research regarding the mind and brain, the processes of thinking and learning and the processes that occur during thought and learning. What scientists have discovered during the past few decades has important implications for education. New theories of learning have emerged giving us a new perspective on what learning is, how learning is taking place in the brain and how teaching practices could be changed to accommodate learning in the classroom.

In the past two decades or so there has been a paradigm shift in theories regarding how learning takes place, moving from a teacher-centred to a learner-centred approach. Traditional methods of teaching based on the behavioural and instructivist approach proved less effective. Cilliers (2005: 22) stated that these approaches of learning had an important shortcoming as "desired behaviour was always seen as dependant on external interventions and it offered no solutions to the transfer of learning". In this view of learning the learner received knowledge passively by the teacher, being a conveyor of knowledge. However, learning is more effective when a learner is actively engaged in the learning process and by making use of cognitive processes.

3.2.1 Behaviourism

Behaviourism, as a new theory of learning has its origin in the early twentieth (Ornstein and Hunkins, 1988: 107-108). J.B Watson, an American psychologist is generally accepted as one of the earliest advocates of behaviourism (Pritchard, 2009: 05). He stated that as a “new psychology” behaviourism “could only become a true science if it became a process of detailed objective observation and scientific measurement” (Pritchard, 2009: 05). Watson’s notion of observation and measurement in behaviourism, became central to the work of other behaviourists such as B.F. Skinner, I. Pavlov and E. Thorndike (Pritchard, 2009: 05).

Behaviourism is founded on the belief that behaviour can be trained and changed to get desired results (McLeod, 2007: para. 02; Ornstein and Hunkins, 1988: 107-108). As a philosophy of psychology, behaviourism is based on the idea that all things people and animals do, should be considered as behaviour (Ornstein and Hunkins, 1988: 107-108). Learning was regarded as the change in behaviour of a learner where observable behaviour was shaped by positive or negative reinforcement (Ornstein and Hunkins, 1988: 107-113, 139). The learning process is defined by the outward expression of new behaviours where a learner shows learning took place by mastering a concept (Weegar and Pacis, 2012: 02). Simply defined, learning is the acquisition of new behaviour (Pritchard, 2009: 06).

Behaviourists emphasised conditioning behaviour and altering the environment to provoke certain responses from the learner (Ornstein and Hunkins, 1988: 108). Learning was conceptualized as a behavioural process by which connections were formed between stimuli (positive and negative reinforcement) and responses (Cilliers, 2005: 22; Wood, 1992: 03). Therefore, a motivation to learn was assumed to be driven by stimuli and other external forces like rewards and punishments (Ornstein and Hunkins, 1988: 107-113; Pritchard, 2009: 05). In behaviourism, all behaviour can be viewed as a simple stimulus-response association (Woollard, 2010: 21). New behaviour could occur through the following: classical or operant conditioning; the modification of old behaviour through rewards and punishments; or through the imitation of observed behaviour, which is also

called modelling (Woollard, 2010: 21). All behaviour therefore, could be explained without considering internal mental states, cognition or consciousness (Woollard, 2010: 02).

Behaviourism has been “intrinsically linked with learning in educational practices for many years” (Surgenor, 2010: 02), to encourage desired behaviour and discourage that which is not (Woollard, 2010: 87). The use of this principle in behaviourism is an ideal way to deal with classroom management and to establish appropriate classroom behaviours (Green, 2002: 01; Pritchard, 2009: 13).

Methods used in the classroom which originated from the behaviourist theory are extinction, positive and negative reinforcements, consequences, and behaviour modification (Woollard, 2010: 38-39, 87-90), for example:

- a) Extinction is the removal of reinforcement of behaviour to reduce the frequency or to eliminate certain behaviour. This is done by ignoring unwanted behaviour (Woollard, 2010: 87);
- b) Positive reinforcement is given with praise, merit marks or rewards (Darby, 2003: para. 16-20; Woollard, 2010: 88, 89);
- c) Negative reinforcement is given by removing a possible detention when the learner provides the expected homework or assignment (Darby, 2003: para. 16-20);
- d) Punishment as a consequence is given by keeping the learner back during break time, by giving detention, by giving timeout or by removing something pleasant from the learners (Darby, 2003: para. 16-20; Woollard, 2010: 89-91);
- e) Behaviour modification is used to change learner behaviour whereby the learner is rewarded for appropriate behaviour and whereby inappropriate behaviour is ignored (Cilliers, 2005: 22; Wood, 1992: 03);
- f) It is assumed that reinforcements and punishments count as learning experiences where learners change their behaviour as a result of what was learned from these experiences (Hergenhahn and Olson, 2001: 06-07).

Wheldall and Glynn (1988: 05-18) are of the opinion that Behaviourism can be used by educators to critically examine the learning environment, as negative behaviour can be a

reasonable reaction to uninspiring lessons. This examination can be done to determine what forerunner stimuli lead to the behaviours we as educators desire in the classroom (Wheldall and Glynn, 1988: 05-18). This notion leads me to question behaviourist practices and whether the use of ICT has the potential to enhance learner performance when using it (ICT) as a tool for teaching and learning. Hence, can the use of ICT within a brain-based context contribute to a change in learner behaviour towards expected outcomes?

Although there has been a shift in teaching paradigms, the “effects of behaviourism remain in some common educational practices” (Rogers, 2002: 24). Sutton (2003: para 1-37) states there are many aspects of behaviourism that are positive and which have led to the development of education instructional technologies. Examples of such behaviourism based technologies are available drill and practice software, computer games, tutorials, simulations, integrated learning systems, as well as programmed instruction (Rogers, 2002: 24-25; Shield, 2000: para. 16). According to Rogers (2002: 24) and Shield (2000: para. 16) this type of educational practice is good for factual and rote learning whereby a learner is progressively rewarded as each level of a game or drill and practice activity is mastered.

3.2.1.1 Implications of a behaviourist approach in the classroom

As this research study mainly focusses on the cognitive learning approach, one could argue that cognitive learning theories are more useful than the behaviourist approach, but, in reality both approaches could be relevant in an educational classroom as both have strengths and weaknesses.

The behaviourist approach predominantly focusses on the manipulation and observation of observable behaviour caused by external stimuli (Ornstein and Hunkins, 1988: 108; Cilliers, 2005: 22; Wood, 1992: 03). Therefore, as an observed behaviour, learning “is based on mastering a set of behaviors that are predictable and therefore reliable” (McLeod, 2003: 37). This implies that a thorough analysis of teaching strategies and desired learner behaviour as well as precise (structured) instruction will lead to the mastering of desirable skills and behaviour (McLeod, 2003: 37).

As a learning theory, behaviourism has the following implications for the educator in the ICT classroom:

- a) Learning objectives (goals) in lessons must be constructed in such a way that they are clear, observable and measurable (Woollard, 2010: 92; McLeod, 2003:37);
- b) Lessons can be organised according to levels of difficulty, therefore learners can work progressively through each level to master concepts (Pritchard, 2009: 12);
- c) Self-paced learning modules can be designed (Pritchard, 2009: 13);
- d) Desired behaviour and skills must be determined in advance and appropriate assessment methods should be chosen to measure the behaviour (McLeod, 2003:37; Ornstein and Hunkins, 1988: 113);
- e) Activities that stimulate, motivate and reward learners should be used (Woollard, 2010: 92; Ornstein and Hunkins, 1988: 112). However, rewards need to have value to learners (Pritchard, 2009: 10);
- f) Accomplishments should be reinforced with appropriate feedback (Green, 2002: 01)
- g) Rote learning (drill and practise) activities should often be repeated to maintain the desired behaviour (McLeod, 2003: 36, 37; Ornstein and Hunkins, 1988: 110);
- h) The learning process and its environment are carefully controlled by the educator, therefore the responsibility for student learning rests mainly with the teacher (McLeod, 2003: 36; Ornstein and Hunkins, 1988: 113).

With the behaviourist approach learning is teacher-directed and teacher-centred in the classroom (Forrester and Jantzie, n.d.: 07). Most lessons are delivered through direct instruction and are highly structured, therefore this approach does not leave room for a learner to direct his own learning processes (McLeod, 2003: 37) as the learner is viewed as “a passive person who only responds to stimuli” (Keese, 2011: para. 02).

The behaviourist learning theory also has a reductionist approach as it ignores a learner’s cognitive processes, consciousness and emotions, (Woollard, 2010: 02; Ornstein and Hunkins, 1988: 110) therefore, “it cannot account for all methods of learning” (Rostami and Khadjooi, 2010: 66). Although the existences of the mental processes are not denied,

their existence is acknowledged as an unobservable indication of learning (Forrester and Jantzie, n.d.: 04). One could argue then that if this theory ignores a learner's cognitive processes, consciousness and emotions, then by implication the educator also needs to incorporate cognitive principles into lessons to activate and enhance learning processes.

3.2.1.2 Roles of the educator and learner in a behaviourist classroom

Within the behaviourist classroom both the educator and learner have roles to play. In the behaviourist classroom the educator plays the following role:

- The educator designs the learning environment and curriculum by means of a task analysis to create activities which are focused and achievable, but also stimulate, motivate and reward learners (Woollard, 2010: 66, 90, 92);
- The educator identifies achievable objectives and learning outcomes, desired behaviours and those that should be discouraged (Woollard, 2010: 66-69). This notion indicates that the educator intends to shape and modify a learner's behaviour with positive and negative reinforcement (Pritchard, 2009: 13; Woollard, 2010: 73);
- The educator determines appropriate learner responses (McLeod, 2003: 37);
- The educator presents learning in small amounts (Woollard, 2010: 60);
- The teacher models appropriate behaviour to set an example for learners to copy or imitate (Woollard, 2010: 92, 97);
- The educator directs the learning process (Chen, n.d.: para. 06);
- The educator provides stimulus material and prompts correct responses (Haberkorn, n.d.: para. 02);
- The educator provides external rewards to reinforce the activity whereby the learner establishes a suitable means of learning. (Chen, n.d.: para. 06; Sotto, 2007: 35);
- The educator rewards achievement in a systematic and fair way (Woollard, 2010: 92);
- The educator assesses and evaluates to establish what the learner has learned and to determine the level of change in the learner's behaviour (Woollard, 2010: 20, 46).

Within the behaviourist classroom the learner learns passively and responds to stimuli (Woollard, 2010: 21). New knowledge and material is absorbed and used to prove in assessment activities that learning has taken place (McLeod, 2003: 37). In the behaviourist classroom learning will take place if the learner is actively engaged in the learning activity and if there is an immediate reward to reinforce learner activity (McLeod, 2003: 37; Woollard, 2010: 21). If a reward does not follow the desired learning, then expected and desired learning may not occur (McLeod, 2003: 37).

Tapscott (2009: 126,133) argues that we are in a digital age of learning where a change in learning is taking place from “broadcast” learning to “interactive” learning. He further argues that today’s learners are no longer satisfied in being passive recipients of traditional teaching, rather, they want to discover and learn new knowledge by becoming interactive with the learning process (Tapscott, 2009: 77). As computer technology is entering every component of our lives, we are compelled to assess its use in the learning process, therefore, we need to question how can it change the learners’ role within the behaviourist paradigm?

When learners play a passive role of receiving information by means of lectures in a teacher centred classroom, they “often fail to develop sufficient understanding to apply what they have learned (Rochelle, et al., 2000: 79). By becoming interactive with the help of computer technologies, learners can become involved in the learning process (Rochelle, et. al, 2000: 79, 80). Behaviourism based technologies such as drill and practice software, computer games, tutorials, simulations, integrated learning systems, as well as programmed instruction allow learners to engage actively in the learning process (Rogers, 2002: 24-25; Shield, 2000: para. 16; Rochelle, et al., 2000: 80). According to Rochelle et al. (2000: 81) reports from researchers suggested that learners who are actively engaged with computer based activities display increased motivation, a deeper understanding of concepts and an increased willingness to master difficult activities.

With a behaviourist approach in the ICT classroom, educators make use of two behaviourist principles, namely, shaping and modelling (Woollard, 2010: 97). When making

use of shaping, a learner carries out specific behaviour by means of repetition, “through steps that enable learning to get closer and closer to the desired outcome” (Woollard, 2010: 97). An example of shaping is drill and practice software as well as computer games that are used in the ICT classroom. Modelling as a strategy is used to show a learner what to do whereby the learner learn by “direct copying of subconscious imitation” (Woollard, 2010: 97). To give an example from my classroom: I would make use of modelling when teaching learners how to do certain actions within certain Microsoft Office applications. Actions such as undo, copy, paste, maximize, minimize, inserting pictures and shapes or deleting them are shown to learners, whereby they follow and copy my actions step by step.

Although behaviourism is not always viewed in a positive light due to its nature of being educator-centred and learning being passive, it has contributed to the body of knowledge regarding “how to structure content to ensure that learning objectives are met and higher levels of thinking are developed” (Stavredes, 2011: 41). Stavredes (2011: 41) states that behaviourism contributes to learning taxonomies used in the “cognitive, psychomotor and affective domains of learning”. This implies that behaviourism based activities can be linked to other learning paradigms such as constructivism and Cognitivism, and therefore, it may successfully contributes towards and complements learning processes in the classroom.

3.2.2 Constructivism

Constructivism as a learning theory developed from cognitive science and derives from the developmental work of Jean Piaget and Lev Vygotsky (Pritchard, 2009: 17; Stavredes, 2011: 37, 38). These theorists viewed constructivism from two perspectives, namely, that of cognitive constructivism (Piaget) and social constructivism (Vygotsky) (Pritchard, 2009: 18-25; Stavredes, 2011: 37, 38). As a learning theory constructivism was first introduced by Jean Piaget who is considered “to be one of the most influential early proponents of a constructivist approach to learning” (Pritchard, 2009: 18). Piaget considered himself a genetic epistemologist with training in biology and philosophy (Tokuhama-Espinosa, 2001: 44). He strongly grounded his finding to biology and tied it to education (Tokuhama-

Espinosa, 2001: 44). He suggested that learning takes place when knowledge is constructed by the learner from prior experiences through the process of accommodation and assimilation (Semenov, 2005: 115; Kozulin and Presseisen, 1995: 67-68; Pritchard, 2009: 20).

Constructivism is primarily a cognitive learning theory as it focuses on the mental processes that construct meaning (Forrester and Jantzie, n.d.: 09). Learning is considered as “mental work, not passive reception of teaching” (Pritchard, 2009: 20). This indicates a shift from teaching in the behaviourist approach to learning where educators assist learners to acquire knowledge in facilitating the learning process (Hokanson and Hooper, 2000: 543). Within the constructivist paradigm learners are actively engaged in their own learning processes where the learner “takes in new information and gives meaning to it by relating to it own prior attitudes, beliefs, and experiences as references” (Stavredes, 2011: 37, 41). This notion implies that if learners are actively engaged in their own learning process, then they are in control of the learning process as well (Pritchard, 2009: 32). It is a learner-centred approach where the acquisition and integration of knowledge is a constructive process (Stavredes, 2011: 37).

Vygotsky’s perspective of constructivism places emphasis on the social nature of learning where learning “could not be separated from the social context in which it occurs” (Stavredes, 2011: 38). As constructivism is social in nature, learning is a collaborative process as explained by Vygotsky’s theory of “zone of proximal development” (Pritchard, 2009: 25; Stavredes, 2011: 38). This theory argues that “with help from an instructor or peer, learners can understand concepts and ideas which they could not understand on their own” (Stavredes, 2011: 38). Learning then moves to a new level of understanding (Pritchard, 2009: 25). Stavredes (2011: 38) states that within the zone of proximal development the learner is only able to work efficiently with the help of support. The process of support is known as “scaffolding” and is given “at an appropriate time and at the appropriate level of sophistication to meet the needs of the individual” (Pritchard, 2009: 25). This scaffolding enables learners to work independently until they’re not able to learn without support (Stavredes, 2011: 38).

Constructivism has enabled educators to follow a more rounded approach to learning where learners are considered as active participants in the learning process (Stavredes, 2011: 42). Therefore, we need to question how this approach can be used effectively in a technology based classroom.

Martin-Stanley and Martin-Stanley (2007: para. 03) suggest that computer based instruction can be effectively used as part of the constructivist approach to learning. Furthermore, it gives learners access to resources and tools that facilitate the construction of knowledge, (Hannafin and Land, 1997: 170). Using computer technologies within a learning environment promotes access to resources and tools which facilitate construction of knowledge. Hannafin and Land (1997: 170), supported by Hokansen and Hooper (2000: 547), found upon examining the potential of computer technologies in education that “learner-centred instructions attempted to engage learners in activities, support knowledge construction through media use”. They further concluded that computers “afford students the ability to present and manipulate a variety of symbols (that is in various computer applications) to work in a number of languages, visually, acoustically, textually and numerically” (Hokansen and Hooper, 2000: 547). With this ability to interact with computers learners “manipulate and create knowledge through rapid manipulation with various symbol systems” leading to the improvement of the ability to generate thinking (Hokansen and Hooper, 2000: 547).

3.2.2.1 Implications of a constructivist approach in the classroom

As learners are actively engaged in the learning process, there are many effective ways to keep learners engaged with their work (Pritchard, 2009:31). For effective engagement to take place, the educator needs to take previous learning and knowledge in account as well as the level of difficulty, learners’ social and cultural context and the level of interest in the subject matter (Pritchard, 2009: 31). This implies that the following should be taken into consideration when planning lessons in the ICT classroom:

- a) Educators need to make a thorough learner analysis to determine the appropriateness of tasks that will promote learning (McLeod, 2003: 41);

- b) Educators need to identify clear goals and specific learning objectives (Pritchard, 2009: 31);
- c) Lessons should be based on learners' existing knowledge to "build" new knowledge (Pritchard, 2009: 31; McLeod, 2003: 41);
- d) Lessons need to take place within an appropriate meaningful context where a learner should be as near as possible to learning content, as it will promote learner engagement (Pritchard, 2009: 31, 33; McLeod, 2003: 29, 41; Jensen, 2005: 31);
- e) Lessons should accommodate opportunities for social interaction and activities as it promotes "collaboration, different points of view and effective understanding" (Pritchard, 2009: 31, 33, 34);
- f) Lessons need to be planned in such a way that they aim to move learners to the next level of understanding to make room for Vygotsky's zone of proximal development (Pritchard, 2009: 31);

Constructivism presents opportunities for multiple representations and perspectives of reality to be used in the classroom, (Pritchard, 2009: 32; McLeod, 2003: 41). Pritchard (2009: 32) states that when "learning involves the use of a variety of resources, alternative viewpoints of the subject in question are formed; this in turn can be used to foster the skills of critical thinking". This notion affords learners to "develop and articulate new and individual representations of information", through which "active knowledge construction" can take place (McLeod, 2003: 41).

A constructivist classroom also presents opportunities for learners to reflect what they have learned (Pritchard, 2009: 33). This phenomenon is known as metacognition (Pritchard, 2009: 27; Cilliers, 2010: 15; Sorensen and Murchú, 2006: 305). Metacognition is the process of "cognition about cognition" as it refers to a person's "ability to think about one's own thinking" (Sorensen and Murchú, 2006: 305; Cilliers, 2010: 14, 15), for example: when a learner has trouble learning certain information and realises that he or she has trouble learning it, then the realisation of his or her own learning process is considered as metacognition. This process also includes a learner finding strategies to regulate the learning process to learn more effectively and to monitor his or her own learning (Cilliers, 2010: 14, 15).

3.2.2.2 Roles of the educator and learner in a constructivist classroom

The roles of an educator and learner in the constructivist classroom are opposite to roles in the behaviourist classroom (Pritchard, 2009: 113). The constructivist based classroom presents the educator and learner roles with a paradigm shift where learning is learner-centred, with an emphasis on the learning process and the educator being a facilitator who facilitates the learning process (Stavredes, 2011: 37; 39). This paradigm shift has contributed to a “more holistic approach” towards efficient learning processes and the achievement of predetermined goals (Stavredes, 2011: 42).

3.2.2.2.1 The role of an educator in the constructivist classroom

The role of a constructivist educator is different to the role of a behaviourist educator (Stavredes, 2011: 40, 41). Constructivism takes the focus from the “educator-centred lecture” and places it upon the learner and his learning (Stavredes, 2011: 39). Thereby the educator takes a role of a facilitator, in facilitating the learning process in the classroom (Stavredes, 2011: 39). Apart from being the facilitator, the educator has the following role to play:

- a) Educators “relinquishes control to empower learners” (Gray, 1995: 67);
- b) Educators “encourage and accept student autonomy and initiative” (Brooks and Brooks, 1999: 103);
- c) Educators provide relevant context for learners (Stavredes, 2011: 40) by using “raw data and primary resources, along with manipulative, interactive and physical materials” (Brooks and Brooks, 1999: 103, 104; Jensen, 2005: 31);
- d) Educators use higher thinking skills as part of activities (Brooks and Brooks, 1999: 104, 105);
- e) Educators encourage engagement with learning content (Pritchard, 2009: 31);
- f) Educators prompt and facilitate discussion by asking learners questions and afford them opportunities to respond to questions and engage in dialogue, both with the educator and with each other (Brooks and Brooks, 1999: 105-108). Strategies which can be applied by discussions are:
 - i. Enquiry where learners are prompted to formulate their own questions (Stavredes, 2011: 41);

- II. By accommodating multiple intelligences by allowing multiple interpretations and expressions of learning (Stavredes, 2011: 40);
- III. By collaborative learning through group work and the use of peers as resources (Brooks and Brooks, 1999: 105-108);
- g) Educators inquire from learners whether they understand concepts before sharing their own understanding of those concepts” (Brooks and Brooks, 1999: 106, 107);
- h) Educators “seek elaboration of learners’ initial responses” (Brooks and Brooks, 1999: 111);
- i) Educators “recognise the importance of learners’ mental activities” (Pritchard, 2009: 29);
- j) Educators promote learning environments that enable engagement in the classroom through exploration, transformation, presentation and reflection (Pritchard, 2009: 31).

O’Neill and McMahon (n.d.: 34) state that the demographics of current learner populations are constantly changing in today’s world and that it provides a climate where learner-centred teaching is thriving. Learner-centred learning has been instrumental in the paradigm shift which educators have to make in a constructivist classroom. Constructivist based teaching “places learners at the heart of their learning processes and in meeting their needs” (O’Neill and McMahon, n.d.: 30-34). This enables learners to learn “what is relevant to them and in ways that are appropriate” to the differences in learning styles and ways of learning (O’Neill and McMahon, n.d.: 30-34). This paradigm enables educators to become partners with learners in the learning process (Martin-Stanley and Martin-Stanley, 2007: para. 02), ensuring success in the achievement of pre-set goals.

3.2.2.2 The role of learners in a constructivist classroom

Learner roles have changed from a passive to an active learning experience in the constructivist classroom. This change in role requires of learners to (be):

- a) Active participants, by participation and being involved in the learning process (O’Neill and McMahon, n.d.: 28);

- b) Taking part in social activities concerning new knowledge by having discussions with each other as well as the educator;
- c) Making use of metacognition to reflect upon what was learnt. Learners need to continually check their understanding, which will result in the modification and improvement of what is retained (Pritchard, 2009: 27). Learning is facilitated when learners are aware of their learning strategies and when they monitor the use thereof (Cilliers, 2010: 14 and 15);
- d) Become engaged by applying their current knowledge and experience, by learning to hypothesize, testing their theories, and drawing conclusions from their findings (Pritchard, 2009: 19-20);
- e) Have increased responsibility and accountability towards their learning (O'Neill and McMahon, n.d.: 28);
- f) Responsible for peer and self-assessment (O'Neill and McMahon, n.d.: 30-32).

From this information regarding the roles of a learner within a constructivist classroom, it is clear that there is a shift of power in the educator-learner relationship (Pritchard, 2009: 34). With this shift of power comes responsibility and accountability for the learner in the learning process (Pritchard, 2009: 34).

Research suggests that constructivist teaching is an effective way to teach. It encourages active and meaningful learning and promotes responsibility and autonomy (Stavredes, 2011: 37-41; Gray, 1995: 34, 142, 148). Furthermore, it fosters critical thinking and creates active and motivated learners (Gray, 1995: 146-148). Constructivist teaching is greatly beneficial towards learners in their learning process and in achieving their desired goals (Stavredes, 2011: 42).

3.2.3 Cognitivism

Cognitivism grew in response to behaviourism in carrying the notion that learning is much more than just responding to stimuli (McLeod, 2003: 38). Cognitivism is “the scientific study of mental processes such as learning, perceiving, remembering, using language, reasoning and solving problems” (Pritchard, 2009: 17). It involves “how people learn,

remember and interact” and has a “strong emphasis on mental processes often with an emphasis on modern technologies” (Pritchard, 2009: 17).

Ornstein and Hunkins (1988: 138) state that Cognitivism is a learning theory conducive to explaining various levels of thinking among humans, including concept thinking, problem solving, and creativity. The term “cognition” which the theory originates from “literally means ‘*meaning*’ and includes all the mental processes by means of which a learner becomes aware of his environment or gains knowledge, organises and applies knowledge” (Cilliers, 2010: 14). It is “the ability to think, to process, and store information, and to solve problems” (Pritchard, 2009: 26).

In Cognitivism, what is observed by the human eye is interpreted or constructed by applying previous learned knowledge (Ornstein and Hunkins, 1988: 141). What is perceived will determine the meaning given to the knowledge (McLeod, 2003: 39). It is from this viewpoint that the use and application of computer technology based tools in the educational process may be beneficial and contribute to the cognitive and learning processes of a learner by movement, what is visually seen, heard, felt and experienced. The interaction between learner and computer acts as a stimulus in triggering cognitive and learning processes (Hokansen and Hooper, 2000: 548). Therefore, the computer can be viewed as a “cognitive medium” which provides “an environment for intellectual growth” (Hokansen and Hooper, 2000: 549).

Computer technology mediated environments are characterised by a richness of vividness and interactivities which may play a crucial role in the learning process (Kozma, 1991: 179-211). Animation, graphics, sound effects and narration found in presentations further enhance vividness. Vividness refers to the colourfulness, vibrancy, liveliness and creativity found in computer mediated environments. Vividness as defined by Nicholson, Nicholson and Valacich (2007: 07) “is the representational richness of mediated environment as defined by its formal features; that is, the way in which an environment presents information to the senses”. Sorensen and Murchú (2006: 313) state that “a rich sensory environment enhances learning with a variety of stimuli”. Thus, the vividness found in

computer technology mediated environments can be used to increase learner satisfaction and interest, to appeal to learner senses, to increase and sustain attention (Nicholson, *et al.*, 2007: 7, 8) in the classroom. It can be successfully integrated into the learning process to accommodate the visual, auditory and kinaesthetic learning styles learners may have a preference to; therefore, enhanced learning can take place (Sprengrer, 2010: 70, 71).

3.2.3.1 Roles of the educator and learner in a cognitivist classroom

As with the constructivist classroom where there is an emphasis on the mental processes where a learner actively contributes to the process of constructing meaning, a cognitivist classroom presents opportunities for both educators and learners to play active roles in the learning process (O'Neill and McMahon, n.d.: 28; Stavredes, 2011: 39). These roles are contrary to that of behaviourism where the educator's role takes the main stage within the classroom and the learner being a passive participant that only responds to stimuli (Woollard, 2010: 21). The educator's role changes from being a lecturer to that of a facilitator, which enables a shift of power towards learners whereby they take responsibility for their own learning experiences (O'Neill and McMahon, n.d.: 28; Pritchard, 2009: 34; Stavredes, 2011: 39). The next two sections discuss the roles of educators and learners within a cognitivist classroom more broadly.

3.2.3.1.1 The role of the educator in the cognitivist classroom

In a cognitivist classroom the educator's main role is to assist the learner in the application of appropriate learning strategies to achieve learning goals (Haberkorn, n.d.: para. 05). However, there is more to the role an educator has to fulfil in the classroom. These roles are:

- a) "To recognise the importance of mental activity in learning" (Pritchard, 2009: 29);
- b) To help learners to organise information for successful processing into long-term memory and recall (Stavredes, 2011: 37);
- c) To determine learning outcomes and direct the learning process with the "help of additional application of specific information-processing strategies to assist the learner in acquiring knowledge" (Stavredes, 2011: 37);

- d) To facilitate learning the educator should arrange the learning environment to “maximise learners’ ability to retrieve prior knowledge relevant to the learning outcomes and organise content to maximise information processing” (Stavredes, 2011: 37);
- e) To “provide appropriate context for learners to draw on prior knowledge and fit new information into existing schema” (Stavredes, 2011: 37; Pritchard, 2009: 22, 33). Stavredes (2011: 37) argues that in the “case of learners with little prior knowledge, educators need to provide opportunities to create new schema by relating the new information to something that is similar to them”;
- f) To promote learners’ autonomy in their learning process (Pritchard, 2009: 33);
- g) To promote social interaction between learners and the educator and learners (Pritchard, 2009: 33);
- h) To allow opportunities for metacognition where learners reflect upon what they have learnt (Pritchard, 2009: 33);
- i) To create opportunities for mental activities and higher order thinking skills (Pritchard, 2009: 33);
- j) To use cognitive strategies to impact both the task and learner. This process is known as content enhancement (Bulgren, Deshler and Schumaker, 1997: 198-208).
Four educator activities are important in content enhancement, namely:
 - I. Selecting the central concepts that make the details and facts come together, and identifying connections among concepts (Deshler, Schumaker, Lenz, Bulgren, Hock, Knight and Ehren, 2001: 96-108);
 - II. To determine the necessary methodologies towards learning that will contribute to learner success (Deshler et. al., 2001: 96-108). This approach includes “selecting and constructing instructional devices that will make the content more understandable and memorable” (Deshler et. al., 2001: 96-108);
 - III. To present the content in a way that actively involves students while enhancing their learning (Bulgren, et. al., 1997: 198-208);
 - IV. To teach with “routines and instructional supports” that will assist learners when they apply “appropriate techniques and strategies” (Swanson and

Deshler, 2003: 129-130). These routines “are sets of inclusive teaching practices that help teachers carefully organize and present critical content information in such a way that students identify, organize, comprehend, and recall it” (Deshler et. al., 2001: 96-108);

From the above roles of an educator in the cognitivist classroom it is clear that the emphasis in a cognitive classroom for an educator is to use various strategies to assist individual learners in organising information for successful processing into long-term memory and the recollection thereof (McLeod, 2003: 38; Stavredes, 2011: 37). By doing so a learner’s mental capacity and skills are increased which in its turn assists in improving the learning process of a learner (McLeod, 2003: 38).

3.2.3.1.2 The role of the learner in the cognitivist

In the cognitivist classroom, learners play an active and critical role in determining what they get out of a lesson (Stavredes, 2011: 37). In order to learn successfully, the learner takes responsibility and is in control of his or her own learning processes by doing the following:

- a) Learners process, store, and retrieve information for future use by creating associations to memorise information and creating new knowledge collections for use in the real world (McLeod, 2003: 41; Sprenger, 2010:102-104, 125) The learner uses an information processing approach to transfer and assimilate new information (Pritchard, 2009: 20);
- b) As with constructivism, a learner uses metacognition to reflect upon what was learnt to continually check their understanding. By questioning themselves and the strategies they are using, learners gain understanding about their own learning processes and tools to enhance their learning. As mentioned previously, learning is facilitated when learners are aware of their learning strategies and when they monitor the use thereof (Cilliers, 2010: 14 and 15; Pritchard, 2009: 27);
- c) Learners develop their own cognitive structures with the facilitation of an educator by “transfer of learning” (Cilliers, 2010: 79-82). These cognitive structures help learners to make connections with already known knowledge and experience to

new knowledge and experiences (Garner, 2007: 03, 05). Furthermore, it also helps learners to compare, analyse and organise information and knowledge into patterns and relationships (Garner, 2007: 05);

- d) Learners need to act on information in ways that will make it meaningful to them (Stavredes, 2011: 37, 41). When information is meaningful, it is easier to be retained (Shaffer and Kipp, 2014: 269; Ambrose *et al.*, 2010: 04);

From the previous given information regarding the roles of a learner within a cognitivist classroom, one may conclude the role of a learner is that of an active learner who has to process, store and retrieve information. Furthermore the learner has to use metacognition to keep track of his or her own learning process, develop cognitive structures and act on information to make learning meaningful. Unlike the passive learner role in behaviourism, this learner role is demanding and requires of a learner to be an active participant in the learning process. Although the role is demanding, it affords learners opportunities to learn better and more effectively to prepare them for the real world outside the classroom.

From the presentation of the three learning theories, namely behaviourism, constructivism and cognitivism, the previous information has presented us with knowledge regarding how learners learn. All three theories play an important role regarding learning in the classroom (Pham, 2011: 414). Learning is demonstrated not only in the observed changes of a learner's behaviour but also by changes in a learner's cognitive processes (Pham, 2011: 406). These theories have implications on how educators teach and the strategies they use in the classroom (Stavredes, 2011: 40). Behaviourism focuses on how learning takes place by a change in behaviour and prescribed teaching strategies to shape behaviour (Ornstein and Hunkins, 1988: 108; Cilliers, 2005: 22; Wood, 1992: 03). Constructivism considers how learning occurs through the change of structures in memory and how learners construct knowledge in the learning process (Semenov, 2005: 115; Kozulin and Presseisen, 1995: 67-68; Pritchard, 2009: 20). With cognitivism, learning is based on the individual mind, its cognitive processes, the role memory plays and how information is processed in the learning process (Jensen, 2005: 15-19; Pham, 2011: 408).

As learners have different learning styles and diverse backgrounds, the three learning theories afford educators to design lessons with combined characteristics of these theories to fill the learning needs of learners and contribute towards effective learning in the classroom (Pham, 2011: 414).

3.3 Defining learning.

What is learning? According to Ambrose, *et al.* (2010: 03) learning is “a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning”. She added that there are three critical components to this definition, namely:

1. “Learning is a *process*, not a product. However, because this process takes place in the mind, we can only infer that it has occurred from students’ products or performances” (Ambrose, *et al.*, 2010: 03);
2. “Learning involves *change* in knowledge, beliefs, behaviors, or attitudes. This change unfolds over time; it is not fleeting but rather has a lasting impact on how students think and act” (Ambrose, *et al.*, 2010: 03);
3. “Learning is not something done *to* students, but rather something students themselves do. It is the direct result of how students interpret and respond to their *experiences* — conscious and unconscious, past and present” (Ambrose, *et al.*, 2010: 03).

The learning process according to Poplin (1988: 404) is “a process whereby new meanings are constructed (created) within the context of a person’s current knowledge”, but, it is also “the ability to think critically, to solve complex problems and express ideas with clarity” (Brandsford, Brown and Cocking, 2001: 4-5). It involves the stimulation of the mind to create, organize, structure and analyse information. During the learning process new knowledge and skills are acquired and remembered. These processes involve critical thinking and solving problems as well as the ability to comprehend and understand. The purpose of the processes is to create new meaning to the learning experience and to create new behaviours (De Jager, 2006: 08).

3.4 Learning as a cognitive process

Research done in understanding cognition has brought an abundance of information regarding the effects it has on learning. Learning is considered a process and cognition can be seen as the processing of information through mental processes such as thinking, perceiving, remembering, comparing, problem solving, etc., by giving meaning to it (Mahoni, 2010: para. 01). Pritchard (2009: 32) considers learning in a cognitivist environment as “a relatively permanent change in mental associations as a result of experience”. It may also refer to the processes by which a person learns and involves strategies to achieve learning. During these processes a person “becomes aware of his environment or gains knowledge, organizes and applies it” (Cilliers, 2005: 14).

3.5 The Learning process

Learning consists of the flow of information (Sigelman and Rider, 2003:192-193) from input of stimuli through its processing to the output thereof. To understand this process of the flow of information, we need to consider the different stages of input, processing and output.

3.5.1 Input

The brain receives input in the form of stimuli from the sensory system (De Jager, 2006: 33; Sorensen and Murchú, 2006: 297). In a classroom situation, the most predominant senses used are the visual, auditory and kinaesthetic senses. Information is received as raw data and needs to be processed before it makes sense. According to Johnson (1998: 01) a person doesn't simply learn because information is put into the brain. Other factors such as physical and emotional factors as well how a person receives and processes information determines what is retained in the learning process. This is echoed by MacLean's theory of the triune brain stating that external factors play an important role in whether learning takes place or not at all (Sprenger, 2010: 94-96; McLean, 1973: 06-66).

3.5.2 Processing

The purpose of processing information is to convert the raw sensory data received via the senses to make sense of and to give meaning to it (De Jager, 2006: 40). When a learner is

able to process the raw data effectively, learning takes place. If the acquired data is new the brain starts to develop new neural connections (Sorensen and Murchú, 2006: 298). When neural connections are strengthened by means of repetition, data is stored in the long-term memory and retained (McLeod, 2003: 36). In the event of not storing data successfully, learning barriers are experienced (De Jager, 2006: 40).

The processing of information as explained above, relates to cognitive constructivism where Piaget regards learning as a “process of adjustment to current schemas” (also known as mental structures or models) due to “environmental influences” (Pritchard, 2009: 19). Piaget describes three procedures which form this “process of adjustment”, namely, assimilation, accommodation and equilibrium (Pritchard, 2009: 19). Assimilation is the “process whereby new knowledge is incorporated into existing mental structures” (Pritchard, 2009: 20). Current knowledge is “increased to include new information” (Pritchard, 2009: 20). Accommodation is the process “whereby mental structures have to be altered in order to cope with the new experience which has contradicted the existing model” (Pritchard, 2009: 20). This is also where existing schema is altered by accommodation (Kibler, 2014: para. 01). After assimilation equilibrium takes place (Pritchard, 2009: 20). Equilibrium is the process of “arriving at a stable state where there is no longer a conflict between new and existing knowledge” (Pritchard, 2009: 20). When a learner’s existing mental structure encounters new knowledge, which creates conflict between the old and new, disequilibrium takes place (Kibler, 2014: para. 01; Kramer, 1999: 07). Kibler (2014: para. 01) describes equilibrium as a “state of cognitive imbalance which requires of the learner to develop a new schema or to modify an existing schema” (Kibler, 2014: para. 01).

3.5.3 Output

During output the learner retrieves and actively uses the information that has been stored in long-term memory (Sprenger, 2010: 121; Pritchard, 2009: 58). A learner’s ability to learn is best reflected by the output he or she produces (De Jager, 2006: 45). This output takes place in the “form of communication and actions” (De Jager, 2006: 45; Pritchard, 2009:

58). Through various ways of output the result from the sensory system will reflect whether effective processing of information took place or not.

3.6 Learning styles

Learning styles refer to the preferred “specific ways according to which a learner reacts to stimuli in the learning context” (Cilliers, 2005: 25). Sprenger (2010: 70) simplified the notion in stating that it is “the way you receive information best”. Learning styles may be visual, auditory or kinaesthetic (Pritchard, 2009: 44, 45; Sprenger, 2010: 70). Although most people use a combination of the three learning styles, they usually have a strong preference for one (Pritchard, 2009: 45).

Visual learners require visual stimuli to activate their brain processes (Pritchard, 2009: 51; Sprenger, 2010: 72, 73). They learn best by looking at graphics, using colour, by watching demonstrations, videos, slide shows or by reading visually appealing information (Pritchard, 2009: 51; Sprenger, 2010: 72, 73). Auditory learners require sound (Sprenger, 2010: 74; Pashler, McDaniel, Rohrer and Bjork, n.d.: 106). They would rather listen to things being explained to them or information that is read out loud (Pashler *et. al.*, n.d.: 106). Computer activities such as group work on the computer, music and audio conferencing via the Internet could be used for auditory learners (Sprenger, 2010: 80). Kinaesthetic learners require movement, touch and hands-on experiences to learn (Sprenger, 2010: 75). Learning may also be efficient when writing down information or by typing and doing learning activities on a computer and movement of the computer mouse (Sprenger, 2010: 80). None of the mentioned learning styles is ‘the better one’ to use in learning as information is gathered through the senses (Cilliers, 2010: 25). Learning styles can be adapted to suit a specific learning activity. Pritchard states that when “pupils are taught with approaches and resources that complement their particular learning styles, their achievement is significantly increased”, and it will help them to achieve their goals (Pritchard, 2009: 51).

Where does computer technology fit into learning styles? Educators currently teach learners who work with technology as though it is second nature to them (Sprenger, 2010: 70, 71). Computer technology offers something for every learner and learning style in the

classroom (Sprenger, 2010: 71). Incorporating learners' different learning styles in lesson planning and activities may provide educators with a variety of choices in the use of available computer technologies in their teaching practices (Pritchard, 2009: 51; Sprenger, 2010: 71).

3.7 The role of computer-based technologies in learning.

The presence of computer technology in a classroom does not necessarily ensure the effective use thereof (Higgins, 2003: 06). Effective use depends on various factors such as learners' and educators' computer skills, technologies available and how computer applications are used (Higgins, 2003: 06). Even though these factors may impact effectiveness, research done by Roschelle, *et al* (2000: 76, 78) has shown that computer technology can support learning and be useful in developing higher-order thinking skills such as critical thinking, analysis and scientific enquiry. Furthermore, research done by Hasselbring and Williams Glaser (2000: 102) showed that computer technologies can play an important role in meeting a variety of needs of learners with learning barriers and disorders.

3.7.1 The construction of knowledge.

As previously stated, learning takes place when learners are actively constructing their own knowledge and attempting to make sense of their experiences. Computer technology's characteristics make it a useful tool in the construction of learners' knowledge (Roschelle *et al.*, 2000: 89-101). To give an example, learners can make use of various applications to interpret data gathered in scientific experiments. Using these technologies for active engagement among learners, construction of knowledge is not limited to specific subjects such as Mathematics and Science, but can be successfully used in other areas of a school's curriculum (Roschelle *et al.*, 2000: 79). Applications such as slide shows, desktop publishing and videos can be used to involve learners actively in constructing presentations which may reflect understanding of their newly created knowledge in any subject (Roschelle *et al.*, 2000: 89, Watkin, 2006: para. 12-22).

Jonassen (1994: 02) supports the notion of using computer technologies as tools that engage and facilitate cognitive processing as well as help learners in the construction of knowledge. Jonassen, Carr and Yueh (1998: 01) regard computer technologies and applications as “mind tools” which may assist learners to “represent what they know” and “engage them in critical higher order thinking about the content they are studying”. Jonassen *et al* (1998: 13) affirms that mind tools do not make learning easier. On the contrary, they require learners to “think harder” about subject matter being studied, while “generating thoughts would be impossible” without the mind tool. When learners think “harder”, they are also “thinking more meaningfully as they construct their own realities by designing their own knowledge bases” (Jonassen *et al*, 1998: 13)

Jonassen *et al* (1998: 02) state that there are different classes of mind tools such as “semantic organization tools, dynamic modelling tools, information interpretation tools, knowledge construction tools, and conversation and collaboration tools”. Semantic organisation tools assist learners in analysing and organising what they know and what they are learning (Jonassen, *et al.*, 1998: 02). It “represents semantic relationships among ideas” (Jonassen, *et al.*, 1998: 04). Examples of semantic organisations tools are databases and concept mapping such a mind maps (Jonassen, *et al.*, 1998: 02, 03).

Dynamic modelling tools assist learners in describing dynamic relationships between ideas (Jonassen, *et al.*, 1998: 04). Examples of dynamic modelling tools are software applications such as spreadsheets, expert systems, systems modelling tools, and micro worlds (Jonassen, *et al.*, 1998: 04). Although spreadsheets are used for numerical record keeping such as accounting, budgeting and mark sheets, I’ve also found it useful for learners to construct timelines, diagrams and charts, interactive pictures and maps.

Information interpretation tools assist learners in having access and process information (Jonassen, *et al.*, 1998: 09). To give examples, information intelligent systems such as search engines help learners to locate resources they need and visualisation tools such as simulating software give learners visual representations of information they are learning. An application such as Google Earth gives learners a visual 3D representation of what

places, towns, cities and countries look like. Chemsketch is a visualisation application used to give a 3D visual representation of chemical compounds and molecules.

Knowledge construction tools refer to the process of knowledge construction resulting from constructing things. When learners as designers create objects, they learn more about those objects than they would from studying about them (Jonassen, *et al.*, 1998: 10). An example would be the West Point Bridge simulation recently used in the Sunlands computer laboratory for Grade 6 Technology classes where learners could build, arch, suspension and truss bridges. In this simulation application learners design a particular bridge. When the design is completed the application would play a simulation of a vehicle crossing the bridge. A successful designed bridge would allow the vehicle to cross safely. If the bridge had weak points in the design, the application would point that out. Should the learner's design not adhere to certain standards, the bridge would collapse.

Conversation and collaboration tools support the social component of constructivism used to construct knowledge (Jonassen, *et al.*, 1998: 11). Online communication applications assist learners to participate meaningfully in conversations where messages can be interpreted, appropriate responses are considered and coherent replies can be constructed (Jonassen, *et al.*, 1998: 11). Applications such as email, blogs, MOOC's, Moodle, Skype and online education communities would serve as examples of conversation and collaboration tools.

Computer applications may help learners understand fundamental concepts in subjects such as Science, Mathematics and Literacy by representing what is learnt in a less complicated manner. Applications making use of visualisation, modelling, interactive content and simulations have been proven to be a power tool in teaching concepts in the mentioned subjects (Rochelle, *et al.*, 2000: 80- 86). When these technologies are used learners are able to grasp and master complicated concepts better (Rochelle, *et al.*, 2000: 78). Where there is better understanding, learning takes place more efficiently.

3.7.2 Learning in a social context

Russian psychologist Igor Vygotsky has been influential in focussing on the social basis of learning (Stavredes, 2011: 37, 38). He suggested that “learning could not be separated from the social context in which it occurs” (Stavredes, 2011: 37, 38). Jackson (2011: 14) supports Vygotsky’s notion in stating that “Learning is socially mediated; we learn from, through, and with others”. The social need to belong may often be a contributing factor and may serve as a motivation for a learner to learn (Sprenger, 2010: 58). A learner’s social identity can be enhanced with group participation and belonging to a group (Sprenger, 2010: 58). Collaboration within the social class setting contributes towards learning in the form of learner discussions (Higgins, 2003: 14; Jonassen, *et al.*, 1998: 11).

3.7.3 Collaboration in the learning process

Apart from discussing constructed knowledge in a social context and what was learnt in learner presentations, computers can be used to support educational collaboration internally in the classroom and among other schools (Jonassen, *et al.*, 1998: 11). The use of technologies such as the Internet, social networks, websites, blogs and e-mail contribute towards collaborative activities in the classroom (Jonassen, *et al.*, 1998: 11). It may enhance social activities and conversation which can lead to learners’ deeper understanding of the learning content (Jonassen, *et al.*, 1998: 15).

3.8 A comparison of behaviourism, constructivism and cognitivism

Keesee (2011: para. 01) states that learning theories provide educators a pedagogical basis for understanding how learners learn. McLeod (2003: 35) explains that learning theories offer educators as instructional designers “clarity, direction and focus throughout the instructional design process”. He further states that by understanding learning theories, educators are able to design and “effectively prepare and present instruction” in the classroom. Although behaviourism, constructivism and cognitivism were discussed earlier in this chapter, Table 3.1 addresses the need to briefly compare the three theories’ key concepts and their implications on instructional design:

	Behaviourism	Cognitivism	Constructivism
Key concepts	<p>A theory of animal and human learning, focussing on observable behaviour and discounting mental activities (Woollard, 2010: 02).</p> <p>It is “useful for building and strengthening stimulus-response associations” (Ertmer and Newby, 1993: 56)</p>	<p>A theory focussing on mental processes of the brain of the individual such as:</p> <ul style="list-style-type: none"> • Learning; • Perceiving; • Remembering; • Reasoning; • Solving problems; • Thinking. 	<p>Constructivism is a theory of learning which emphasises the social construction of knowledge (Stavredes, 2011: 41).</p> <p>Social constructivism is rooted within the cognitivist domain of learning theories (Pritchard, 2009: 17).</p> <p>It is a theory focussing on the mental processes that construct meaning or new concepts based on current or past knowledge, social interactions and motivation. (Forrester and Jantzie, n.d.: 20).</p> <ul style="list-style-type: none"> •The learning process takes place both internally and externally Stavredes, 2011: 41). <p>Constructivism emphasises the “flexible use of existing knowledge rather than the recall of schemas (mental models)” (Ertmer and Newby, 1993: 63).</p>
What is learning?	<ul style="list-style-type: none"> • Learning is a change in behaviour (Weegar and Pacis, 2012: 02). • The environment influences behaviour and learning (Ornstein and Hunkins, 1988: 108). 	<p>Learning is seen as the mental processes used by learners to gain knowledge, to organise and apply the knowledge (Cilliers, 2010: 14).</p> <p>Learning is also:</p> <ul style="list-style-type: none"> •A process taking place within an individual (Pritchard, 2009: 17). •An active process 	<ul style="list-style-type: none"> • Learning takes place by knowledge construction through accommodation and assimilation (Semenov, 2005: 115). • Learning takes place as a result of mental construction (Pritchard, 2009: 17). • Learning is an active process (Stavredes, 2011: 37, 41). • Learning is a collaborative process where social dialogue within a group is

	<ul style="list-style-type: none"> • Learning is reinforced with repetition and reinforcement (McLeod, 2003: 36). • Learning is passive as learners just respond to stimuli (Keese, 2011: para. 02). 	<p>(Ertmer and Newby, 1993: 58)</p> <ul style="list-style-type: none"> • A change in memory structure of an individual (Stavredes, 2011: 41). <p>Metacognition plays an important role where the individual's knowledge of his/her own cognition is used to consider and control their own cognitive processes (Pritchard, 2009: 27).</p>	<p>used to develop and share alternative views (Ertmer and Newby, 1993: 65; Pritchard, 2009: 25, 31).</p> <ul style="list-style-type: none"> • The creation of meaning through learning experiences (Ertmer and Newby, 1993: 62).
<p>Implications for Instructional /Lesson Design</p>	<ul style="list-style-type: none"> • Designers need clear, measurable goals regarding the desired behaviour (Woollard, 2010: 92) • Learning is "based on mastering a set of behaviours that are predictable and reliable" (McLeod, 2003: 37). • Repetition and reinforcement should be regular activities to prevent 	<ul style="list-style-type: none"> • Thorough analysis and consideration for appropriate task are needed in instructional design (McLeod, 2003: 39). • Instructional goals should include individual learner needs (McLeod, 2003: 39) • Educators are responsible for "assisting learners in organizing information" in an optimal manner (Ertmer and Newby, 1993: 59). 	<ul style="list-style-type: none"> • A thorough analysis of appropriate tasks should be done (McLeod, 2003: 41). • Identification of clear goals and learning objectives (Pritchard, 2009: 31). • Transfer of previous knowledge to new knowledge (Pritchard, 2009: 31). • Learning activities takes place in a real meaningful context (Jensen, 2005: 31) • Creation of opportunities for social interaction (Pritchard, 2009: 33). • Planning of lessons need to accommodate Vygotsky's zone of proximal development, where a learners has mastered a skill, but can achieve more with the input of another adult or peer (Pritchard, 2009: 25, 31). • The goal of instruction is to

	weakening of the stimulus. (McLeod, 2003: 37)		ensure that learners elaborate on and interpret information (Ertmer and Newby, 1993: 63). • To accommodate the reflection on previous learning experiences. This is done to integrate new learning experiences into existing knowledge (Pritchard, 2009: 33)
--	--	--	---

Table 3.1 – A comparison of learning theories

Although the mentioned learning theories each have their own strengths and weaknesses, it provides different opportunities in which learning can be optimised in the classroom. McLeod, as cited in Keese (2011: para. 01) suggests that “since the context in which the learning takes place can be dynamic and multi-dimensional”, a combination of the learning theories should be considered and included into the instructional design process of lessons to enable optimal learning to take place.

3.9 Conclusion

Chapter 3 defined learning as a process that leads to change, which occurs as a result of experience and increases the potential for improved performance and future learning. It was also stated that learning is a cognitive process. The study in this chapter also looked at the process of learning; how it takes place and how the learning styles of learners differ.

It was stated that computer technologies contribute towards how learners learn and could be used as a cognitive tool to enhance the learning process. The implication of this chapter, therefore, is that the ability to learn effectively could be achieved with the use of computer technologies as a cognitive tool, thus, contributing to higher academic achievement.

Chapter 4

Cognitive Education

4.1 Background

In chapter 3 different learning theories were discussed and how they could be used within the ICT-enabled classroom. However, there is a need to promote whole brain learning with the use of computers as a learning and cognitive tool. Whole brain learning is built on the premises of cognitive education which claims to be a teaching technique that promotes the use of all mental (cognitive) processes whereby “a learner becomes aware of his environment or gains knowledge, organises and applies knowledge” (Cilliers, 2010; 14). Chapter 4 will focus on cognitive education, tenets it is built on and how these tenets can be successfully applied with the use of computer technologies.

4.2 What is cognitive education?

Cognitive education, also known as brain-based education is now an established paradigm in the United States of America and other countries (Jensen, 2005: 01), but has only recently been introduced in South Africa (Goodyer, 1997: v). Ashman and Conway (1997: xiv) state that cognitive education refers to the application of cognitive theories and the principles thereof to assessment, instruction, remediation and education practise within the classroom. As a learning theory, cognitive education “brings together the disciplines of cognitive psychology and education” (Ashman and Conway, 1997: no page no.).

Cognitive education presents a paradigm shift in learning where emphasis is put on “learning how to learn” (Ashman and Conway, 1997: 15) and refers to instructional techniques that are grounded in the neuroscience of learning (Abbott, 2014: para. 03). The application of Cognitive education aims to enhance learners’ learning potential by means of “effective learning and teaching processes, seeking the best conditions in which learning takes place in the brain” (Ozden and Gultekin, 2008: 02).

Cognitivists view the learning process as one that is internal and active and which develops

within a learner, increases his or her mental capacity and skills to learn better (McLeod, 2003: 38). During the learning process there is a relatively permanent change in internal mental associations which results from experience (Pritchard, 2009: 32).

In cognitive education an educator's role is to assist learners in maximizing their cognitive and thinking skills by stimulating as many cortical lobes as possible during the learning process (Cilliers, 2005: 13; McLeod, 2003: 39). The main cortical lobes needed in learning are the frontal lobes (needed for cognitive thinking, planning and a sense of responsibility), temporal lobes (hearing), occipital lobes (vision), parietal lobes (haptic functions) and limbic lobe (emotions) (Cilliers, 2005: 13; Sprenger, 2010: 157, 158). Simultaneously the whole brain should be optimised in making use of the conscious, sub-conscious, cortex and sub-cortex (Buzan, 2003:33; Cilliers, 2005: 7, 8; Jensen, 2005: 19; Sorensen and Murchú, 2006: 305).

4.3 Principles on which cognitive education is built.

Cognitive education is built on the premises of neuroplasticity, the triune brain theory, Suggestopedia and attention whereby each plays a role in the learning process (Cilliers, 2005: 9-13, 37-40; Jensen, 2005: 10-13, 35, 36). Where neuroplasticity plays an important role in understanding how learning changes the brain, the triune brain theory, Suggestopedia and attention are strategies used in an ICT-enabled classroom for optimal brain functioning. For an educator, these principles are important to know as they impact lesson planning and design, teaching strategies, learning activities, the learning environment, assessment methods and the use of technology (Jensen, 2005: ix). These principles shall now be discussed.

4.3.1 Neuroplasticity

The human brain is changed by experience and learning due to having a high degree of plasticity (Tokuhamma-Espinosa, 2001: 29). Neuroplasticity is the changing in structure and actions of neurons so that they hold information in the long-term memory in temporal and parietal lobes of the cortex. "The brain is literally shaped by experience as axonal circuits change, modify and redevelop as humans' age" (Sorensen and Murchú, 2006: 296).

Reuven Feuerstein as cited in Cilliers (2005: 04) stated that “Change is the most stable characteristic of human beings”. He further mentioned as cited in Cilliers (2005: 26) that “all people possess hidden or latent potential which can be optimised”. The optimising of latent potential refers to neuroplasticity and the changes in the brain when learning takes place. If one considers that the brain is modifiable and able to change, then the conclusion can be made that learners have the potential to learn effectively.

Potential is “the possibility of something that may come into existence” (Hornby, *et al.*, 1983: 651). This may refer to a belief that a person possesses the capability for growth and development (Hornby, *et al.*, 1983: 651). If a learner then has latent potential, then the capacity for growth and developing abilities and skills is present, but, not yet active (Hornby, *et al.*, 1983: 475).

4.3.1.1 Neuroplasticity’s role in learning

Brain cells are known as neurons (Sprenger, 2010: 151). When learning occurs, neural connections are developed (Sorensen and Murchú, 2006: 308). When neurons develop within current knowledge structures in the brain, learners construct meaning from information and activities they take part in (Sorensen and Murchú, 2006: 308).

According to Jensen (2005: 17) neurons and the glia are responsible for the processing of information and the storage thereof. Neurons (see Figure 4.1 below) have a cell body and an extension called an axon which is covered with a fat-like substance called myelin (Jensen: 2005: 17; Sousa, 2011: 21; Sprenger, 2010: 152). Sousa (2011: 21) states that the myelin covering serves to insulate the axon from other neurons and “increases the speed of impulse transmission”. The cell body of the neuron has branchlike extensions called dendrites which connect to other neurons via their axons (Jensen: 2005: 17; Sprenger, 2010: 152). The intersections where axons and dendrites meet are called synapses (see Figure 4.2) (Jensen: 2005: 17; Sousa, 2011: 21). The axons and dendrites do not touch each other at the synapse (Jensen: 2005: 17; Sousa, 2011: 21), as the end of the axon has openings which contain neurotransmitters in synaptic vesicles, which are released during electrical impulses and transmit the impulses to the neighbouring neuron (Sousa, 2011: 21;

Sprenger, 2010: 152). When learning occurs specific neurons connect and form a junction at the synapse through “the alteration of synaptic efficacy” (Jensen: 2005: 18).

The brain has more than 100 billion neurons which give the possibility of one quadrillion synaptic connections (Pritchard, 2009: 86; Sousa, 2011: 22). This large amount of synaptic connections allows the brain to process data from new incoming information and enables the brain to store large amounts of information for later use (Sousa, 2011: 22).

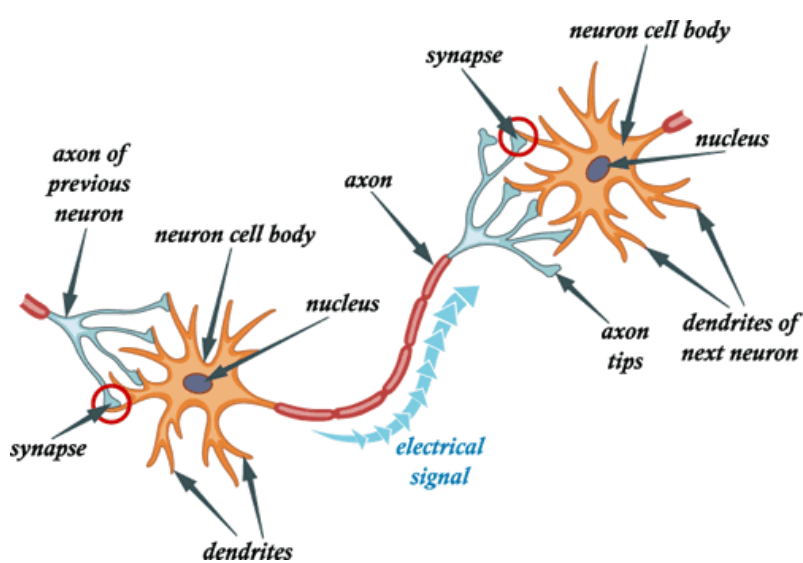


Figure 4.1 – Neurons. (Shen, 2013)

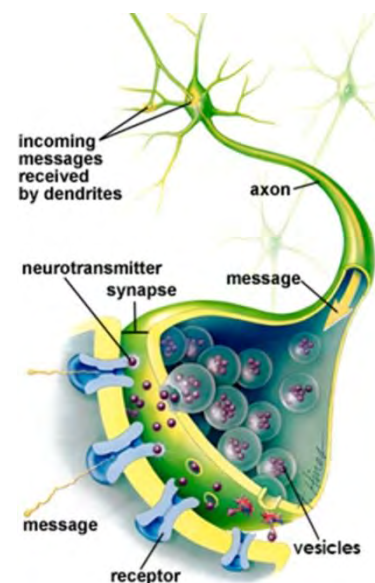


Figure 4.2 – A synapse. (Mayfield Clinic, 2013)

4.3.1.2 Implications of neurotransmitters in learning

There are about fifty identified transmitters in the brain (Sousa, 2011: 22; Sprenger, 2010: 154, 155). These neurotransmitters act as a stimulus that excites or inhibits a neighbouring neuron (Jensen: 2005: 161; Sousa, 2011: 22). This ability to excite or inhibit neurons plays an important role in the learning process (Sprenger, 2010: 154). For this study, focus will be placed on dopamine, serotonin and acetylcholine as they play a profound role in learning and the classroom.

Dopamine is a powerful transmitter which is responsible for producing positive feelings and has a calming effect (Jensen: 2005: 160; Sprenger, 2010: 156). It impacts memory and learning (Tokuhamas-Espinosa, 2001: 129). Sprenger (2010: 156) states that it plays a major

role in helping learners to focus and make decisions. She further states that “dopamine controls brain activity so that we can pay attention to one thing at a time”.

Educators often have learners with ADD (Attention Deficit Disorder) and ADHD (Attention Deficit Hyperactivity Disorder) in their subject and ICT-enabled classrooms. Such learners have low levels of dopamine in the frontal cortex which influences their control of their behaviour and their ability to pay attention (Sprenger, 2010: 156). This lack of dopamine levels could be raised by playing soothing music from the baroque and classical periods such Bach, Vivaldi and Mozart via computer technology, MP3 files from the Internet or an iPod connected to a speaker system (Medina, 2010: 216; Sutoo and Akiyama, 2004: para. 01). According to Sutoo and Akiyama (2004: para. 01) previous medical studies indicated that calcium increases brain dopamine synthesis through a calmodulin (CaM)-dependent system (see Figure 4.3) when classical music was played and might be effective to rectify symptoms of low dopamine levels.

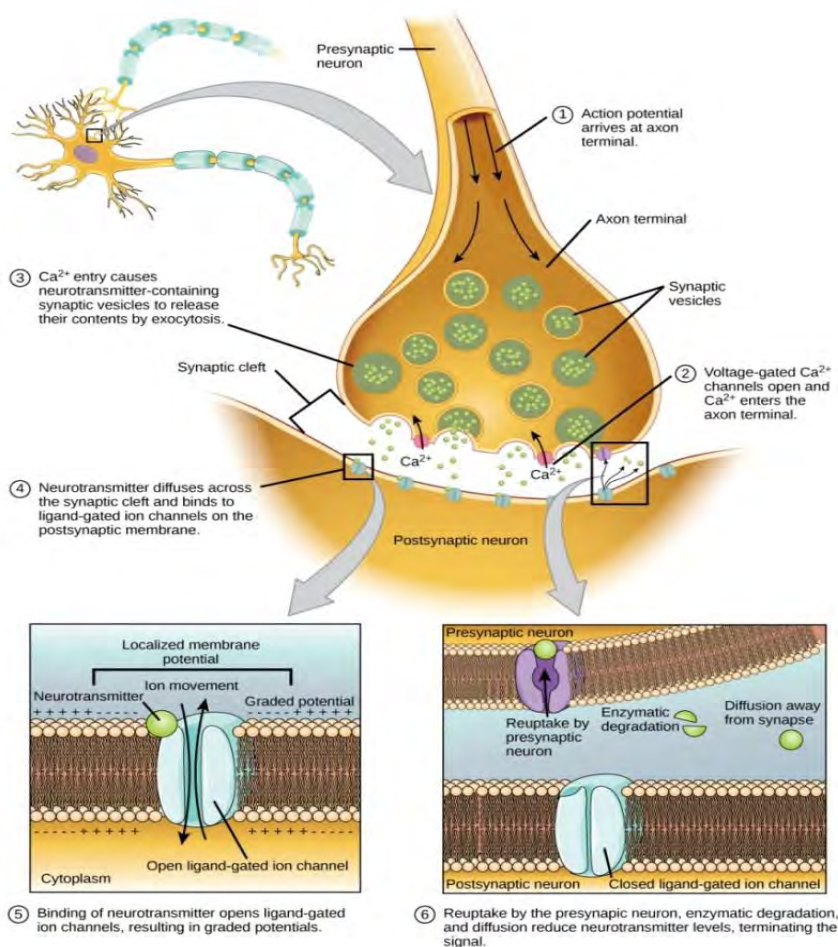


Figure 4.3 – How neurons communicate. (Open Stax, 2014)

From this research one could come to the conclusion that playing the previous mentioned music might be effective to raise learner dopamine levels and improve learner attention levels and their ability to control their behaviour.

Sprenger (2010: 156) and Tokuhamma-Espinosa (2001: 278) state that dopamine is also a neurotransmitter which has an influence on the reward system of the brain. It serves to stimulate motivation. Jensen (2005: 104) states that human brains are designed to “predict, process, enjoy and remember rewards” as rewards “induce pleasure” and “increase the frequency of goal setting behaviours”. He further stated that rewards “maintain learned behaviors, increase social behavior, reinforce existing learning” and “increase the success rate of new learning” (Jensen, 2005: 104).

Jensen (2005: 104) suggests that the brain has two reward systems. The first system “includes codes for rewards prediction” and is responsible to create attentiveness (Jensen, 2005: 104). The second system is used for error correction which creates better learning (Jensen, 2005: 104). With Jensen’s statements one could argue that raised dopamine levels via the brain’s rewards systems can create better attentiveness and learning among learners. Sprenger (2010: 27) echoes this notion in stating that if learners enjoy their learning activities, intrinsic motivation may occur.

Stimuli that trigger our reward centres will release dopamine, which is related to feelings of excitement and anticipation (Jensen, 2005: 104, 105). To raise dopamine levels for the stimulation of motivation among learners, computer and internet based games can be used for factual and rote learning whereby the learner is progressively rewarded as each level of a game or drill and practice activity is mastered. Sprenger (2010: 06, 26), further states that enjoyable learning experiences with computer technologies may reinforce changes that occur within the brain.

Serotonin is mostly responsible for producing relaxation, controlling appetite, emotions, moods, learning, consciousness and sleep (Jensen, 2005: 160; Sprenger, 2010: 155). Jensen (2005: 71, 96) also states that serotonin levels regulate memory systems in the brain,

attention and aggression. Antoniadis, Ralph and McDonald as cited in Jensen (2005: 86) further states that when serotonin levels are lowered, a learner's mood, alertness and cognitive performance are compromised. To counterbalance low serotonin levels and reduce anxiety in the classroom a computer's CD ROM can be used to play baroque or classical music or a combination of movement with music and song (Sprenger, 2010: 94).

Acetylcholine's primary function is to assist learners during the learning process in forming long-term memories (Jensen, 2005: 139; Sprenger, 2010: 154), but also assists attention and arousal. Sprenger (2010: 154) states that it assists with the processing of factual memories in the hippocampus and is increased during sleep at night. It is during this time that neuroscientists believe that memories are stored (Sprenger, 2010: 154).

4.3.2 Strategies that optimise brain functioning

Research according to Cilliers (2010: 06) has shown that "educators who have an in-depth understanding of the concept 'total learner' can facilitate the optimisation of their learners' brain potential". The question arises then regarding how learners' cognitive and learning potential can be optimised. Cognitive education focuses on activating a learner's cognitive skills in order to develop his capacity to learn (Pritchard, 2009: 86). There are certain strategies and methods which can be implemented and applied to optimise learners' cognitive and learning potential (Cilliers, 2010: 9-13, 37-40). In this study, some focus will be placed on the strategies and principles of the Triune brain and Suggestopedia, and how these principles can be applied in using computer technology as a cognitive tool.

4.3.2.1 The triune brain

The triune brain as shown in figure 4.4 is a model of brain evolution and structure, developed by Paul D. MacLean (Hand, 1984: 9-21; MacLean, 1990: 15-18). The word triune refers to three separate levels in the brain, each with its own individual operative unit, which make up the brain (Cilliers, 2010: 09). They are the reptilian complex, the limbic system and the neocortex which is also known as the cerebral cortex (Cilliers, 2010: 09, Pritchard, 2009: 89, 90). Each layer is equipped with separate abilities and functions of the brain, but all three layers cooperate with each other to a large extent (De Jager, 2006: 15).

According to McLean (1990: 15-18) the triune brain has an impact on the learning process and behaviour of individuals. This notion is echoed by Johnson (2010: 120) who states that “When we perceive something, an object or an event, all three brains react and contribute to our thought and behaviour”.

The reptilian complex is made up of the brain stem and cerebellum (De Jager, 2006: 16; Sousa, 2011: 18). The term ‘reptilian’ derives from the fact that a reptile’s brain is dominated by its brain stem and cerebellum which controls instinctive survival behaviour (De Jager, 2006: 16; Cilliers, 2010: 10, 11). It controls the muscles, balance and autonomic functions such as heart beat and breathing (Pritchard, 2009: 89; Sousa, 2011: 18). This layer has preference in most situations as it is the basis of basic needs (De Jager, 2006: 16). Basic needs such as hunger, the need for sleep and being comfortable have to be satisfied before preference moves to the need of the limbic system (De Jager, 2006: 17). A hungry child, with a need for sleep or one who is uncomfortable due to extreme temperatures, or one having a numb ‘bum’ (being seated too long) will not be able to learn (Cilliers, 2005: 11; De Jager, 2006: 18).

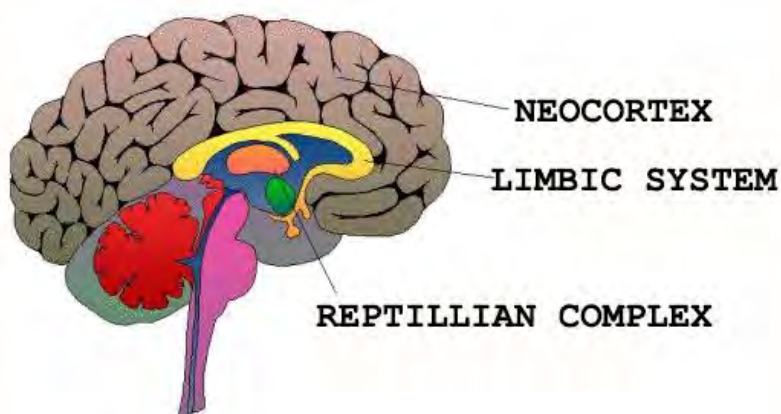


Figure 4.4 – The triune brain. (Paine, 2010)

The limbic system consists of the amygdala, hypothalamus, hippocampus and pituitary gland and is the source of emotions, attitude, prejudice and motivation (Cilliers 2010:10). When these parts of the brain are stimulated, emotions are produced (Sorensen and Murchú, 2006: 296). The hippocampus is also active in changing information into long-term memory and memory recall (Jensen, 2005: 129; Sprenger, 2010: 95). Repeated use of

neural networks in the hippocampus enhances memory storage (Cilliers, 2010: 10; Sprenger, 2010: 118). As the limbic system is the basis of emotions, powerful emotions increase the strength of neural signals and engrave memory into the brain (Jensen, 2005: 71). Negative emotions inhibit learning from taking place (Pritchard, 2009: 90). Imbalance in the endocrine system, which is controlled by the pituitary gland, produces mood swings which has an influence on emotions experienced (Cilliers, 2010: 10; Jensen, 2005: 72-74). The amygdala is activated in situations that evoke feelings such as fear, pity and anger (Sousa, 2011: 19; Sprenger, 2010: 122). As the limbic system links emotions with behaviour, it acts to hamper the reptilian complex and its preference for ritual and habitual behaviour (De Jager, 2006: 21-25). It can be concluded that emotions play a substantial role in the learning process of learners. Learning may be inhibited or enhanced, depending on the emotions of learners and hormones being released (Pritchard, 2009: 90). Jensen (2005: 80) agrees with Pritchard in saying that research supports the value of engaging appropriate emotions as they are integral and invaluable part of a learners' learning process.

The neocortex consisting of the occipital, temporal, parietal and frontal lobes in the brain is responsible for higher order thinking skills, reasoning, learning, imagination, consciousness and speech (Cilliers 2010:10; Tokuhamas-Espinosa, 2001: 278). It controls intellectual functions and is the centre of logic (Cilliers 2010: 10, 11; De Jager, 2006: 27). The limbic system cannot activate emotion without linking with the neocortex (Cilliers 2010: 11). These two layers are interconnected with a two-way network of nerves which enables continuous communication between these two layers and links thinking and emotions (Sousa, 2011: 19).

As previously stated, the three parts of the brain do not operate independently of one another, but they are interconnected and cooperate with each other. This is where the process of downshifting plays a big role in brain functions (Bocchino, 1999: 25). Bluestein (2013: para. 13) describes downshifting as a “neurological *shift* when under perceived threat from being able to access cognitive (more rational) parts of the brain to functioning from the survival center (emotional, midbrain)”. An overload of stress and negative

emotions interferes with neural processes for learning (Sousa, 2011: 47, 72). When learners experience stress or fear, cortisol and epinephrine (adrenaline) are released (Sousa, 2011: 89; Tokuhamma-Espinosa, 2001: 250). It is primarily responsible to arouse a state of fight or flight which affects a learner's metabolic and heart rate, blood pressure, emotions and mood (Jensen, 2005: 160; Sousa, 2011: 89). When the heart rate increases, blood is sent from the cognitive areas of the brain to the muscles for quick movement (Jensen, 2005: 160). Reasoning and comprehension is then inhibited and a learner's memory affected (Sousa, 2011: 47). The neocortex can't function properly when the limbic system has preference over it (Cilliers, 2010: 11; Bocchino, 1999: 25). Bocchino (1999: 26) states that "In fact all of our higher-order thinking abilities are compromised during downshifting". Downshifting also takes place when a learner's basic needs aren't met, as the reptilian brain has preference over the limbic system (De Jager, 2006: 16; Jensen, 2005: 82). While the brain reacts to the situation it is no longer able to store or learn new information as all energy is taken up for self-preservation, therefore learning becomes impossible (Sorensen and Murchú, 2006: 312; Sousa, 2011: 89). Only when both the needs of the reptilian complex and limbic system are met, the neocortex can function optimally and learning can take place (Cilliers, 2005:11). Therefore, it is important for educators to ensure the learning environment is free of threats, be they basic or emotional, to prevent the brain from downshifting into its more primitive parts (Sorensen and Murchú, 2006: 312).

4.3.2.2 Implications of the triune brain in the computer technology rich classroom

In order for the triune brain and the neocortex to function optimally and for the prevention of downshifting, educators need to use computer technologies more effectively in their teaching practices in a way that will meet basic needs and contribute towards the positive emotion of learners (Sorensen and Murchú, 2006: 302). This can be done in the following ways:

- a) Feeling safe and reducing stress and cortisol levels – Use a computer's CD ROM to play music such as baroque or classical music or a combination of physical activities, music and song to release dopamine and serotonin (Sprenger, 2010: 34, 35, 94; Sutoo and Akiyama, 2004: para. 01). Releasing these transmitters will alter the

state of the brain positively and reduce anxiety and stress levels (Jensen, 2005: 72, 104, 105, 160, 162). Music also motivates learners to engage in learning activities (Sprenger, 2010: 94). Excellent resources are available online on You Tube which can be used for music related learning activities. Music can also be used as a carrier (using a melody or beat to encode content, an arousal (to calm down or energize) and as a primer (to prepare specific pathways for learning content) (Wilson and Spears, n.d.: 06);

- b) Motivation - Motivate learners as it triggers the amygdala and frontal lobe activities and releases dopamine (Jensen, 2005: 104). By creating an element of enjoyment with various technologies such as playing music, singing songs with videos and the application of work learned in education games, intrinsic rewards are created which leads to the creation of intrinsic motivation (Sprenger, 2010: 27, 94). Through professional observation done over the past seven years, the researcher has noted that educational games available on the Internet, serve not only as a tool for application and repetition of what is learned, but also as a good motivator as learners not only compete with themselves, but with other learners in the class. Trying to achieve higher scores with educational online games and rewards such as going 'to the next level' motivate learners to try to achieve their next goal;
- c) Positive suggestions by means of self-image songs and videos - Make use of positive suggestions to build self-image and positive attitudes (Cilliers, 2010:38-40). Developing positive attitudes will enhance hippocampus activities and long-term memory storage. It will have a positive influence on the sub-conscious which does everything in its might to make suggestions true (Cilliers, 2010:39);
- d) Learning activities should be a pleasant experience - Emotion helps us recall information at a later stage when it is needed (Jensen, 2005: 55, 56 Pritchard, 2009: 90). Make learning activities exciting and fun (Pritchard, 2009: 90). The brain loves novelty (Jensen, 2005: 120; Sprenger, 2010: 6, 44). To include the element of fun and novelty in lessons, educators can make use of computer technology in its various forms such as interactive slide shows, Power Point presentations, videos (found on You Tube and other websites), colour, songs, interactive educational games offered online or via software applications, movement, rhythm and music.

Music affects emotion and increases learning (Sprenger, 2010: 92). Physical activities create patterns in the brain and when patterns are established, learning takes place (Sorensen and Murchú, 2006: 314).

4.3.2.3 Suggestopedia

Suggestopedia, also known as accelerated learning was developed by the Bulgarian psychotherapist Georgi Lozanov (Gill, 2010, Kindle, no page no.)¹. It was originally used in foreign language learning, but the method is not limited to language learning and can be used to enhance the learning process of individuals (Cilliers, 2010: 38; Gill, 2010, Kindle, no page no.). Suggestopedia is built on the premises that “each learner has relatively unlimited brain potential” and “that the brain is largely under-utilised” (Cilliers, 2010: 38). According to Lozanov (1978: 11), the aim of suggestopedia is “to release the reserve capacities of the brain which will ensure that optimal learning takes place”

Suggestopedia derives from the English meaning ‘to suggest’ which means to put “ideas to the mind” (Hornby, 1983: 865). When looking at Suggestopedia from a cognitive educational point of view, Lozanov (1978: 225) describes it as an approach to “organised instruction, the simultaneous utilization and activation of the conscious and para-conscious functions, the simultaneous participation of man’s mental and emotional sides, the simultaneous participation of the left and right hemispheres of the brain, as well as that of the cortex and sub-cortex”. This description implies that the method of Suggestopedia utilizes the whole brain in the learning process and contributes to total brain integration.

The methodology of Suggestopedia works on removing distractions and negative feelings which may inhibit learning (Cilliers, 2010: 38.) It focuses on using learners’ natural talents in a holistic way to maximize their learning and performance. When the Suggestopedia method is applied it is supposed to “create a learning environment which is stress-free,

1. In-text references of Kindle books with no page numbers will be shown as (Author, year, Kindle, no page no.).

positive, focuses on the needs of the learner and enhances his self-esteem” (Clark, 2009: para. 28).

The sub-conscious parts of the brain are very receptive towards suggestions (Cilliers, 2010: 38; Gill, 2010, Kindle, no page no.). Suggestions lead to a certain result and the sub-conscious brain’s function is to find a way to make it happen (Cilliers, 2010: 39). Learners are bombarded with verbal and non-verbal suggestions (Cilliers, 2010: 39). Whatever tone the suggestions may have, the sub-conscious will find a way to make it happen (Cilliers 2005:39). When what is suggested eventually happens, the suggestion is confirmed to the learner. As the sub-conscious is highly receptive to spoken words and suggestions, educators should work towards giving positive suggestions to build and maximize learners’ learning and performance in the learning environment (Cilliers 2005:39).

Cilliers (2005: 39, 40), suggests that educators should adopt strategies such as Suggestopedia and mind maps to develop and optimise learners’ cognitive brain potential and the whole brain should be utilized to ensure successful learning takes place.

Teaching strategies which can be used within the framework of Suggestopedia are:

- a) The purposeful recall of earlier successful and enjoyable learning experiences (Cilliers, 2005: 40; Jensen, 2005: 135). An educator may make use of previously used Power Point slide shows, videos, music, songs or any other digital media that was used in the original lesson to help learners recall previous enjoyable learning experiences. As the brain is willing to repeat successful learning experiences, neural circuits can be re-stimulated and used as a benefit in introductory activities prior to new learning activities (Jensen, 2005: 135).
- b) Mind maps assist learners with the visual processing of information by which learning is enhanced (Sprenger, 2010: 101). Buzan, Griffiths and Harrison (2012: Kindle, no page no.) state that when a mind map is created it involves the whole brain by using both cortical hemispheres and it generates whole brain thinking. Mind maps were developed by Tony Buzan, a British Professor, at the University of Warwick. According to Buzan the ability to think is infinite and explains that a mind map is an ‘external mirror of you own

radiant thinking and allows you to have access into your vast thinking powerhouse' which refers to the brain (Buzan and Buzan 2003:34). Mind maps creates visual representations (Sprenger, 2010: 101) of information and make use of the full range of cortical skills which includes words, images, numbers, logic, rhythm, colour and spatial awareness. Learning is about making connections. When creating a mind map, associations with pictures and words are used to make these connections (McCullough, 2014: 54). When the recalling of information is needed, the brain uses the connections and associations it made to retrieve the information wanted. Buzan and Buzan (2003:82) state that the brain finds it "easier to accept and remember visually stimulating, multi-coloured, multi-dimensional mind maps, rather than monotonous, boring linear notes".

Mind-mapping has its benefits. It develops artistic skills and visual perception (Buzan, Griffiths and Harrison, 2012: Kindle, no page no.). This will in its turn enhance memory, creative thinking and add to the confidence of a learner (Buzan, Griffiths and Harrison, 2012: Kindle, no page no.). Examples of mind mapping software that can be used effectively in the ICT-enabled classroom are Buzan's iMindMap software (Figure 4.5) and the Inspiration Software applications. Using mind mapping software applications on the computer has the following benefits:

- I. It helps learners brainstorm and explore ideas, concepts, or problems (Inspiration Software Inc., 2014: para. 03);
- II. It facilitates a "better understanding of relationships and connections between ideas and concepts" (Inspiration Software Inc., 2014: para. 03; Sprenger, 2010: 103);
- III. It makes communicating new ideas and thought processes easy (Buzan, Griffiths and Harrison, 2012: Kindle, no page no.; Inspiration Software Inc., 2014: para. 03);
- IV. It allows learners to recall information more easily (Buzan, Griffiths and Harrison, 2012: Kindle, no page no.; Inspiration Software Inc., 2014: para. 03);
- V. It helps learners to take notes and plan tasks more effectively (Inspiration Software Inc., 2014: para. 03);

- VI. It makes organising ideas and concepts easier (Buzan, Griffiths and Harrison, 2012: Kindle, no page no.; Inspiration Software Inc., 2014: para. 03).

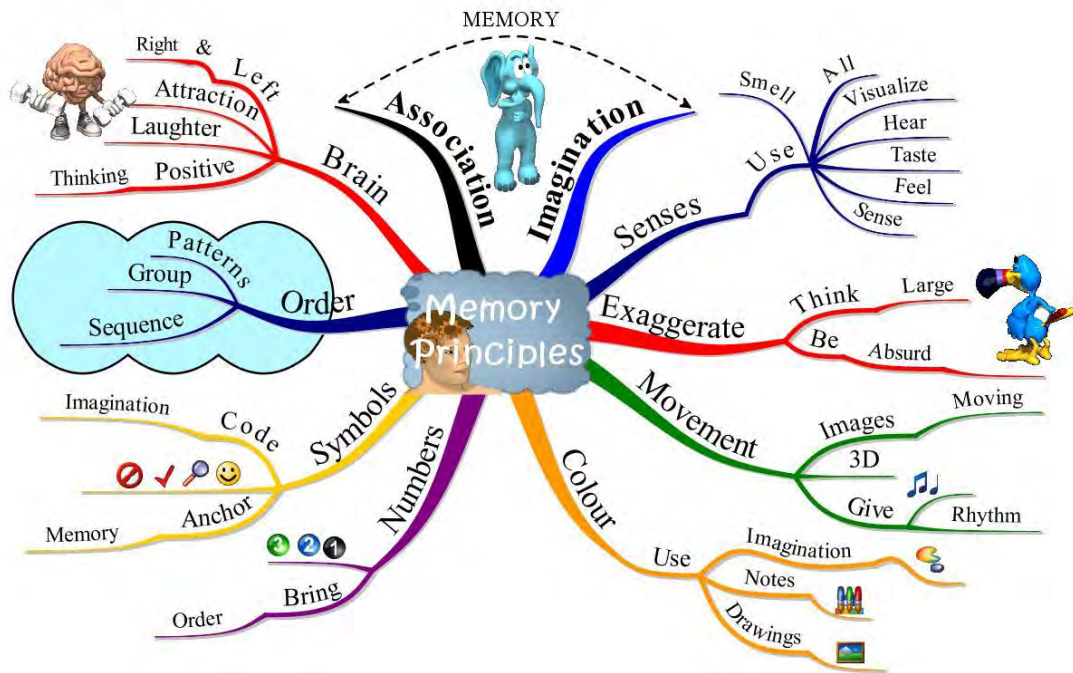


Figure 4.5 – iMindMap. (Memory Principles, 2010)

c) Music is a “magical tool” for learning and retaining information (Sprenger, 2010: 92). Previously it was discussed how music assisted the brain in the release of neurotransmitters and aided the learning process. However, music also has an influence on brain waves which can aid accelerated learning (McCullough, 2014: 33). To understand the benefits music may have in a classroom, one needs to discuss various conditions, also known as the states a brain may find itself in. These states also match up to different brain waves (Sprenger, 2010: 93). For this study focus will be placed on the beta, alpha and theta states.

According to Sprenger (2010: 93) the beta state is used by the conscious mind. When in the beta state people are wide awake and able to solve problems. The alpha state “signifies relaxed alertness” and is considered as the preferred state of learning (Sprenger, 2010: 93). When in this state memory is advanced and information more easily grasped (Sprenger, 2010: 94). The theta state causes a person to go into a “deep meditative state of high suggestibility and great creativity” (Sprenger, 2010: 93). These

states can be accessed by different kinds of music, especially baroque and classical music (McCullough, 2014: 33; Sprenger, 2010: 93, 94). Baroque music, accelerates learning, it enhances both short-term and long-term memory and “aids in the whole-brain approach to learning” (Sprenger, 2010: 94).

Music reduces stress levels (Paget, 2006: 05). Baroque music with a tempo of sixty beats per minute induces a state of relaxed alertness which in its turn increases the receptivity of the brain (Sprenger, 2010: 94). Furthermore, researchers have found that when baroque music is played an individual’s blood pressure lowers; the heartbeat slows down to a healthy rhythm (O’Donnel, 1999: 04); the beta brain waves decrease by 6%, while alpha waves increase by an average of 6% (Wagner and Tilney, 2012: 5-17). The increase of alpha waves induces a state of relaxation and contributes to memory enhancement (Sprenger, 2010: 94) and the reduction of stress and anxiety (Campbell, 2009: 27-30; Paget, 2006: 05). The absence of threat or fear activates the Limbic System in the triune brain and prepares the neo-cortex for the learning process (Cilliers, 2010: 11). Webb, as cited in Bennet and Bennet (2008: 05) states that “baroque music acts as a signal carrier whose rhythms, patterns, contrasts and varying tonalities encode new information in the brain”. It also creates a positive emotional response (McCullough, 2014: 33; Sprenger, 2010: 92). It is known that emotion plays an important role in the learning process (Pritchard, 2009: 90). Learning takes place successfully where a learner experiences positive emotion and finds the learning activity an enjoyable experience (Sprenger, 2010: 06, 26).

Furthermore, baroque music also increases molecular energy (Paget, 2006: 05) and a strong mode of alert relaxation is created. This is a state in which the body functions more efficiently on less energy, making more energy available for the brain (Rose and Nicholl, 1997: Kindle, no page no.). This state is also known as the state of accelerated learning and “super learning” (Cilliers, 2010: 37).

Computer technologies such as a computer’s CD-ROM, music files on the hard drive, or MP3 players can be used in the classroom for playing baroque and classical music to induce the necessary state of learners’ minds for learning. However, McCullough (2014:

33, 85) advises that the music should be played with a low volume as background noise, being barely audible. Their reason for it is that the learner should focus on the learning task at hand and not the music being played (McCullough, 2014: 33).

4.4 Attention

Attention is one of the cognitive processes used in the learning process. Wickens and McCarley (2008: 02) argue that attention “encompasses a broad array of phenomena”, meaning that the word represents several varieties of attention, but they also state that irrespective of what circumstance it is used in, “there is a toll on human cognition due to trying to mobilize the high effort to perform a task for a long period of time”. From this view point one can argue that when attention is used, it involves human cognition. This is echoed by Anderson (2004: 519) in stating that attention is “the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things”.

The human use of attention plays an important role in the learning process (Jensen, 2005: 34-36). Yet, many learners battle to pay attention as it is a difficult task to maintain on a conscious level (Jensen, 2005:35, Sprenger, 2010: 07). It requires “highly disciplined internal” states and the right balance of neurotransmitters in the brain (Jensen, 2005: 35). Wickens and McCarley (2009: 01) state that attention “is necessary to hold information in working memory to efficiently move information to long-term memory, that is, to learn it”. Furthermore it requires a learner’s visual and auditory systems to focus into the activity at hand (Medina, 2010: 109).

4.4.1 How does attention work?

Levine (2002: 31) describes attention as the “administrative bureau of the brain, the headquarters for mental regulators that patrol and control learning and behaviour.” Furthermore, he claims that the ability to control attention directs the distribution of mental energy within our brains (Levine, 2002: 31). This enables us to finish what we started and stay alert throughout the day (Levine, 2002: 31). Attention keeps us focused while filtering out things that may distract us (Levine, 2002: 31).

When attention regulators operate as they are supposed to, they help a learner to learn and to be productive (Levine, 2002: 52). The question that arises is: how can we connect it to teaching and learning with computer technologies? Sousa (2011: 29) states that today's learners are part of a rapidly changing environment where computer technologies play an important role. Due to these technologies learners' attention are scurrying between many tasks and therefore, they "seem to have shorter attention spans and bore easily". Although today's learners are able to change their attention rapidly among a number of things, their brains can only focus on one thing at a time as the brain isn't able to carry out two cognitive processes at one specific time (Sousa, 2011: 31). The answer therefore, seems to be that educators need to incorporate technologies learners are frequently using into their lessons (Sousa, 2011: 29).

The human use of attention plays a profound role in how computer users (learners) react and interact with a computer. Computer technologies can be used to enhance the ability to focus attention on cues in the learning environment which are relevant to the learning activity. Focus will now be placed on factors affecting attention for the purpose of understanding how it can be used and applied in the design of lessons, teaching aids and learner interaction in the ICT-enabled classroom.

4.4.2 Things that affect attentional focus

There are a number of factors connected with the stimuli we receive, the way they are mentally processed, our state of mind at a given time that affects the way we are able to pay attention for a period of time. Sousa (2011: 31) states that the brain "is constantly scanning its environment for stimuli. When an unexpected stimulus arises..... a rush of adrenalin closes down all unnecessary activity and focuses the brain's attention" so that it can take action. Stimuli have different properties which affect our intentional focus. These properties will now be discussed.

4.4.2.1 The effect of motion and change.

According to Lee, Klippel and Tappe (2003: 12) "Animations have become an important design tool in recent graphical user interfaces, as they motivate interactions and draw

attention to specific contents". Furthermore, they (Lee *et al.*, 2003: 13) have stated that the "property of motion in animated graphics has shown some promise as an effective mechanism for visually organizing complex information by grabbing user's attention and perceptually grouping otherwise dissimilar objects" and that "if the motion in an animated display can effectively draw user's attention to task relevant information, then it may facilitate learning".

Our peripheral vision is good at detecting movement and change which help to direct our attention to what is important (Johnson, 2010: Kindle, no page no.). Flashing, motion and change are great techniques to attract attention (Johnson, 2010: Kindle, no page no.). An example of making use of peripheral vision is when motion and flashing objects in a slide show or school website are positioned on the sides of the graphic user interface (GUI) when the teaching aid is designed. Learners' attention will be drawn to these moving or flashing objects, as their peripheral vision will 'pick up' the movement caused by them.

Johnson (2010: Kindle, no page no.) states that when a computer beeps, it tells the user "something has happened that requires attention". Similarly, I've found that this principle can be effectively used in a MS Power Point slide show where sound may be added to a specific animation where both the sound and the animation are simultaneously activated in the slide show to draw learners' attention to what is important or to enhance specific information.

4.4.2.2 The effect of colour, size and intensity of stimuli.

The use of colour helps to emphasise important information, to identify subsystems of structure, it increases a learners' comprehension of information and adds appeal to a page (McCullough, 2014: 78). Colour impacts memory better than information presented in black and white as colour assist in the retention of information and increases attention (Wichman, Sharpe, and Gegenfurther, 2002: 510, 518). McCullough (2014: 78) agrees with Wichman et al. in stating, that learners' memory of information that stands out more vividly is enhanced and that colour makes the information more memorable. McCullough (2014: 78) furthermore states that the brain "is good at noticing differences" as it "grabs"

attention and redirects focus. When it impacts memory, learners may learn more effectively. To give examples, colourful illustrated e-textbooks, videos, slide shows, animation, colourful graphics and pictures in learner activities books may impact learners' memory more profoundly than information presented in black or white (Wichman, Sharpe, and Gegenfurther, 2002: 510).

4.4.2.3 The amount of stimuli competing at a given time.

Mayer and Moreno (2003: 43) state that “meaningful learning requires that the learner engage in substantial cognitive processing during learning, but the learner’s capacity for cognitive processing is severely limited” which may lead to a cognitive overload when too much stimuli and information must be processed. They define cognitive overload as the point when “the learner’s intended cognitive processing exceeds the learner’s available cognitive capacity” (Mayer and Moreno, 2003: 45). A learner’s ability to store information in the long-term memory is essentially unlimited, but, the ability to store information in the working memory is limited (Mayer and Moreno, 2003: 43). For learners the ability to learn meaningfully often requires a considerable amount of cognitive processing while they have a cognitive system that “has severe limits on cognitive processing” (Mayer and Moreno, 2003: 43). Therefore, when cognitive overload takes place, retrieving learned information and storing new information may be compromised (Sprenger, 2010: 113).

To prevent a state of cognitive overload, Mayer and Moreno (2003: 50) suggest that lessons should be designed in ways that should minimise cognitive overload. They suggest the following can be done:

- a) In the case of video or animation, words should be given as narration instead of on-screen text as the visual processing demands are decreased (Mayer and Moreno, 2003: 46);
- b) To present information in segments to allow learners the “time and capacity to organize and integrate the selected words and images (Mayer and Moreno, 2003: 47);
- c) By providing cues regarding how the information should be selected and organised. For example in a slide show or animation emphasis can be place on

certain words in the narration, by adding red and blue arrows to the narration, by adding headings and outlines or by organising images with an added map showing important part in a lesson (Mayer and Moreno, 2003: 48).

4.4.2.4 Visual structure and grouping.

Banikowski (1999: no page no.) states that attention can be facilitated when information is presented in a structured manner. Johnson (2010: Kindle, no page no.) agrees with Banikowski in stating that creating visual structure and grouping may help the student to focus on items and information deemed as important in a specific activity. Furthermore, new information presented in a structured way enhances perusal and understanding among learners (Banikowski, 1999: no page no.; Johnson, 2010: Kindle, no page no.). To give an example, two presentations of which one gives unstructured information and the other structured information are displayed in Figures 4.6 and 4.7:

An unstructured instruction:

For this assignment online research needs to be done regarding different cell phone contracts available at Vodacom, MTN, Cell C and Telkom. You need to make notes of the information for use in your assignment template. Thereafter, open the MS Word template in your folder and fill in the necessary information. Compare the contracts and decide which contract is the best. Give reasons why you think the chosen contract is the best. Save your work.

Figure 4.6 – An unstructured instruction.

The set of instructions set out in figure 4.6 is unstructured prosed text. As the text is unstructured, the learner may find it difficult to focus on the different tasks. Johnson (2010: Kindle, no page no.) states that unstructured text may slow learners down in reading the information and may cause them to miss important words. After reading the text, learners first have to analyse the instructions before meaning can be given to it. Analysing the unstructured text may impose extra cognitive processes on the learner's brain, therefore, it might take the brain longer to process information and give meaning to it.

The second set of instructions in figure 4.7 gives structured text in an outlined form. The structured set of instructions can be skimmed through and understood more quickly than

A structured instruction:

Do online searches to find available South African cell phone contracts.

Find information at the websites of:

- Vodacom
- MTN
- Cell C and
- Telkom

Make notes of the information.

Use the MS Word template in your folder.

Fill in the necessary information on the MS Word template.

Compare the contracts.

Decide which contract is the best.

Give reasons why you think the chosen contract is the best.

Save your work.

Figure 4.7 – A structured instruction.

the first set. This action may minimise the needed cognitive processes to process the information, it may increase understanding and speed up the process to give meaning to it. It may also serve as an organiser to help learners keep track of what they've done and still need to do.

Numbers are easier to skim and understand when segmented and data-specific controls provide more structure by giving known information (Johnson, 2010: Kindle, no page no.; Mayer and Moreno, 2003: 47). Consider the following Maths problems in Figures 4.8, 4.9 and 4.10:

2. What are the next numbers in the pattern?
0, 4, 8, 12, 16, __, __, __.

2. What are the next numbers in the pattern?

0	4	8	12	16			
---	---	---	----	----	--	--	--

Figure 4.8 – Non-segmented pattern Figure 4.9 – Segmented pattern

Number patterns are displayed in figures 4.8 and 4.9. If the same number pattern displayed in figure 4.9 is displayed as ordinary text shown in figure 4.8, then learners may perceive the numbers in the pattern as a group at first. The number pattern in figure 4.8 is not segmented and therefore it may compromise the readability of the pattern and makes analysing the pattern more complicated (Johnson, 2010: Kindle, no page no.). The number

pattern not being segmented may make it more difficult for learners to identify the pattern. The number pattern in figure 4.9 is segmented and provides visual structure which may improve readability and prevent number entry errors in completing the pattern (Johnson, 2010: Kindle, no page no.).

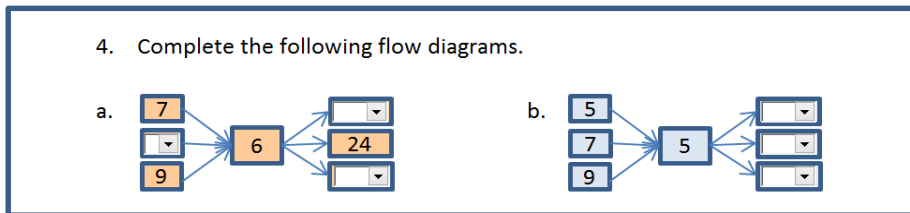


Figure 4.10 – Drop-down lists

In figure 4.10 drop-down lists with possible numbers are given in a multiplication maths problem. Drop-down lists provides visual structure by mixing segmented text fields with data-specific controls (Johnson, 2010: Kindle, no page no.). Drop down lists narrow down the number of possible answers and aims to get learners to focus on the possible answers, help them to retrieve learned information more easily and help to “share the cognitive load by providing support for lower level cognitive skills so that resources are left over for higher order thinking skills” (Lajoie and Derry, 1993: Kindle, no page no.).

Johnson (2010: Kindle, no page no.) states that structured information is used to provide a visual hierarchy that may enable learners to separate relevant information from irrelevant information, which in its turn enables learners to focus their attention on relevant information. Furthermore, not only does structured information focus learners’ attention on relevant information, but it assists learners in remembering content better and assists learners’ perception (Jordan, Carlile and Stark, 2008: 235). Graphic organisers can be used to represent abstract or understood information, to show relationships, to help organise ideas and facts, help to link known to new information and assist with the storage and retrieval of information (Banikowski, 1999: no page no.).

Structured information given in the ICT classroom are not only limited to the examples given above. Graphic organisers such as mind maps (discussed in page 69), story maps, diagrams such as Venn diagrams, processes, cycles, relationship, matrix’s and pyramids can

be used to structure information. These graphic organisers can be applied in various computer software applications such as MS Office applications, Buzan's iMindMap and the Inspiration Software applications.

4.5 Conclusion

In chapter 3 learning paradigms such as behaviourism, constructivism and cognitivism were discussed. Chapter 4 shed light on cognitive education in the classroom. These discussions included methodologies that can be used as teaching strategies. Although each methodology has its strong and weak points, each has a place in the ICT classroom. For the purpose of this case study, emphasis was placed on cognitive education which was described as a philosophy of education and associated methodologies that develop the learning potential of each learner to acquire thinking skills needed to become a lifelong learner and independent thinker. It was stated that this could be acquired by activating and enhancing learners' cognitive processes. The chapter also discussed how cognitive education principles can be applied with computer technologies to enhance learning processes.

The use of computer technologies as a cognitive tool in teaching strategies and learner activities may contribute to the activation and enhancement of cognitive processes. This will be discussed in chapter 5 with an in-depth study.

Chapter 5

The use of computer technologies as cognitive tools.

5.1 Background

In chapter 4 cognitive education and its underlying principles were described. The importance of applying these principles by activating and enhancing learners' cognitive processes were highlighted. Examples were given as to how these principles could be applied towards more efficient learning in the classroom.

Chapter 5 will focus on the use of computer technologies as cognitive tools in the classroom to design effective teaching instruction, teaching aids and learner activities to activate and enhance learners' cognitive processes in the classroom.

5.2 Using computer technologies as a cognitive tool.

Computer technologies are increasingly used in the educational domain and have the ability to play an important role to assist learners in accomplishing cognitive tasks as cognitive tools (Lajoie and Derry, 1993: Kindle, no page no.). Jonassen (1994: 02) defines cognitive tools as "computer tools that are intended to engage and facilitate cognitive processing". He further states that cognitive tools are "both mental and computational devices that support, guide, and extend the thinking processes" of learners (Jonassen, 1994: 02).

As mentioned in chapter 4, Kozulin and Presseisen (1995: 67-75) stated that human "cognitive functions do not appear spontaneously" or automatically in a formal teaching situation due to contributing factors such as an educator's inexperience with cognitive tools and mediated learning not taking place. This notion implies that if cognitive functions do not appear spontaneously, they have to be triggered or activated in the learning environment to enable effective learning processes.

How can computer technologies support cognitive processes? Computer technologies are part of many people's cognitive strategies, helping to create and develop new ideas

(Hokanson and Hooper, 2000: 541). Salomon, Perkins and Globerson (1991: 02) state that software programmes and tools can be used with technology, to “potentially affect learners’ intellect”, whereas intellect refers to the “quality of learners’ cognitive processes”.

Pea, as cited by Salomon et al. (1991: 04), states that it “makes sense to call computer tools that offer an intellectual partnership *cognitive tools* or *technologies of the mind*” as they have the potential to make the partnership between the learner and technology more ‘intelligent’ than what it could be, should the learner construct learning on his own.

Hokanson and Hooper (2000: 543), as well as Jonassen (1994: 02) describe computer tools (referring to programmes and applications, multi- and digital media) as advanced cognitive tools intended to engage and facilitate cognitive processing. This notion is echoed by Lajoie and Derry (1993: Kindle, no page no.) who argued that “the appropriate role for a computer system is not that of a teacher/expert, but rather, that of a mind-extension ‘cognitive tool’ ”. These tools are used to expand learners’ thinking and problem solving skills but, can also be viewed as “computational and mental devices which support, guide and extend the thinking processes of users” (Jonassen and Reeves, 1996: 693).

Cognitive tools can be characterised as “technologies that enhance the cognitive powers of human beings during thinking, problem solving and learning” which can be used to engage and facilitate cognitive processing (Jonassen and Reeves, 1996: 693). Pea (1985: 167-182), further views cognitive tools as “amplification and reorganizational tools as they extend the learner’s thinking by transcending the limitations of the mind”. Pea’s notion implies that cognitive tools may exceed limitations a learner’s mind might have. Therefore, Pea’s notion support’s Lozanov’s (1978:11) theory that each learner has “relatively unlimited potential” where the brain’s reserve capacities can be released to ensure optimal learning takes place (Cilliers, 2010: 38)

Lajoie, identified at least four types of cognitive tools which can be identified according to the functions they perform (Lajoie and Derry, 1993: Kindle, no page no.). They can:

- a) Support learners' cognitive processes, such as, memory and metacognitive processes (Lajoie and Derry, 1993: Kindle, no page no.);
- b) Share learners' cognitive load by providing support for lower levels cognitive skills, to reserve resources for higher order thinking skills (Lajoie and Derry, 1993: Kindle, no page no.);
- c) Allow learners to engage in cognitive activities that would be unlikely otherwise (Lajoie and Derry, 1993: Kindle, no page no.);
- d) Allow learners to generate and test hypotheses in the framework of problem solving (Lajoie and Derry, 1993: Kindle, no page no.).

Apart from the functions computers can perform as cognitive tools as discussed above, computers can be used to enable learners to engage in knowledge construction rather than knowledge reproduction (Jonassen, 1994: 01). This notion is echoed by Jonassen (1994: 02) suggesting that computer technology should be 'taken away' from educators in it being a medium of conveyance and knowledge acquisition and rather be given as a tool to learners being designers in constructing their own knowledge. In his view "learners function as designers using the technology as tools for analysing the world, accessing information, interpreting and organising their personal knowledge and representing what they know to others" (Jonassen, 1994:02). This notion of Jonassen relates to constructionism. When learners construct and represent knowledge structures, it also refers to constructionism (Papert, 1991: para. 02). Constructionism according to Papert (1991: para. 14) revolves around the notion of "learning-by-making" and by actively creating ideas.

Salomon et al. (1991: 03) are of the opinion that intelligent technology (computer technology) and learners form a partnership to activate cognitive processes. This led them to asking the question how can the partnership be made to have transferable cognitive residues in the learner's mind? As an answer to the question they distinguish two different ways in which computer technology might have an effect on human intellect or more specifically on the quality of learners' cognitive processes. They refer to "effects *with* technology and effects *of* technology".

Effects with technology refer to the partnership between learner and computer technology where there is “mindful engagement” by learners when interacting with technology (Salomon et al., 1991: 03). He argues it is not about “what intelligent tools do to people” but rather how the partnership affects cognition and how the partnership can be made to have transferable cognitive residues. The possibilities of the effect cognitive residues may have rest on an important assumption that “higher order thinking skills are either activated during an activity with an intelligent tool or they are modelled by it” (Salomon et al., 1991: 08). Salomon et al. further states that the partnership with intelligent tools could be seen “as an invitation to operate within” Vygotsky’s “zone of proximal development” (Salomon et al., 1991: 05). The partnership between learners and intelligent technologies allow learners to “engage in cognitive processes that are of a higher order than the ones they would display without that partnership” (Salomon et al., 1991: 05).

Effects of technology occur when a partnership between the learner and technology leaves a cognitive residue equipping people with thinking skills and strategies that reorganise and enhance their performance (Salomon et al., 1991: 08).

Hokansen and Hooper (2000: 541) state that “computers exist as part of many people’s cognitive strategies, helping them to create and develop new ideas”. Ong, as cited in Hokansen and Hooper (2000: 541), furthermore states that computers assist in transforming consciousness. Hokansen and Hooper (2000: 548) believe a cognitive medium is “one that provides an environment for intellectual growth”. This perspective causes a shift in how computers should be used in education. It is a shift that moves from the representative use of computers to transmit information to that of a generative use for the construction of knowledge (Hokansen and Hooper, 2000: 543, 548). Kay (1990: 191-201) echoes this in saying that if we view computing as a medium, a condition for cognitive growth, we will change our understanding of how computers can be used. With this viewpoint, Hokansen and Hooper (2000: 541), as well as Kay (1990: 191-201) refers to the generative use of computers to generate cognitive processes. According to Hokansen and Hooper (2000: 548) when computers are used in a generative manner, then computer technology “may affect how people think, and learn and how we understand and evaluate

computer-enhanced cognitive processes". With this notion they consider the generative use of computers as enabling the flow of information and conceptual change towards stimulating changes in cognitive processes such as mental organisation and thought processes.

5.3 Computer technologies as cognitive tools create cognitive changes.

Learning triggers change in the brain (Sorensen and Murchú, 2006: 308; Sprenger, 2010: 26). Sporns (2001: 03) states that "changes in sensory input or cognitive task result in highly specific patterns of brain activation". With this notion one can argue that computer technologies can be used as a cognitive tool to bring changes into the sensory input of a learner user to result in highly specific patterns of brain activation.

The brain needs multifaceted experiences to learn effectively (Jensen, 2005: 03). For the brain to change on a long-term basis, it needs experiences that reinforce changes that have occurred (Jensen, 2005: 03). The use of computer technologies and various software applications may assist learning experiences that are multifaceted with the following:

- a) Multisensory input that enhances the learning: Learning experiences will be more powerful and the retrieval of information will be enhanced as more senses are involved (Nicholson *et al.*, 2007: 07, 08; Sorensen and Murchú, 2006: 298, 313; Sprenger, 2010: 27);
- b) Creating intrinsic motivation and rewards through enjoyment of activities and educational games (Jensen, 2005: 104; Schneiderman and Plaisant, 2010: 51; Sprenger, 2010: 27, 58): Educational games promote intrinsic motivation and constructive activities such as goal setting. Furthermore, they satisfy the basic requirements of learning environments and may provide engaging learning experiences (Schneiderman and Plaisant, 2010: 51);
- c) Affecting learners' emotion through enjoyment: Enjoyment releases the neurotransmitter Dopamine (Jensen, 2005: 75). Evidence links dopamine to positive cognitive functioning. Attention is enhanced which in its turn improves our semantic memory (Jensen, 2005: 75). Experiences linked to emotion are easier to remember (Pritchard, 2009: 90; Sprenger, 2010: 26, 27). This implicates LeDoux's (1994: 57)

notion that an individual learning is enhanced when emotion is triggered, as emotion has a powerful influence on an individual's storage and strength of memories;

- d) Increasing memory retention by repetition and rote learning: Without repetition, memories are difficult to recall (Jensen, 2005: 118; Sprenger, 2010: 27). Repetition and rote learning causes neural connections to reactivate therefore, increasing the chance of retaining memory (McLeod, 2003: 36);
- e) Assist in the learning process of abstract concepts through visual presentations: Thinking and learning occurs in the frontal lobe (Jensen, 2005: 118). This part of the brain develops slowly and may only mature around the age of 30 (Jensen, 2005: 30). Sprenger (2010: 27) states that is better to start with concrete examples before moving to the abstract;
- f) Practicing of concepts and newly learnt knowledge: Practice makes learning concepts permanent (Sprenger, 2010: 27). Practicing what is learnt is often required to strengthen neural connections (Jensen, 2005: 40). The more a connection is used, the larger the neural network grows and the more secure the links becomes (Jensen, 2005: 40). As activities are practiced, pathways in the network get more efficient and transmission speed increases (Sprenger, 2010: 27);
- g) Using brain plasticity: Software programs that “use brain plasticity to retrain the visual and auditory systems, may improve attention, hearing and reading abilities” (Jensen, 2005: 03). Many senses are engaged when learners do assignments and research on the computer (Sprenger, 2010: 70-76). The work is visual, auditory and kinaesthetic, perfectly lending itself to learning styles (Sprenger, 2010: 70-76). The more elaborate a memory is in terms of vision, sound and touch, the easier it is to access (Sprenger, 2010: 70-76);
- h) The improvement of higher order thinking skills: Hopson, Simms and Knezek (2001: 109) state that using computer technologies may enhance learners' problem solving, critical thinking and higher-order thinking skills.

The use of these strategies enables educators to provide learners with the needed multifaceted learning experiences to learn more effectively. Furthermore, these strategies

also enable educators to provide learners with more personalised learning experiences resulting in meaningful learning (Jonassen and Reeves, 1996: 698).

5.4 The benefit of using computers as cognitive tools.

What are the benefits of using computers as cognitive tools? Lajoie and Derry (1993, no page no.), Jonassen and Reeves (1996: 697-698) state that cognitive tools may benefit learners as follow:

- a) Cognitive processes such as memory and metacognitive processes are supported (Lajoie and Derry, 1993: Kindle, no page no.);
- b) By providing support for lower level cognitive skills so that resources are left for the use of higher order thinking skills computer help to share a cognitive load (Lajoie and Derry, 1993: Kindle, no page no.). Furthermore, they offload some of the unproductive memorising tasks to the computer, allowing learners to think more productively (Jonassen and Reeves, 1996: 698);
- c) By assisting learners to engage in cognitive activities that would be unlikely otherwise (Lajoie and Derry, 1993: Kindle, no page no.);
- d) They support learners to “do deep reflective thinking that is necessary for meaningful learning” (Jonassen and Reeves, 1996: 698);
- e) They allow learners to generate and test hypotheses in the context of problem solving (Jonassen and Reeves, 1996: 698);
- f) They “empower learners to design their own representations of knowledge” (Jonassen and Reeves, 1996: 698);
- g) They “engage learners in creating knowledge that reflects their comprehension and conceptualisation of information” (Jonassen and Reeves, 1996: 697);

Furthermore, cognitive tools support the transfer of skills when used in a partnership with computer tools (Levin, Riel, Miyake and Cohen, 1987: 254-260). Transfer of skills is one of the basic criteria needed for adequate mediation in the learning process as set by Reuven Feuerstein and his colleagues as cited in Rossouw (1995: 105-111).

5.5 Computer Technologies contribute to collaborative learning experiences.

Today's learners are making much more use of technology (Prensky, 2001: 01; Tapscott, 1999: Kindle, no page no.). Most learners have access to cell phones and computers at home (Prensky, 2001: 01). Learners are making use of social media to communicate and socialise more and more (Sprenger, 2010: xiii; Tapscott, 1999: Kindle, no page no.). As mentioned previously, technology offers opportunities to discuss projects, school work and home work. In cases where learners might not feel free to voice their opinions or discuss work in class, they are more willing to engage in discussion and voice their opinion through social media (Sprenger, 2010: 13). This phenomenon may contribute to collaborative learning experiences and more effective learning (Sprenger, 2010: 13). Schneiderman and Plaisant (2010: 412) echo this in saying that "pairs often learn better than individuals because they can discuss their problems and learn from each other". Furthermore, they state that the verbalisation of problems often demonstrated to be an advantage during the learning process.

5.6 Computer technologies and memory.

Much of our everyday activities rely on memory. Our memory contains stored factual knowledge, but also knowledge of actions which enables us to repeat actions, use language and to use newly stored information (Sousa, 2011: 82). What is memory then? Memory is the process by which information received by one's senses is encoded, stored and retrieved (Sousa, 2011: 83). Rhoda (n.d.: 29) describes memory as "the system that enables us to record past experience and use it in the present". From a cognitive neuroscience perspective memory is considered as the retention, reactivation, and reconstruction of previous knowledge (Jensen, 2005: 127-143).

People recognise things better than being able to remember and recall them from memory (Johnson, 2010: Kindle, no page no.). In contrast, recalling memories, such as retrieving them without perceptual support, is much harder to do (Johnson, 2010: Kindle, no page no.). This places limitations on learners' cognitive skills, but, computer technologies are able to help learners to overcome this limitation by augmenting cognitive skills (Jonassen, 1994: 05). Computer technologies therefore, help users to use less of the memory by

offloading cognitive operations onto technology (Dror, 2013: para. 02; Jonassen and Reeves, 1996: 698). Furthermore, Dror (2013: para. 02) and Jonassen (1994: 05) stated that such offloading reduces cognitive load, frees up cognitive resources and allows learners to think more productively. It allows learners to increase their memory capacity and free them from needing to memorise offloaded information (Jonassen, 1994: 05).

5.7 Motivation for using technology to enhance teaching and learning in a South African context

As discussed in chapter 1, South African Education is faced with a plethora of factors which affect teaching and learning negatively. Change is a constant in our educational system where our educators had to adapt to the changes brought by OBE, Curriculum 2005 and CAPS among others. The debate continues regarding the effectiveness or the lack thereof and the impact curriculum changes have on teaching and learning. With the continual curriculum changes educators had to face, one gets the impression that our education authorities are constantly trying to find a solution, a panacea that will bring about effective change to teaching and learning. Perhaps the time has come for South African educators not to wait for the government to bring about the panacea, but, to be the change themselves. The needed change might be brought about with the effective use of computer technologies as cognitive tools in our classrooms.

Furthermore, learners' daily lives revolve around computer technologies in the digital era we live in. They are making use of cell phones, smartphones, tablets, computers, iPod's to play games, communicate, listen to music, watch online videos and movies, and to browse websites available on the Internet for entertainment (Sprenger, 2010: 03, 04). As previously stated learners have an affinity with computer technologies (Heafner, 2004: 42). This affinity with computer technologies may put educators in a favourable position to take advantage of this phenomenon by incorporating it into lessons and to make learning a positive and enjoyable experience for learners.

Learners are very willing and would rather do school tasks and projects with the help of computer technologies as they enjoy doing the tasks in such a manner (Heafner, 2004: 46).

Research done by Heafner (2004: 42-49) found that learners preferred using computer technologies to do school tasks for the following reasons:

- a) They've experienced enjoyment in doing the tasks (Heafner, 2004: 46);
- b) Learners viewed doing tasks as "fun" (Heafner, 2004: 46);
- c) Learners found the tasks as "fresh and invigorating" (Heafner, 2004: 46);
- d) Working with computer technologies enabled learners to refine their technology skills (Heafner, 2004: 46);
- e) Using computer technologies made their work easier to do and manage (Heafner, 2004: 46);
- f) Learners found it easier to search for and find information online than using traditional methods (Heafner, 2004: 46).

Furthermore, Heafner (2004: 46) found that the computer technologies assisted learners' cognitive and thinking processes. They contributed to collaboration in the classroom (Heafner, 2004: 48). Learners' tasks were neater; they were structured and looked more professional. Learners were focussed, on task and able to finish the tasks more efficiently and at a quicker pace (Heafner, 2004: 46). Learners were able to present their work with pride. She attributed this to learners having more self-confidence in completing the tasks, due to their familiarity with technology (Heafner, 2004: 47).

Learners learn more effectively when computer technologies are used in the learning process (Schneiderman and Plaisant, 2010: 23). Lee, Waxman, Wu, Michko and Lin (2013: 133) state that computer technologies offer a "broad variety of modalities, tools and strategies" for learning and intervention strategies when needed. The question that arises from that statement then is how can computer technologies contribute towards effective teaching and learning? From reviewing the literature it was found that computer technologies contributed towards effective teaching and learning in the following ways:

- a) By creating motivation: Heafner (2004: 47) found that computer technologies have the potential to increase student motivation based on the expectancy-value model of motivation. This model focusses on three areas, namely: value (the importance of the task), expectancy (learners' beliefs about their ability or skill to do the task) and

learners' affinity with technology (Heafner, 2004: 43). Learners' belief regarding the value or importance of a task impacts their engagement with the task (Heafner, 2004: 44). Expectancy impacts willingness to engage in the task. When learners perceive a task as within the range of their capabilities and if there is an expectation of being able to successfully complete a task, then learners will advance into doing the task (Heafner, 2004: 42). Learners' affinity with technology originates from the technology creating positive emotions and self-worth (Heafner, 2004: 42);

- b) Computer technologies have the potential to make learning memorable: Knowledge tends to be “memorable when it has been deeply processed and visualised, and when recall has been practised” (McKeown and McGlashon, 2012: Kindle, no page no.). Knowledge is retained and remembered more successfully when it is memorable (McKeown and McGlashon, 2012: Kindle, no page no.);
- c) Computer technologies serve as a tool to overcome learning disabilities: Computer Technologies serve as a tool to overcome learning disabilities and enable learners with barriers to learn more efficiently, take part in educational activities, produce work and complete assignments with success (Hasselbring and Glaser, 2000: 102). Florian (n.d.: 10) states that computer technology serves as an equaliser for learners with learning disabilities as it “serves as a cognitive prosthesis” to overcome learning disabilities. Hasselbring and Glaser (2000: 102) state that computer technologies offer “a broader range of educational activities to meet a variety of needs” for learners with learning barriers and disorders, for example:
 - I. Word processing software enables learners to revise and edit text more easily, produce clean and readable text, especially learners with impaired fine motor skills as it enables them to write legibly (Hasselbring and Glaser, 2000: 106);
 - II. Word prediction software allows learners to express their words and ideas in a manner that reflects their thinking more closely (Hasselbring and Glaser, 2000: 107);
 - III. Multimedia applications enable learners to express their knowledge in more different ways than linear writing. Furthermore, it enables them to “demonstrate higher-level performance and attention to detail working on

multimedia projects than they normally exhibit” (Hasselbring and Glaser, 2000: 109);

- d) Using technology as a mediator to facilitate learning: Research done by Nicholson, et al. (2007: 03) suggested that a computer-mediated environment has a great influence on improving learning outcomes. Computer technology provides a sensorial rich mediated environment which captures the learners’ attention, leads to increased learning, interest and satisfaction in the learning environment (Webster and Hackly, 1997: 1282-1309);
- e) Using computer technologies as a strategy to optimise brain functioning: The computer may be used as a tool to help students work through complex problems and assist in higher-order thinking skills (Wenglinsky, 2005: 13, 30). Computer simulations of real life models are “powerful tools to not only teach knowledge content, but also thinking and reasoning skills necessary for problem solving” in the learning process (Gokhale, 2012: no page no.). Research done by Gokhale, (2012: no page no.) confirmed that where computer simulation software was integrated into learner activities, students performed better in problem solving and higher order thinking by giving them opportunities to practice and refine their higher-order strategies;
- f) Using multimedia presentations to promote deep understanding: Multimedia aids teaching as visualisation, modelling and simulation create understanding. This type of media is especially effective for learning as it involves both spatial and verbal working memory (Brunye, Taylor and Rapp, 2007: 02). Vivid representations of information are believed “to require less cognitive effort to process” information as they “act to simplify complex information and help provide an individual with a concrete and accurate mental image of the instructional material” thus “decreasing cognitive load and increasing performance” (Nicholson et al., 2007: 08-10). Multimedia enables meaningful learning, as it “requires less cognitive effort to process, as the meaning can be directly inferred and does not require to extrapolate meaning artificially” (Nicholson et al., 2007: 08-10). Therefore, it promotes deeper understanding (Mayer and Moreno, 2002: 111);

- g) Using computer games to engage: Computer games engage learners as the technology represents reality and fantasy (Mitchell and Savill-Smith, 2004: 17). The visual and spatial richness of games excite and bring pleasure (Mitchell and Savill-Smith, 2004: 17). Meta-cognition is used and it improves strategic thinking and insight (Mitchell and Savill-Smith, 2004: 20). It benefits psychomotor, analytical and spatial skills as well as visual selective attention (Mitchell and Savill-Smith, 2004: 20). Furthermore computer games afford opportunities for engagement with the use of drill and practice activities, which in its turn enhances knowledge acquisition and retention (Mitchell and Savill-Smith, 2004: 17-20). Engagement through computer games facilitates deeper understanding resulting in a “better command of the information” (Nicholson et al., 2007: 11);
- h) Using computer technology to assist learners in retaining their learning and memory better: Learning is enhanced as learners learn information in less time than traditionally taught learners (Ragasa, 2008: 02). Visual, audio and spatial richness of digital media used with computer technologies create elaborate memories making it easier for the mind to access (Sorensen and Murchú, 2006: 298). Furthermore the use of games and software by which learners can practice what was learnt, is “believed to aid in the efficient transfer and retention of knowledge” of learners’ short-term and long-term memory (Nicholson et al., 2007: 09);
- i) Using computer technologies contribute towards accommodating multiple intelligences and the facilitation of learning regarding different learning styles and abilities: Learners have different learning styles and multiple intelligences. Computer technology allows educators to incorporate activities and teaching methods to meet the needs of learners with visual, auditory and kinaesthetic learning styles as well as multiple intelligences. (Sprenger, 2010: 70-80); Hill, as cited in Nicholson et al., stated that when instruction is provided in a “manner consistent with an individual’s particular learning style” it “may reduce extraneous cognitive load and enhance learning” (Nicholson et al., 2007: 11);
- j) Computer technologies contribute towards learning being an active process: According to McKeown and McGlashon (2012: Kindle, no page no.) computer technologies contribute to active learning when learners “search for and present

information, running simulations or communicating and sharing through social media”;

- k) Computer technologies contribute towards collaboration inside and out of the classroom: Learners have opportunities to collaborate with each other as well as learners from all over the world (Sprenger, 2010: 13). Sprenger (2010: 13) states that collaboration in the classroom may help learners develop emotional intelligence through their interaction when working on projects;
- l) The creation of positive learner attitudes: Computer technology is effective in amplifying affective responses leading to better and more positive attitudes among learners (Heafner, 2004: 43; Ragasa, 2008: 02);
- m) Using computer technologies play the following positive roles in learner achievement in academic tasks:
 - I. Word processing helps learners to more easily express their ideas (Hasselbring and Glaser, 2000: 107; Wenglinsky, 2005: 32);
 - II. The design of learners’ own representation of constructed knowledge (Jonassen and Reeves, 1996: 694, 695);
 - III. The investigation of phenomena through simulation software brings learners in touch with the real-world (Gokhale, 2012: no page no.);
 - IV. The creation of spreadsheets, charts, tables and graphs help learners to think abstractly about economic, social and physical phenomena (Jonassen and Reeves, 1996: 711, 712);
 - V. Supporting reflective thinking, known as metacognition (Jonassen, 1994: 04);
 - VI. Assisting learners with skills such as project management, research, organisation and presentation and reflection (Jonassen and Reeves, 1996: 704);
 - VII. Making learning meaningful (Jonassen, 1994: 04);
 - VIII. Facilitating critical thinking and higher order learning (Gokhale, 2012: no page no.).

From the previous discussion, one may conclude that computer technologies contribute towards effective teaching and learning. Jonassen (1994: 04) states that learners form a

partnership with computer technologies in the learning process. In this partnership, computer technologies enhance learners' thinking and learning (Jonassen, 1994: 05).

Having discussed the tenets which cognitive education is based on in chapter 4 and the use of computer technologies as cognitive tools in this chapter, one may come to the realisation that computer technologies may indeed support cognitive education as a tool to enhance teaching and learning. As previously mentioned, cognitive education aims to enhance learning potential by:

- a) Making learning meaningful and vivid to enhance retention of what is learned (Hokansen and Hooper, 2005: 548; Pritchard, 2009: 31, 33; Sorensen and Murchú, 2006: 313);
- b) Minimising the effect of threat and creating relaxed alertness to prevent downshifting of the brain (Cilliers, 2005: 11);
- c) Establishing association between old and new knowledge (Jensen, 2005: 135; Pritchard, 2009: 31);
- d) Active processing in the brain through the establishment of patterns from learning experiences, organisation of information and making associations to store new information in the brain's long-term memory (McCullough, 2014: 54; McLeod, 2003: 36).

Previous discussions in this chapter suggested how computer technologies can support the above mentioned tenets of cognitive education.

5.8 Application of cognitive education principles with the use of computer technologies and software in the classroom for this study

Certain principles of cognitive education can be applied in the ICT-enabled classroom to enhance teaching and learning (Sprenger, 2010: 26). As previously mentioned, learning is a process "that leads to change" (Ambrose et al., 2010: 03). In order for the brain to change on a long-term basis, the brain needs experiences that will reinforce these changes (Sprenger, 2010: 26). Principles of cognitive education that were focussed on for this project were:

- a) Multisensory input;
- b) Multifaceted learning experiences;
- c) Attentional focus;
- d) Rewards and motivation;
- e) Enhancement of memory to retain what was learned;
- f) Linking prior knowledge with new knowledge;
- g) Making abstract concepts concrete;
- h) Practice of knowledge through educational games and
- i) Making learning meaningful

Lessons were designed to apply cognitive education principles with the use of computer technologies as cognitive tools in the following way:

- a) Microsoft Power Point Presentations for both teaching and applying decimal principles by learners in their workbooks (see Appendix nr. 1 and 2) were prepared to present multisensory output which involved the visual, auditive and kinaesthetic senses. Abstract knowledge was made concrete with visual information. The use of multisensory input and concrete information aimed at creating better understanding and enhancing memory. The information was set up to link known knowledge with new knowledge. Furthermore, the activities catered for learners' various learning styles. This was done by:
 - I. The animation of contents, concepts, words and graphics. Animation created movement visible by the visual senses which drew learners' attention to specific contents (Lee, Klippel and Tappe, 2003: 12) and contributed to the explanation of concepts. For example, movement was used when a decimal number's various number and place values were explained. This assisted learners in understanding how digits in a number fitted into a decimal number. Furthermore animation was controlled by the educator in such a way that each animation only became visible with the click of the computer mouse. This gave

the educator more control over what was discussed in each stage and allowed the educator to move back or forth between concepts or to repeat them when necessary.

- II. Different colours in the font were used to emphasise words and concepts. This aimed at increasing learners' comprehension of information, but also to add visual appeal to what was displayed. The use of colour aimed at impacting learners' memory (Wichman, Sharpe and Gegenfurter, 2002:510) leading to effective learning. Figure 5.1 shows an example of coloured font used in emphasising words.
- III. Graphics were used to visually display the application of decimal principles. Figure 5.2 shows an example of visual display in the application of place values which aimed at enhancing the understanding of place values.

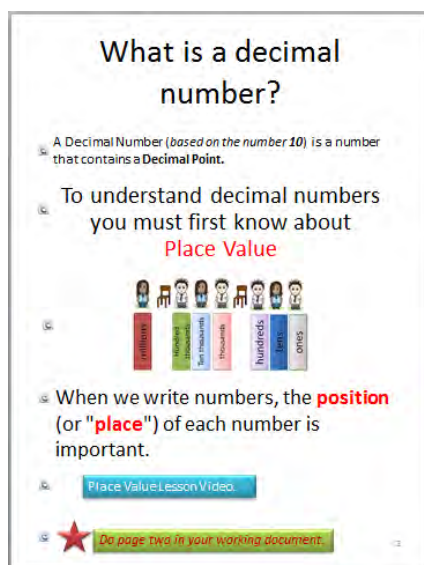


Figure 5.1 – Use of coloured font.

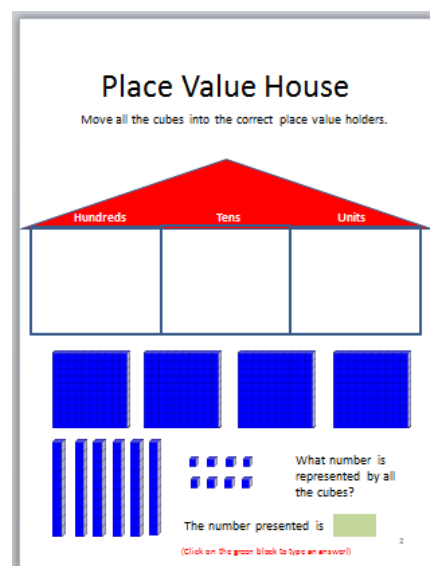


Figure 5.2 – Graphics for visual display.

- IV. Visual structure on the Power Point slides aimed at helping learners to focus on items and important information in specific activities and the application of decimal concepts. Figure 5.3 shows an example of structure used.

Writing decimals in expanded notation.

Remember your place values as they will help you to write your decimal number in expanded notation!

First label your place values.

Write your expanded notation.

$$1 \times 1000 + 6 \times 100 + 4 \times 10 + 8 \times 1 + 3 \times \frac{1}{10} + 7 \times \frac{1}{100} + 5 \times \frac{1}{1000}$$

Whole numbers
decimal numbers

This is where the decimal point will be!

★ Do page 9 in your working document

Visual structure was used to display a decimal number.

The gestalt principle of figure and ground was used to focus learners' attention on important instructions or concepts.

Figure 5.3 – Visual structure and Figure and Ground.

- V. The teaching Power Point had links to videos available on You Tube and the Khan academy. This gave the educator the opportunity to alternate between different media to explain various decimal concepts and to make use of multisensory input which aimed at enhanced retrieval of information and efficient learning.
- b) Microsoft Power Point was also used to create 'workbooks' where learners had to apply learnt decimal principles. It was decided to create these workbooks in Microsoft Power Point as it is more user friendly than Microsoft Word documents where elements may shift and move around when learner information is added. These workbooks were prepared to incorporate principles found in Gestalt psychology and elements that affect attentional focus. Figure and ground were used to separate certain visual fields into foreground and background and the workbook 'pages' and sections had structured outlays. The colour and size of picture graphics used aimed at creating attentional focus. Visual structure and grouping were used to get learners to focus on certain items and important information needed to apply what was learned previously (See figure 5.3).
- c) Videos available on You Tube and of the Khan academy were used to explain the following decimal principles:

- I. What is a decimal?
- II. The explanation of place value and the impact it has on a digit's number value;
- III. How to read a decimal.

The videos made use of multisensory output which was visual, auditory, kinaesthetic, and which supported learners' individual learning styles. The use of movement, colour, sound and changes aimed to create attentional focus and enhancing understanding. Videos were used when a new decimal concept was introduced.

d) The use of Internet based decimal games activities aimed to:

- I. Create intrinsic motivation, enhanced attention and improved semantic memory;
- II. Affect learners' emotion with enjoyable activities to contribute to the release of neurotransmitters such as Dopamine and Serotonin to enhance cognitive functioning. The use of these games was aimed at reducing stress and cortisol levels which may inhibit cognitive functions;
- III. Reactivate neural connections by means of repetition to improve and retain memory;
- IV. Reward learners by allowing them to move to higher game levels;
- V. Practice and apply what was learned previously. This aimed at strengthening neural connections and making the recall of what was learned easier;
- VI. Internet based games aimed at creating intrinsic motivation and to enhance rote learning. Games that were played applied the following principles of decimals:
 - Reading and writing decimals;
 - Ordering decimals;
 - Expanded notation;
 - Converting fractions to decimals;
 - Comparing decimals;
 - Adding decimals;

- Subtracting decimals;
- Multiply with decimals;
- Decimal number lines;
- Linking number in words with the correct decimal number.

Constructivism, discussed in chapter 3, suggests that learning takes place when the learner constructs his/her own knowledge and is actively engaged in his/her own learning process. During the research project learners were able to construct their own knowledge of decimals by exploring various educational websites and did research regarding the principles and concepts of decimals.

Furthermore knowledge construction took place whereby computer technologies supported learner-centred instruction found in the visited websites and learner workbooks. This approach engaged learners in the learning process with the use of online activities and supported knowledge construction with the use of various media such as videos found on You Tube and Khan Academy. Internet based activities that were done allowed learners to present and manipulate a variety of decimal symbols. These activities aimed at the improvement of the ability to generate thinking as one of the cognitive processes used in learning.

5.9 Conclusion.

In this chapter the use of computer technologies as cognitive tools in the learning environment was described. The chapter described how the use of computer technologies may create cognitive changes and how they may contribute towards collaborative learning experiences and what the benefits are in using them as cognitive tools.

Notwithstanding the value of cognitive processes and their application in the classroom, the absence of scientific validation and detailed scientific research studies in a South African context necessitated subjecting the use of computer technologies as a cognitive tool to scientific evaluation, as described in chapter 6. This evaluation was conducted within a South African context by designing and implementing a case study as the research method.

Chapter 6

Research design and Execution

6.1 Background

Preceding chapters contain the theories supporting this research study and serve as background to succeeding chapters. Theories exist to interpret the phenomena we observe, but also function to integrate existing facts and arrange them in a manner to give them new meaning. This study sought to put educational theories to the test through the practical application of computer technologies as cognitive tools in a specific classroom environment.

In the previous chapters theories indicated the importance of a learner's affective, cognitive and physical state to enhance learning based on MacLean's Triune Brain Theory (Cilliers, 2005: 09-12). Furthermore it was indicated that perception which involves the senses enhanced the learning process and the retention of patterns formed in the memory. The mentioned theories supported the use of computer technology as a cognitive tool to enhance teaching and learning processes.

According to Mouton (1996: 108), "the rationale for a research design is to plan and structure a research project in such a way that the eventual validity of the research findings is maximised through either minimising or, where possible, eliminating potential error". The focus of this chapter is to present a research strategy and design.

The nature of this study required a multifaceted approach to address the research problem in a scientific and ethical manner. This approach included concept analysis through an informative and analytical literature study as addressed in previous chapters and qualitative research in the successive chapters.

6.2 A Quantitative case study

This research study is conducted as a quantitative case study, an empirical inquiry where the focus is on a phenomenon within a real-life context. Nisbet and Watt, as cited by

Cohen, Manion and Morrison (2007: Kindle, no page no.), describe a case study as “a specific instance that is frequently designed to illustrate a more general principle”. It is “a study of an instance in action” (Cohen, Manion and Morrison, 2007: Kindle, no page no.), where an instance refers to a school in action. In general terms, Nisbet and Watt’s notion refers to a case study as an in-depth study of a particular situation.

This case study followed a quantitative approach, which is explanatory and structured in nature to test existing theories and their implementation. By design it is a single-case study which observed a particular phenomenon taking place at a primary school. A single subject research, namely Grade 6 Mathematics, provided the statistical framework for making inferences from quantitative data to test the impact theories may have on learner achievement.

A quantitative approach was selected as the approach is more adequate to give the researcher an opportunity to draw more reliable inferences from quantitative data to determine the difference in learner achievement as opposed to qualitative case studies, where data is collected from observations, interviews, surveys, historical documents and artefacts (Olivier, 2009: 100). Observations are difficult to measure (Olivier, 2009: 100). Interviews, surveys, historical documents and artefacts may limit the ability to make reliable inferences to assess and support the impact of the theories discussed in the study (Cohen, Manion and Morrison, 2007: Kindle, no page no.).

Case study research design is beneficial for testing whether known theories and models actually work in naturally occurring social situations (Swann and Pratt, 2003: 115). It “provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than simply by representing them with abstract theories or principles” (Cohen, Manion and Morrison, 2007: Kindle, no page no.). Furthermore, case studies enable the establishment of “cause and effect” as they “observe effects in real contexts”, where contexts are “unique and dynamic”, and “report the unfolding interaction of events, human relationships and other factors in a unique instance” (Cohen, Manion and Morrison, 2007: Kindle, no page no.). Cohen, Manion and Morrison further

mention that case studies may “contribute towards the ‘democratization’ of decision-making” (2007: Kindle, no page no.). Therefore, this case study may provide a solution for educators to bring about the change needed to teaching and learning in the South African context.

6.3 The research question

The primary research question for this study is: “Does the use of ICT as a cognitive tool to teach decimal concepts by means of a developed brain based cognitive approach have the potential to lead to improved learner results compared to learners not exposed to the intervention?” It is envisaged that this study’s results may suggest that computer technologies and software have the ability to enhance the cognitive processes of learners, resulting in effective and optimal learning taking place in the ICT enabled classroom.

6.4. The research environment

The preferred research methodology was undertaken in a school setting at Sunlands Primary School which is situated in Kenwyn, Cape Town. The case study was of a collaborative nature where collaboration existed between the Grade 6 Mathematics educator and the computer educator who is also the researcher. The research project took place over the course of two school terms.

The Grade 6 group as a whole took part in the research project. There were three classes, where each was divided into two groups, equalling six groups in total. Both groups of each class spent the same number of weeks in the computer lab for a period of seven weeks spread over the third and fourth terms according to the school’s timetable. In this routine the first group (known at the school as the blue group) visited the computer class as the research group and the other (known as the yellow group) served as the control group. This routine was used for both school terms during the research project.

The number of learners per class, per research and control group was an aspect the researcher had no control over. Therefore, as reflected in table 6.1 one will note that the

GROUP	FREQUENCY	% OF SAMPLE
Research group (Blue group)	37	45.67%
Control group (Yellow group)	44	54.33%
Total	81	100%

Table 6.1 – Representation of the research and control groups.

percentage of the research group sample was less than that of the control group. Also contributing to the research group's lower percentage is the fact that learners who did not write both the pre- and post-test due to being absent with one of the tests, were not included in this study as that could influence the validity of the scores and the interpretation of the data.

The host primary school for this study was selected because of its involvement with ongoing professional development and a quest to find ways in which learning could take place more effectively. All educators have access to a computer, the internet and other digital technologies. While there are a computer and an interactive whiteboard available for each grade, all educators have access to a computer and interactive whiteboard in the school library for teaching purposes. The school's computer laboratory is equipped with the needed computer technologies, software and infrastructure, which created a suitable environment for conducting the research in. The computer laboratory has 23 computers, an interactive whiteboard and other digital technologies.

6.5. Sampling

Feuerstein discovered that the human brain was not fixed but is cognitively modifiable; therefore, every child has the potential to learn effectively (Cilliers, 2010: 26). Consequently the target population could consist of any learner, irrespective of cognitive abilities, background, age, culture, gender or ethnic group. Purposive convenient sampling was used to acquire in-depth information and to have the needed cognitive, socio-economic, culture, gender and ethnic representation, to ensure an appropriate statistical analysis of learner achievement. Due to the extent of the study and resources available the

target population was reduced to a sample that was as representative as could be of a target population.

To enable adequate comparisons across groups it was important that both groups were heterogenic in composition. Groups were chosen to be similar in number, gender and academic ability.

The sampling body for this research study was made up of 81 learners chosen from the whole Grade 6 group at Sunlands Primary School. The Grade 6 group consisted of 43 boys and 38 girls (Table 6.2). Age groups were evenly distributed in the group. A total of 3 learners were 11 years of age, 72 were 12 years of age and 6 were 13 years of age (Table 6.3).

GROUP	GENDER		
	Boys	Girls	Total
Research group	18	19	37
Control group	25	19	44
Total	43	38	81

Table 6.2 – Gender representation.

GROUP	11 years old	12 years old	13 years old	TOTAL
Research group	2	34	4	40
Control group	1	38	2	41
TOTAL	3	72	6	81

Table 6.3 - The distribution of age amongst the research and control groups.

The frequency and time in which class groups attend the computer laboratory according to the timetable structure impacted the distribution of learners in both the research and control groups. In the case of Sunlands Primary School, the groups into which each class is divided into (blue and yellow groups) and the duration of the school term have an impact on their frequency in attending the computer lab. Depending on the duration of a school term, each group only spend 3-4 continuous weeks in the computer lab which can be

devoted to teaching and learning activities. The same number of weeks is devoted to classes in the art room when the groups swap. Activities in the art room consist of creative art where learners create works of art with the use of different art mediums such as paint, pencils, graphite, coloured pens, oil pastels, art clay and paper mache.

Sunlands Primary School was selected as the target population for this study, based on the following reasons:

- a) The greater school population represents a diverse socio-economic environment with learners representing various economic backgrounds, cultures, ethnic groups and different home languages. The diversity afforded the researcher a suitable opportunity to address the research question as the school community can be viewed as representative of learner populations in South Africa.
- b) Data from previous assessments suggested that the majority of Grade 6 learners struggled to understand and apply decimals in Mathematics. Very low achievement levels in this Mathematics area afforded the researcher a more enhanced opportunity to determine the level of impact on learner achievement than what could have been the case if learner achievement levels were normally distributed.

6.6 The research period

After an initial interview with the principal and management team was completed, the necessary permission was obtained and the research design and programme development were completed. The research project started at the beginning of Term 3, 2013 and concluded at the end of Term 4, 2013 with a short school holiday break in between from 1 to 10 October 2013.

6.7. Instrumentation

Instruments used for intervention and teaching the mathematical concept of decimals reflect the conceptualisation of the phenomenon in a manner that is consistent with the learning theories discussed in this study. As discussed in chapter 5, teaching and lesson

activities were carefully set up to enhance learner attention and to activate and enhance cognitive processes to make learning meaningful and more efficient.

The measuring instruments namely, tests used to assess learner achievement pre- and post-intervention, were of a quantitative nature. According to Blaikie (2003: 47) “quantitative methods are used when the data have been collected in or are soon converted into numbers for analysis”. The rationale for selecting quantitative methods in collecting data was that the methods were structured to provide the researcher with data that was precise, numerical and unbiased. This enabled the researcher to validate claims regarding the use of computer technology as cognitive tools to activate and enhance cognitive processes of learners.

The pre- and post-tests were non-parametric as they were specifically designed for Grade 6 learners. The results of both tests confirmed their non-parametric nature. This enabled the researcher to collect statistics to determine the effect computer technologies and software may have on learners’ cognitive processes.

The pre- and post-tests were also criterion-referenced, as they indicate whether learners have achieved a certain set of criteria regarding their levels of understanding in decimals. Cohen, Manion and Morrison (2007: Kindle, no page no.) state that a criterion-referenced test provides researchers with information regarding what exactly a learner has learned, or what the learner is able to do.

6.7.1 Structure of the measuring instruments

To further ensure that findings were valid, both the pre- and post-tests were standardised according to the Curriculum and Assessment Performance Standards (CAPS) as released by the Department of Basic Education. A standardised test as defined by Huyshamen (1994: 124) is a “collection of tasks of which i) the content, ii) the administration and iii) the scoring of the obtained responses are the same irrespective of who is administering it, on whom it is administered and by whom it is scored”. One may assume that standardised tests promote a degree of certainty in which statements can be made regarding the

existence of a causal relationship between variables (Heppner, Kivlighan, and Wampold, 1998: 58) which are the learners' test scores in the testing of pre and post use of computer technology as cognitive tools.

Although there are many software applications available that can be used for testing learner achievement, Microsoft Excel was chosen as the medium of testing, due to the following reasons:

- a) It enabled the researcher to standardise the tests;
- b) It has the ability to assist in marking the tests;
- c) The test had to be uniquely set up for decimals according to the Grade 6 CAPS and work done according to the text book and WCED workbook used by the Mathematics educator and learners;
- d) Applications and tests found on the Internet are set to American learning standards which are different to the standards set out in the South African CAPS curriculum;
- e) Learners were familiar with tests done in MS Excel as the format was used for summative assessments at the end of each term.

The marking and calculation of learner scores were computerised with MS Excel formulas. This was done to prevent human calculating errors, to ensure consistency in marking the tests and results, as well as to prevent possible bias. Both tests consisted of three sheets, namely, a front page sheet, a test page sheet and the answer and formula sheet. The answer and formula sheets were hidden with the Microsoft Excel 'hide function' and were password protected. This was done to prevent learners from tampering with, changing or deleting formulas. This prevention also contributed to the validity and consistency of scores.

The pre-test (see Appendix 3) was set up in such a way that it reflected an ordinary test with a combination of multiple choice and closed questions as done on paper. The test contained no colour in the text, pictures or other media that could draw learners' attention to specific content, except for the last instruction which indicated that learners had to save the test. The coloured blocks used defined the area where learners had to type

their answers and not for any other reason. The test was set up with developer tool functions such as a scroll down list and formulas that ‘marked’ given answers. The test page sheet consisted of three sections. Section A consisted of multiple choice questions where possible answers were given by means of scroll down lists. The scroll down lists were designed with the Form Control function in Excel’s Developer tool and were linked with the ‘answer and formula sheet’ which contained formulas to mark the learners’ answers. Figure 6.1 and 6.2 illustrated on show example questions from Section A to illustrate the marking process.

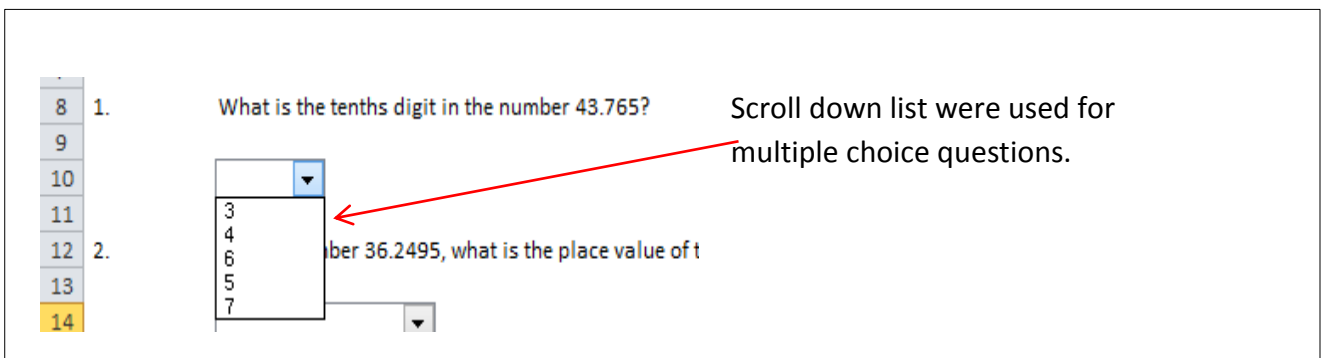


Figure 6.1 – An example from Section A in the ‘test page sheet’.

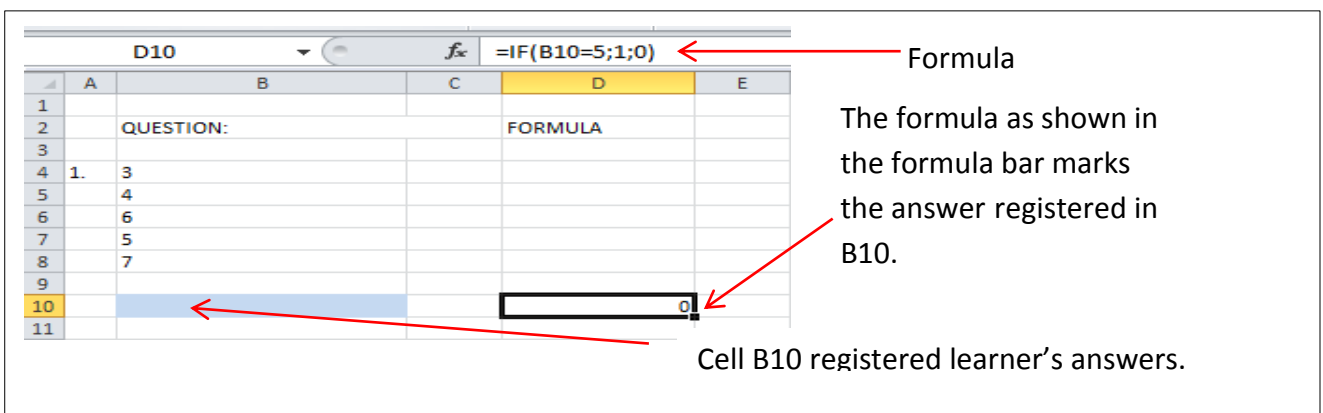


Figure 6.2 – An example from the ‘answer and formula’ sheet.

The example given in Figure 6.1 shows the drop down list with possible answers. The learner had to use the computer mouse to click on his/her answer of choice. The chosen answer registers in cell B10 as shown in Figure 6.2. The formula set up in cell D10 would then mark the answer. In the event of a correct answer, a ‘1’ would be scored and an incorrect answer would score a ‘0’.

Section B consisted of closed questions where learners had to type answers into cells that were indicated by coloured blocks on the test sheet. Figures 6.3 and 6.4 show example questions from the tests Section B to illustrate the marking process.

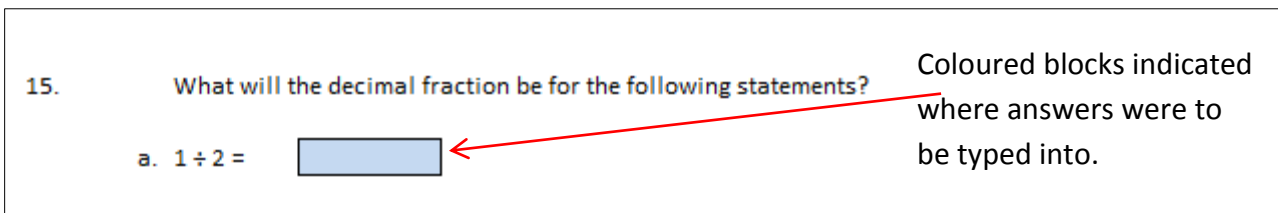


Figure 6.3 – An example of a coloured spreadsheet cell in Section B.

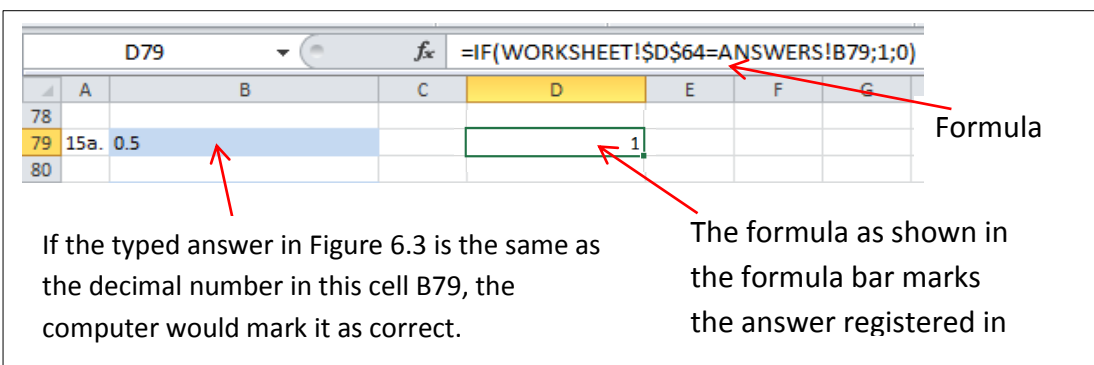


Figure 6.4 – An example from the ‘answer and formula sheet’ in the post-test.

The answer (a decimal number) type into the ‘coloured block’ as shown in figure 6.3 would register the answer and link it with a cell in the answer and formula sheet as shown in Figure 6.4. The formula would then mark the answer as previously explained.

Section C consisted both of drop down lists and coloured blocks where learners had to type in their answers and marking formulas behaved in the same manner as those found in sections A and B.

The post-test (see Appendix 4) was set up to activate and enhance learners’ cognitive processes. This test focused on visual perception which aimed at increasing learners’ comprehension of instructions and to focus their attention on certain information and concepts. The post-test focused on enhancing cognitive processes. Figures 6.5 to 6.10 show examples of the above mentioned concepts.

INSTRUCTIONS:
 1) Click on the ▼ when there is a ▼ to see the possible answers. Then click on the answer of your choice.

Figure 6.5 – An example of a triangle and scroll down list in the post-test.

In figure 6.5 graphics such as the triangle and the drop down list box aimed at improving comprehension of the given instruction.

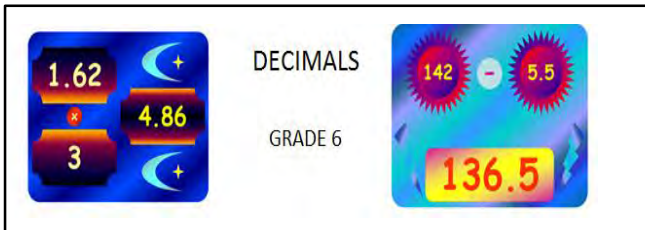


Figure 6.6– Graphics added appeal and novelty.

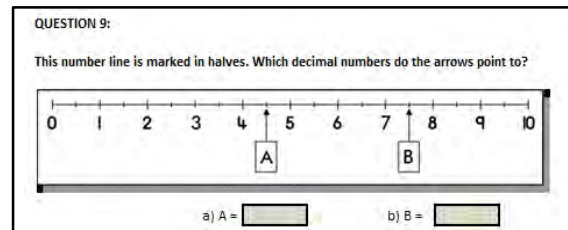



Figure 6.7- Giving meaning by displaying a ruler

Graphics as displayed in figure 6.6 graphics were used to add appeal and novelty to the test page and graphics as displayed in figure 6.7 aimed at improving comprehension by making abstract concepts concrete.

QUESTION 15:
Decimal word problems
 Solve the following problems. Click inside the coloured block to type your answer.
 Use a separate sheet of paper to do your calculations.

a) 

A movie ticket cost R25,50. What is the cost of 9 tickets? (Remember to add the 'R' for 'Rand' to answer!)

The answer is

Figure 6.8 – Giving meaning with reality.

Graphics as shown in both Figures 6.7 and 6.8 aimed at making content meaningful by linking it with real life examples.

SECTION B

QUESTION 4:

Give the **values** of the following digits in the numbers below:

a) The '9' in the number 1587.3**9**

b) The '2' in the number 3**2**1.048

c) The '8' in the number **8**920.765

d) The '3' in the number 58.154**3**

e) The fourth digit in 888.**88**

Figure 6.9 –Coloured font

QUESTION 8:

Expanded notation (Type the correct digit into the blue block).

a) $523.12 = \square \times 100 + \square \times 10 + \square \times 1 +$
 $\square \times \frac{1}{10} + \square \times \frac{1}{100} .$

Figure 6.10 – Coloured concepts

Coloured font in Figures 6.9 and 6.10 were used to draw learners' attention to specific words, digits, numbers, fractions, content or concepts such as multiplication and addition.

Similar to the pre-test, the post-test also made use of scroll down lists and formulas. Drop-down lists (Figure 6.9) were used to provide visual structure by missing segmented text fields with data-specific controls. The drop-down lists also arrowed the number of possible answers and aimed at getting learners to focus on the possible answers, to help them retrieve information more easily and to share cognitive load by providing support for lower level cognitive skills so that resources are left over for higher order thinking skills.

The number pattern as shown in Figure 6.11 was segmented and structured. This visual structure aimed at enabling learners to skim through the information and improving readability.

QUESTION 10:

Type each decimal number in ascending order in the blocks below:

2	0.2	1	2.5	0	1.5	1.25	1.75
---	-----	---	-----	---	-----	------	------

Answer:

Figure 6.11 – Segmented information giving structure.

The coloured answer blocks as shown in Figure 6.12 gave visual structure and aimed at giving a visual hierarchy to enable learners to separate the given information from the answers to be given.

QUESTION 7:

Turn the following fractions into decimals (Type your answer into the coloured blocks):

a) $\frac{5}{10}$ \equiv 	f) $\frac{1}{2}$ \equiv
b) $\frac{3}{100}$ \equiv 	g) $\frac{1}{4}$ \equiv

Figure 6.12 – Visual structure to separate given information from answers.

The test page sheet consisted of two sections. Section A consisted of multiple choice questions where possible answers were given by means of scroll down lists. Section B consisted both of drop down lists and coloured blocks where learners had to type in their answers. The marking of learner answers and the calculation of scores were done by MS Excel in the same manner as in the pre-test.

6.7.2 Validity and reliability

Validity and reliability is of very high importance in a research project. When research is taking place then precision of the process is expressed in validity and reliability. This refers to the research being accurate and exact. When research isn't accurate, conclusions drawn from it can't be valid and reliable. It can't bear testimony of what the researcher wanted it

to show. On the other hand if the research conducted is reliable and valid then the research community is more likely to accept the researcher's findings.

Having a closer look on the terms validity and reliability then it can be explained as follows:

- a. Validity refers to how well the instrument measures what it says it is measuring. Validity of the instrument refers to the accuracy and truthfulness it is measuring. In other words "Does it measure what it is supposed to measure?" (Le Grange, 2009: 7)
- b. Reliability refers to an instrument's ability to measure things consistently and repeatedly. McMillan and Schumacher (1993:385) explains reliability as "the extent to which independent researchers could discover the same phenomena and to which there is agreement on the description for the phenomena between the researcher and participant."

To ensure that the measuring instruments were valid, accurate and truthful, activities learners had to do in the pre- and post-tests as mentioned previously were based on counting, comparing, ordering and decimal place values as well as relations between decimal and common fractions, calculating and solving word problems found in the Mathematics textbook (Jooste, *et al*, 2012: 171-197) and a workbook (DBE, 2013: 162-183). This ensured that activities in the tests were according to learners' mathematical abilities on Grade 6 level as well as the Grade 6 Curriculum and Assessment Performance Standards. Activities were designed to be similar to those found in the textbooks to make sure that learners are familiar with it.

After the set-up and design process of both tests, a trial run was done by the researcher together with the Mathematics educator to ensure that the tests were reliable, that no errors were found and that the formulas responded and added scores correctly. Only after ensuring both tests were correct, that they tested what they were supposed to test, were they used in the research project.

6.7.3 Ethics

When education research is conducted researchers make use of people, their perceptions, attitudes, beliefs and opinions. As people are involved it has certain implications for researchers and respondents. McMillan and Schumacher (1993:23) are of the opinion that educational research is “constrained by ethical and legal considerations as research is conducted on human beings, the public nature of education, the complexity of educational practices and methodological limitations.” These constraints influence knowledge acquired in educational research and therefore all measures should be taken so that ethical dilemmas and considerations are dealt with to ensure the validity of the research.

What is understood as ethics of research? The term ‘ethics’ is generally interpreted as moral principles, values or codes about what is right or wrong, proper or improper, good or bad. In the case of educational research one can conclude that ethics in research is a set of ethical principles by which the studies are conducted.

In this research project, the following ethical principles as discussed by McMillan and Schumacher (1993:182-184) were followed:

1. The researcher was responsible for the ethical standards to which the study adhered to.
2. The researcher made sure that participants were protected from mental and physical discomfort, harm or danger. There were no physical risks involved for partaking in the research.
3. Ethical clearance was first obtained from the Science Faculty at the University of Cape Town.
4. Information regarding participants was held confidential. No information regarding participants was released. The information was not accessible as the server used to store the tests and data, was password protected and locked away in the secure computer lab with burglar bars, a security gate and an activated alarm system. No educators, learners or any other persons had access to the computer lab in the absence of the researcher. Only the researcher had access to the data on the server during school hours.

5. Permission was obtained from the principal, the School Governing Body and the parent community to conduct the research at the school as it involved the school's learners. Respondents and parents were ensured that personal information of learners would not be disclosed. When data was collected, learners were given numbers and their names were removed to ensure anonymity.
6. The researcher took steps to ensure that scores couldn't be tampered with by any participant. Learners were closely monitored and the marking structure in the Excel pre- and post-tests were hidden from learners and password protected. Steps were taken to ensure the validity and reliability of the tests and scores they produced. Results were straightforward and clear. Results were clearly communicated to all parties concerned to minimise misunderstanding.
7. Participants were given an opportunity to receive the results of the study in which they were participating.

6.8 Research procedure

The research was conducted in seven phases. Phase one commenced when the researcher and Grade 6 Mathematics educator met at the start of Term 3. The problem area for the research project was identified, namely low achievement in area of decimals in Mathematics which occurred during the previous school term. Decimals were part of the school's second term curriculum, but not the third and fourth terms. Objectives of the research project were discussed as well as how cognitive education and computer technologies would be used as cognitive tools for the activation and enhancement of learner cognitive processes and learning. Thereafter planning was done to design effective lesson instruction, teaching aids and learner activities that were based on using computer technologies which made use of cognitive education principles.

During phase two both the research and the control groups first wrote the same pre-test in the computer lab to test their understanding of decimals and their underlying principles. Learners were briefed regarding the terms and rules that applied during the test session. The set-up of the pre-test was explained and how learners had to approach each section.

Learners were then given 60 minutes to complete the test. The allocated time was adequate for completion and enabled all learners to complete the test.

Phase three consisted of acquiring learner test scores which were then recorded in a pre-set Excel document. The scores gave the researcher an idea of learners' understanding of decimals on Grade 6 level.

During phase four the intervention process took place in the computer lab where the research group attended lessons in decimals where principles and concepts were taught with cognitive education based teaching aids (as explained in chapter 5). Activities engaged learners in exploring various aspects of decimals and applied new knowledge in brain-based designed computer workbooks, by playing interactive decimals games (available on the Internet) which may have contributed to the enjoyment of activities, which in its turn may have contributed to positive emotions among learners. Internet games were also used to practice decimal concepts and to increase memory retention by repetition and rote learning. Videos which explained basic decimal concepts were used to involve learners' visual and auditory senses and to assist the learning process of abstract concepts found in decimals. The videos were also used to enrich the learning experience and could have contributed to improved retrieval of information and retention of newly learned knowledge. Different activities which were visual, auditory and kinaesthetic accommodated individual learners' learning styles. Learners from the research group were required to complete the pre-designed brain-based computer workbook in which decimal principles and concepts were to be applied. Learners also made use of interactive slide shows created in MS Power Point, in which they could apply decimal principles. Individual assistance was given to learners where necessary.

The research group covered the following aspects pertaining to decimals:

- What is a decimal number?;
- Place Value;
 - The position of digits;
 - The place value of digits;

- The difference between the various place values
- The number value of digits;
- The powers of 10;
- How to read digital numbers;
- How to write digital numbers in words;
- Writing digital numbers in expanded notation;
- Digital number sequences;
- Ordering decimals in ascending and descending order;
- Decimal number lines;
- Comparing decimals;
- How to change fractions into decimals;
- Writing fractions in decimal numbers and
- Addition, subtraction and multiplication of decimals.
- Decimals in real life and
- Problem solving.

Videos that were used explain digital concepts visually and auditory:

- What is a decimal? (Obtained from YouTube);
- How to read a decimal Place value (Obtained from YouTube) and
- Place value (Obtained from YouTube) and
- How to read and write decimals (Khan Academy video).

Teaching slide shows:

- The decimals teaching tool;
- Decimal revision teaching tool and
- Writing decimals.

Internet games that were played by learners covered the following aspect of decimals:

- Place Value;
- Expanded notation;
- Reading and writing decimals;

- Ordering decimals;
- Fractions to decimals;
- Comparing decimals;
- Adding decimals;
- Multiplication of decimals;
- Decimal number lines and
- Recognising the correct decimal number.

The control group's sessions in the computer laboratory were also based on cognitive education principles, with the difference that the control group covered different topics in the school's Mathematics curriculum, namely measuring volume, capacity, mass, length and distance, money, fractions and shapes. The reason for the control group covering a different area was to establish if there would be a significant difference between the decimal pre- and post-test scores of the research group compared to that of the control group.

Both the research and control groups continued Mathematics classes with their Mathematics teacher in their normal school day as indicated by their school time table, throughout the duration of the research project. In the Mathematics classroom, the curriculum's focus wasn't on any principles or aspects of decimals the research group was exposed to in the computer lab. However, the control group covered measuring volume, capacity, mass, length, distance, money and fractions. These areas in the curriculum also contained decimal related aspects, but the focus thereof was not on the same aspects which the research group was exposed to.

The control group also did not have the brain-based designed decimal workbooks to work in. The above was done to ascertain whether the approach that the research group followed and was exposed to would lead to better results, even though both groups have been exposed to decimals since grade 4.

Due to the continuance of Mathematics teaching of both groups with the Mathematics educator according to the school's time table, it was assumed that there will be changes in the scores of both groups, but it was expected that a difference in the research group's scores will be higher with the intervention of cognitive education and computer technologies as cognitive tools than that of the control group who didn't have the intervention.

After the short school holiday, phase five took place with the revising of decimals principles and concepts to the research group in the computer lab by the researcher. The revision was done by replaying the videos that were used in phase four again. The research group was allowed to play the games used in phase 4 again for enjoyment and the retention of the revised work. Learners applied what was revised with a set of activities in their revised computer workbooks. The brain-based designed computer workbook's activities were of the same format as the workbook in phase 4, but, the content (the decimals numbers used in the previous book) were changed.

The researcher felt it necessary to revise the principles of decimals at the beginning of Term 4 again. The reason for the revision being done was that 8 weeks went by since the last week (5 – 9 August) in which the research group in Term 3 attended the computer lab to the start of Term 4 when the group attended the computer lab again (see figure 6.13 on page 110). The researcher felt the time frame in which the research group did not attend the computer lab from the third to the fourth terms was too big as it could have impacted the research group's memory and what they've learned negatively. If learners in the research group's memory and what was learned was impacted negatively from long absence computer lab, then that also would have impacted the post-test results negatively.

The control group did not do any revision as they continued with multiplication activities as planned in the fourth term work schedules according to the Mathematics curriculum.

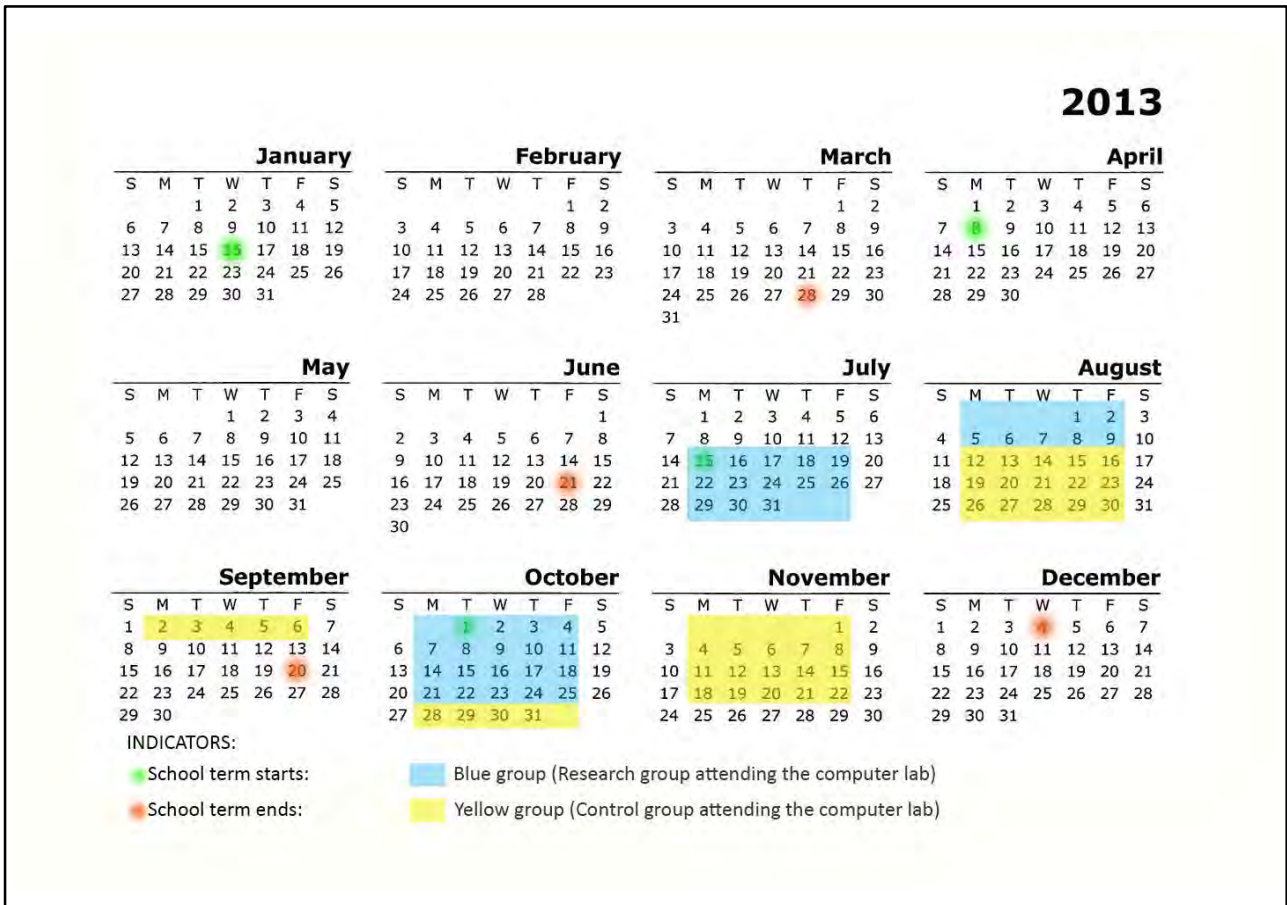


Figure 6.13 – 2013 School Calendar (Both groups’ attendance in the computer lab during the research project).

Phase six consisted of both the research and control group completing the same post-test to determine what the effect of using computer technologies as a cognitive tool or the lack thereof was on learning. Once again learners were briefed regarding the terms and rules that applied. Learners were used to the way in which the test were setup and how the tests should be answered, as they had previous ‘experience’ regarding how it should’ve been done. This ‘experience’ was due to the fact that they have done similar tests in different Mathematics areas during their Grade 4 and 5 years. Therefore, it wasn’t necessary to explain in detail how the test should have been done or answered. The instructions on the test page were clear. Learners were only reminded that answers should be typed into the coloured blocks where necessary and how the scroll-down lists worked. The learners had 60 minutes to complete the test.

The research project was then concluded in phase seven by acquiring learner post-test scores. Results of both tests were then compared to give the researcher a time for

reflection regarding the effects of cognitive education and computer technologies as a cognitive tool in the classroom. Thereafter the data was professionally analysed by the University of Cape Town's statistics Department.

To optimise the possibility of comparative data, both groups were evaluated in terms of gender, age and home language. In terms of gender, the distribution of boys and girls in the research and control groups were recorded and analysed to determine any imbalance in the distribution that could impact on the validity of the results. The analysis of results enabled the researcher to interpret the results and draw conclusions from them.

6.9 Conclusion

Chapter 6 subjected the use of computer technologies as a cognitive tool to scientific evaluation by means of case study within a South African context. The rationale for this was to do an in-depth study regarding aspects pertaining to the current situation in South African Education, Learning, Cognitive Education and the use of computer technologies as computer tools.

The procedures taken to evaluate the effectiveness of computer technologies as a cognitive tool and steps that were taken to ensure the validity, reliability and ethicality of the research process were described. Chapter 7 serves to give the results obtained from the case study.

Chapter 7

Research findings and interpretation of results

7.1 Background

Chapter 6 focussed on the research design and the process that was implemented to examine the quality of the effectiveness of using computer technology as a cognitive tool. The method of obtaining the data and measures that were taken to ensure reliability, validity and the ethical nature thereof were described.

This chapter will focus on a description of results obtained from the collected data. Heppner, *et al.* (1999: 41) stated that sense must be made of results once the research data has been collected. The purpose of this is to test the research question. This chapter, therefore, will serve as the researcher's undertaking to examine the quality of the effectiveness of using computer technology as a cognitive tool.

7.2 Implementation

Causality will be examined in this chapter by discussing the implementation of a teaching programme in which cognitive education principles and computer technologies were used. Included in this discussion is the measurement of results to evaluate the effectiveness of cognitive education and computer technologies as cognitive tools in the learning process and learner achievement.

According to Berkeley (n.d.: para. 01), causality "refers to the relationship between events where one set of events (the effects) is a direct consequence of another set of events (the causes)". Furthermore it is stated that causal inference "is the process by which one can use data to make claims about causal relationships" (Berkeley, n.d.: para. 01). This chapter aims at showing the relationship of a set of events (effective learning and learner achievement) as a direct consequence of a set of events, namely that of cognitive education and computer technologies as cognitive tools (the cause). The causal inference will display the causal relationship with the use of quantitative data.

This evaluation was specifically done in terms of cognitive education principles such as the triune brain, neuroplasticity, Suggestopedia, factors that affect attentional focus and the use of computer technologies as cognitive tools to activate and enhance cognitive processes.

7.2.1 Data Collection

Heppner, et al. (1999: 44) states that once all data is collected, sense must be made thereof so that it can be used to test the research question. A quantitative approach was used to collect data. The analysis of the quantitative results will now be presented in terms of descriptive as well as inferential statistics.

7.2.1.1 Descriptive statistics of the research and control groups.

For the purpose of this study, two kinds of descriptive statistics were used, namely statistics in terms of the research control groups and statistics to describe the tests.

To minimise the threat to validity, the research sample was divided into a research group and a control group. A summary of the research sample of both groups is shown in table 7.1.

GROUP	FREQUENCY	% OF SAMPLE
Research group (Blue group)	37	45.67%
Control group (Yellow group)	44	54.33%
Total	81	100%

Table 7.1 – Representation of groups.

Table 7.1 indicates that 81 learners participated in this research project of which 45.67% were representative of the research group and 54.33% of the control group.

Originally there were 110 learners in the Grade 6 group, but due to a high percentage of absenteeism and two learners who violated the post-test procedure, the number of learners who participated in the pre and post intervention was reduced to 81.

To further optimise the possibility of comparative data, both groups were further evaluated in terms of gender, age and home language. In terms of gender, the distribution of boys and girls in the research and control groups were recorded and analysed to determine any imbalance in the distribution that could impact on the validity of the results. This summary is displayed in table 7.2.

GROUP	GENDER		
	Boys	Girls	Total
Research group	18	19	37
Control group	25	19	44
Total	43	38	81

Table 7.2 – Gender representation.

Table 7.2 indicates that 43 of the participants were boys and 38 were girls. These statistics indicate that class composition regarding gender was equally distributed between the classes. This indicates a comparative distribution.

A second variable that could have influenced the validity of results was the age of participants. The distribution of age among the Grade 6 learners is displayed in table 7.3.

GROUP	11 years old	12 years old	13 years old	TOTAL
Research group	2	34	4	40
Control group	1	38	2	41
TOTAL	3	72	6	81

Table 7.3 - The distribution of age amongst the research and control groups.

Table 7.3 indicates that the distribution of 11 to 13 year old learners was evenly between

the classes; therefore age wasn't considered a variable that could influence the validity of results.

7.3 Research results and findings

The purpose of this data analysis and interpretation is to transform the collected data into credible evidence regarding the development of the intervention that took place and to find out whether performance of the intervention impacted learner achievement, suggesting the effective use of computer technologies and software as cognitive tools.

7.3.1 Inferential statistics

Huysamen, (1980:12) states that inferential statistics reflect assumptions that can be made regarding the norms, correlations and other constraints on the grounds of corresponding statistics calculated for specific population samples.

To evaluate the effectiveness of using computer technology as a cognitive tool, test results obtained from the research group, were compared to test results of the control group.

7.3.1.1 Normality of data

Firstly an analysis was done to check the normality in the distribution of data. This was done to determine what kind of tests needed to be used for data analysis. The normality results are shown in figures 7.1 and 7.2.

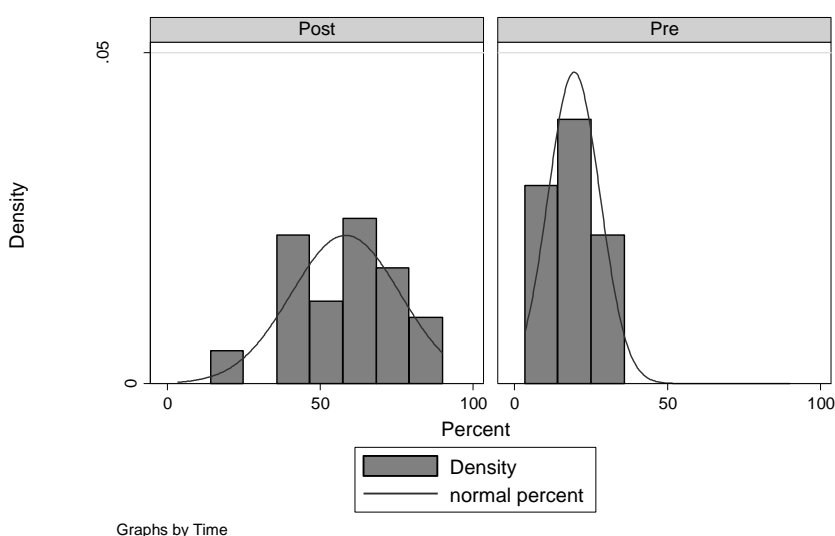
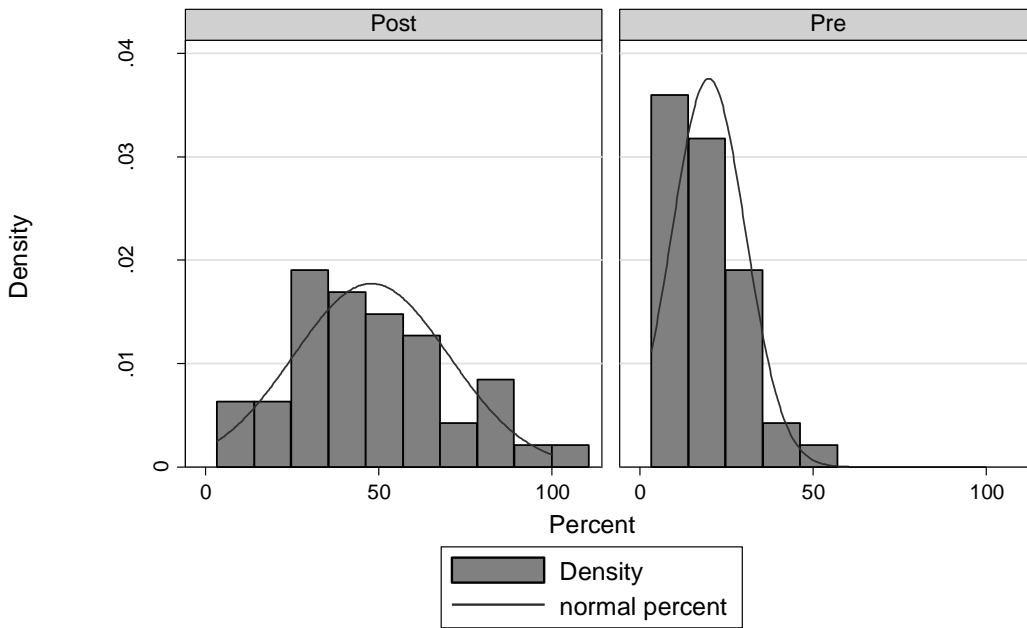


Figure 7.1 Distribution of normality - Research group.



Graphs by Time

Figure 7.2 Distribution of normality - Control group.

Figures 7.1 and 7.2 show that data isn't normally distributed, therefore non-parametric tests were to be used in the calculation of statistics.

7.3.1.2 Variability of data

Data was examined graphically by using boxplots to check the amount of variability. These plots looked at the median values (middle point of the data-horizontal line), the interquartile range (middle 50% of the data-box) and minimum and maximum values (whiskers) not to be considered outliers (dots). Figures 7.3 and 7.4 give a graphical representation of the amount of variability in the data.

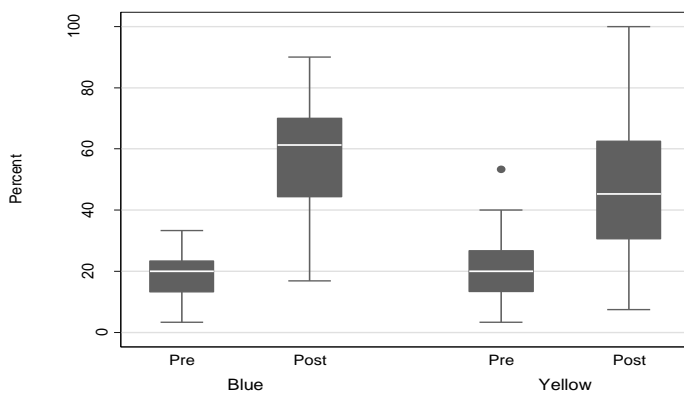


Figure 7.3 Distribution of variability – Research (blue) and control (yellow) groups.

In Figure 7.3 the median values pre-test to post-test appear to be very different for both the research (blue) and control (yellow) groups, although the boxes overlap somewhat (indicating a fair amount of variability). The effect appears to be slightly more pronounced in the research (blue) group.

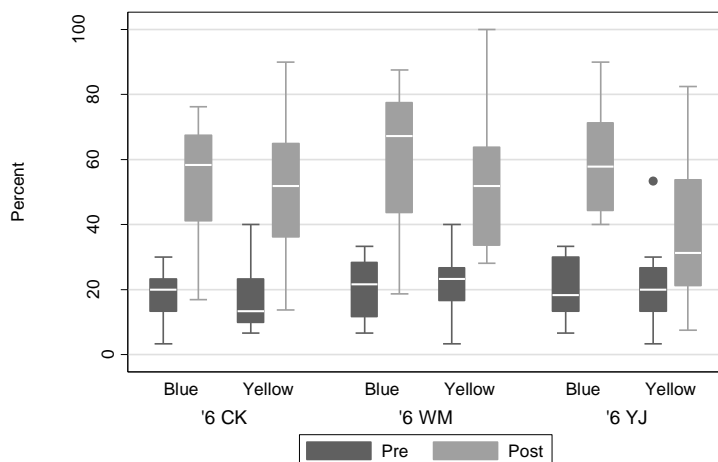


Figure 7.4 Distribution of variability – Grade 6 classes (CK, WM and YJ refer to the different Grade 6 class names obtained from the educators’ initials).

When we examine the data by class as well (Figure 7.4), we see the same general pattern occurring in each class where the research (blue) group does slightly better than the control (yellow) group. The effect is most pronounced in the class, Grade 6 YJ.

7.3.1.3 Interpretation of data

Secondly an analysis was done to establish whether there was a difference in the level of understanding of decimal principles and concepts. The pre-test scores of both the research and control groups were compared. The aim was to note no difference in the levels of both groups. Having no difference would indicate that the lack of or minimal use of cognitive processes were on the same level in both groups. The hypothesis for this test would be:

$$H_0 : \text{Median}_{\text{Research}} = \text{Median}_{\text{Control}}$$

$$H_A : \text{Median}_{\text{Research}} \neq \text{Median}_{\text{Control}}$$

The Wilcoxon Signed Rank test was used to provide evidence of whether there was a difference between the two groups or not. The aim was to have the same median

percentages for both groups and a $p > 0.05$ for the research group for the H_0 to be accepted. A summary of the analysis of scores is given in table 7.4

PRE-TEST DATA		
	Research group	Control group
Observations	37	44
Median	20	20
25th Percentile	13.33	13.33
75th Percentile	23.33	26.67
Mean (Average) in scores	19.46	19.92
P(T=t)	$p=0.8047$	$p=0.0178$

Table 7.4 – Analysis of pre-test data.

Table 7.4 indicates that there is no difference in the median percentages for both groups as both have a median percentage of 20. The p-value of 0.8047 is higher than 0.05. This indicates that both groups were homogenous in low achievement and the understanding of decimal concepts.

After the completion of the intervention process the research and control groups took part in the post- test. Upon completion of the post-test the results were collected for analysis. Two analyses were done with the collected data. It was expected that a difference in the research group's scores would be higher with the intervention of cognitive education and computer technologies as cognitive tools than that of the control group who didn't have an intervention.

The methodologies used for analysis were restricted. In particular, the Wilcoxon Signed Rank test was used, rather than the t-test, to compare the pre- and post-test scores within each group (See table 7.5). Additionally the groups themselves were compared at both the Pre-intervention time and again Post-intervention by using the Mann-Whitney U test. The latter is used when there are independent groups for comparison, for example the pre-research group vs. the post-control group. The former is used in instances where there are paired data for example the pre-research group vs. the post-control group.

Group	Time	N	Minimum	Maximum	Mean	Std. Dev	Median	25th Percentile	75th Percentile
Research group	Pre	37	3.33	33.33	19.46	8.48	20.00	13.33	23.33
	Post	37	16.88	90.00	58.33	17.81	61.25	44.38	70.00
	Total	74	3.33	90.00	38.90	23.98	33.33	18.75	61.25
Control group	Pre	44	3.33	53.33	19.92	10.63	20.00	13.33	26.67
	Post	44	7.50	100.00	47.86	22.49	45.31	30.63	62.50
	Total	88	3.33	100.00	33.89	22.43	27.40	17.40	48.44

Table 7.5 – Distribution of data as given by the UCT Dept. of Statistics.

First an analysis was undertaken to see whether there was a positive difference in scores between the pre-test and the post-test data of the research group. The Mann-Whitney U test was done to calculate the data. The same was done with data obtained from the control group. This analysis was undertaken to establish if a degree of learning took place regarding decimals. A summary of the analysis of scores is given in table 7.6.

PRE- vs POST-TEST DATA				
	Research group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Observations	37	37	44	44
Median	20.00	61.25	20.00	45.31
25 th Percentile	13.33	44.38	13.33	30.63
75 th Percentile	23.33	70.00	26.67	62.50
Mean (Average) in scores	19.46	58.33	19.92	57.386
P-Value	p<0.0001		p<0.0001	

Table 7.6 – Analysis of pre- vs post-test data.

As the data was not normally distributed, reference will be made to the median and interquartile ranges to interpret data. Table 7.5 indicates a difference of 41.25 between the pre- (20.00) and post-test (61.25) of the research group while a difference of 25.31 is indicated for the control group. The interquartile range of the research group's pre-intervention (13.33-23.33) indicates a significant difference to that of post intervention (44.38-70.00), where the range for the control group's pre-intervention (13.33-26.67) also indicates a difference to that of post intervention (30.63-62.50). The difference in the

medians of both the research and control groups suggests more efficient learning has taken place in the research group, due to their exposure in using computer technologies and software as cognitive tools during the research project.

A second analysis was undertaken to establish the difference in improvement between the research and control groups. The post-test scores of the research and control groups were compared. The aim was to establish the difference in median and interquartile range of the post-test data of both groups. The reason for doing this is that a considerable difference for both groups would suggest that the intervention programme indeed contributed towards the rise in levels of achievement in the test data. The hypothesis for this test would be:

$$H_0 : \text{Post-test}_{\text{Research}} = \text{Post-test}_{\text{Control}}$$

$$H_A : \text{Post-test}_{\text{Research}} \neq \text{Post-test}_{\text{Control}}$$

The Mann-Whitney U test was used to provide evidence of whether there was a difference in achievement levels between the two groups or not. The result would indicate a difference in the improvement or lack thereof in learner scores. Furthermore the aim was to have a p= level of $p < 0.05$ for the research group so that H_0 could be rejected. If the H_0 can be rejected it will suggest that the impact of intervention was significantly different.

Table 7.7 as shown on page 121 indicates a difference between the two groups. The research group's pre-invention median percentage was 20 and significantly different to that of the post-intervention median of 61.25. The research group's median percentages from pre- to post intervention differ with 41.25 percent. The control group's pre-invention median percentage was also 20 and significantly different to that of the post-intervention median of 45.31. The control group's median percentages from pre- to post intervention differ with 25.31 percent. This shows a significant difference between the two groups' and suggests an improvement has taken place by in using computer technologies as cognitive tools. Furthermore the research had a p-level of 0.0178 which is less than 0.05, indicating that the H_0 can be rejected. Therefore, valid conclusions can be made regarding difference in the median of both groups in the post-test.

POST-TEST DATA				
	Research group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Observations	37	37	44	44
Median	20.00	61.25	20.00	45.31
25 th Percentile	13.33	44.38	13.33	30.63
75 th Percentile	23.33	70.00	26.67	62.50
P-Value	P<0.0001		P<0.0001	

Table 7.7 – Analysis of post-test data.

Lastly the difference for each learner pre-test to post-test was additionally computed with a Mann-Whitney U test. Differences between the groups were compared.

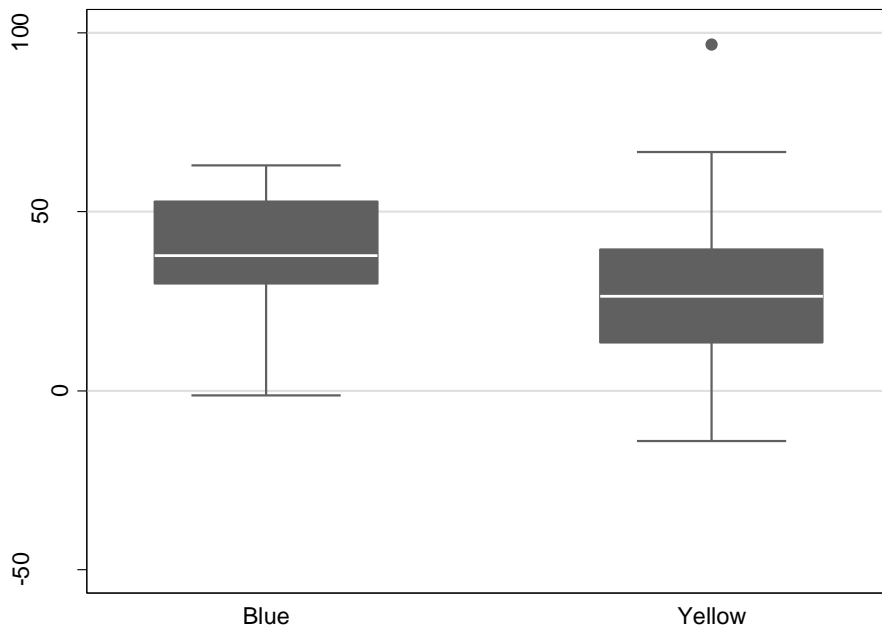


Figure 7.5- Pre and post difference between the research (blue) and control (yellow) groups.

Group	N	Minimum	Maximum	Mean	Std. Dev	Median	25th Percentile	75th Percentile
Research	37	-1.25	62.92	38.88	15.00	37.71	30.00	52.92
Control	44	-13.96	96.67	27.93	20.48	26.46	13.54	39.48
Total	81	-13.96	96.67	32.93	18.89	32.92	20.00	46.25

Table 7.8 – Analysis of pre- vs post-test for each learner.

Table 7.7 indicates the median difference between pre- and post-test in the research group was 37.71 and the interquartile range 30-52.92. This was significantly different (higher) than that in the control group with the median being 26.46 and the interquartile range 13.54-39.48, with $z=2.996$ and $p=0.0027$. This analysis confirms the previous suggestion that enhanced learning has taken place through the use of computer technologies as cognitive tools.

7.4 Conclusion

The results suggested an improvement in learner achievement which may indicate an enhancement of learners' cognitive processes. Based on the results obtained, a conclusion could be made that using computer technologies and software as cognitive tools may have an influence on learners' cognitive processes.

Chapter 8

Summary of findings, limitations and recommendations

8.1 Background

This chapter will establish whether the research question has been addressed. In an attempt to meet this objective, the essence of the research will be summarised as well as the subsequent findings and conclusions.

8.2 Summary of findings related to research question

The primary research question is: “Does the use of ICT as a cognitive tool to teach decimal concepts by means of a developed brain based cognitive approach have the potential to lead to improved learner results compared to learners not exposed to the intervention?” There is a need for techniques in our country’s schools to enhance learning effectiveness. Previous research described in chapters 2-5 regarding learning, cognitive education, its application with the use of computer technology as cognitive tools, and a current need for higher academic success in South African schools has motivated the researcher to embark on this study to evaluate the merit of claims made. With this study an attempt was made to evaluate these claims within a South African context given the fact that the computer technologies are available at schools.

8.2.1 Summary of the literature study findings

From an in-depth study in chapter two which described the current education scenario in South Africa, it is clear the country is in dire need of teaching methodologies that will make a positive impact on the learning processes of learners. Therefore there is an urgent need to find ways to effectively address learning needs in the country and to evaluate using computer technology as a cognitive tool to activate and enhance the cognitive processes of learners.

Literature studies as given in chapters 2 to 5 gave more light regarding possible ways to make a positive impact on the learning processes of learners, especially in the current South African educational scenario.

To address the first two primary objectives regarding the currently level of learning effectiveness in South African school and barriers to learning, a study of the objectives was given in Chapter 2.

To evaluate the claims regarding the use of computer technologies as cognitive tools and to address the question “What is learning?” the concept *learning* was examined. Chapter 3 was used to clarify the concept, but it also included a literature study on the process of learning, learning theories, learning styles and how computer-based technologies change learning in the classroom.

To address the question “What is cognitive education?” a literature study on cognitive education was carried out. This was done by defining and describing cognitive education, cognitive brain processes and concepts such as neuroplasticity, the triune brain and Suggestopedia. Chapter 4 was used to clarify cognitive brain processes and the use thereof to enhance the learning processes of learners.

The sub-question “How can computer technologies be used as cognitive tools in the classroom?” was addressed in Chapter 5. This chapter gave more light on principles in using computer technologies as cognitive tools to activate and enhance cognitive processes of learners. The study showed that computer technologies can be used to activate learners’ cognitive processes which are needed for optimal learning to take place.

In Chapter 6 the research design and method for the scientific evaluation of computer technologies as cognitive tools was described, while chapter 7 served to describe the research findings, and methods utilised to obtain these findings.

This chapter, therefore, serves to present a summary of the findings and to address the research question: “Does the use of ICT as a cognitive tool to teach decimal concepts by means of a developed brain based cognitive approach have the potential to lead to improved learner results compared to learners not exposed to the intervention?” The

findings resulting from the application of quantitative measuring instruments are presented here.

8.2.2 Summary of the quantitative research findings

An analysis was done to evaluate whether there was a difference between the pre-scores and the post-scores of the research group and the control group. In both the research group and control group a significant difference was noted in the pre and post-tests as discussed in chapter 7. This suggests that there was a change in the use of learners' cognitive processes ranging from a lack of or little use of these processes during the pre-test to considerable improved use of cognitive processes in the post-test.

A difference in the median range of both groups in the post-test is noteworthy. However, the research group's improved median range ($m= 61.25$) was higher than that of the control group ($m= 45.31$). Although both the research and control groups were exposed to the same teaching methodology, but different learning content, this difference could be attributed to the fact that the teaching methodologies used and activities done throughout the research project were based on principles of cognitive education with the sole purpose of activating and enhancing the cognitive processes of learners.

8.3 Limitations of the study

In any research study undertaken there are uncontrolled variables that could possibly impact the findings. In this research study some of the uncontrolled variables may have been the duration of the research study and time spent in the computer laboratory.

The frequency of computer lab attendance and the amount of time spent there, according to the timetable structure, may have impacted the intervention and results obtained. In the case of Sunlands Primary School, the groups into which each class is divided (blue and yellow groups) and the duration of the school term have an impact on their frequency in attending the computer lab. Depending on the duration of a school term, each group only spend one hour per week for 3 to 4 continuous weeks per school term in the computer lab, which can be devoted to teaching and learning activities (see figure 6.13). The same

number of weeks is devoted to classes in the art room when the groups swap. Activities in the art room consisted of creative art where learners create works of art with the use of different art mediums such as paint, pencils, graphite, coloured pens, oil pastels, art clay and paper mache. The remaining time as scheduled by the school timetable was interrupted by academic summative assessment activities, class outings, public and religious holidays. Therefore the time spend by learners in the computer lab per school term is limited.

The real time spent in the computer laboratory by the research group throughout the two school terms was 8 weeks. The research group's attendance of the computer lab was interrupted due to the school's timetable and a school holiday. Therefore, this interruption lasted 8 weeks. The computer educator (also the researcher) revised decimal concepts with the research group with the use of computer technologies as cognitive tools, which aimed at helping learners' memory to retain and remember decimals concepts that were learnt during the previous school term.

Another important factor that could have impacted the study is the fact that both the research and control groups still continued with Mathematics lessons with the Mathematics educator as per the school's timetable. As explained previously, the Mathematics educator covered measuring volume, capacity, mass, length, distance, money and fractions. These areas in the curriculum also contained decimal related aspects, but the focus thereof was not on the same aspects which the research group was exposed to. This could have had a positive impact on their understanding of decimals and contributed to an improvement in scores in the post-tests.

An important limitation is that the study's sample size was small and its findings would need to be confirmed with a larger study in terms of both the sample size and the number and variety of schools involved.

8.4 Conclusions

The findings indicated that there was a significant improvement as measured by the

selected pre- and post-tests. Although no similar aspects on decimals were done as an intervention with the control group, the approach that has been implemented with the research group suggests that it holds promise as a learning tool when ICT is used in collaboration with special designed brain-based workbooks and teaching methodology. Therefore, from the findings it can be concluded that the use of computer technologies as cognitive tools did bring about measurable improvement in activation and enhancement of cognitive processes. This study indicated that all learners have the potential to enhance their learning processes with the use of computer technology as a cognitive tool.

Using computer technology as a cognitive tool can address the educational challenges and barriers to learning currently experienced in South Africa and result in higher learner academic achievement. Therefore it can be reasoned that the researcher's contribution to the body of knowledge in describing the use of computer technologies as cognitive tools to activate and enhance cognitive brain processes, enables educators to change their teaching methodologies and instructional design of lessons for the benefit of learners' academic improvement.

There are important lessons to be learned by applying cognitive science principles with the use of computer technologies in the classroom. The rationale regarding aspects pertaining to the current situation in South African Education, Learning, Cognitive Education is that the use of computer technologies as computer tools may enhance the learning processes of learners. Therefore, with this research study I have simply endeavoured to set a stage for possible frameworks in South African education where cognitive science and computer technologies interconnect.

The researcher would like to recognise this research study as limited. Although data and findings during this research relate well to research done elsewhere in foreign countries, only a small fraction of participants among the South African population contributed to this study. Findings of this study are significant in suggesting the use computer technologies as cognitive tools to activate and enhance cognitive functioning resulting in

enhanced learning and academic success. While this study has its limitations, it may leave room for others exploring further possibilities in this hypothesis.

8.5 Recommendations

In the light of the value of using computer technologies as cognitive tools, it is recommended that schools which have the technologies to do so develop CAPS aligned learning programmes and learner activities for their computer laboratories. Implementing such programmes would enable learners to benefit from enhanced cognitive processes and remove some of the learning barriers they may encounter. Ultimately these programmes may afford learners opportunities for higher academic achievement and success.

9. References:

1. Abbott, S (Ed.). 2014. *Brain-Based Learning*. The Glossary of Education Reform. Retrieved from <http://edglossary.org/hidden-curriculum>
2. Ambrose, S.A., Bridges, M.W., DiPetro, M., Lovet, M.C. and Norman, M.K. (2010). *How Learning Works. Seven Research-Based Principles for Smart Teaching*. San-Francisco: John Wiley and Sons.
3. Anderson, John R. (2004). *Cognitive psychology and its implications*. (6th Ed). New York: Worth Publishers.
4. Ashman, A and Conway, R. (1997). *An Introduction to Cognitive Education: Theory and Applications*. Routledge: London.
5. Banikowski, A. K. (1999). *STRATEGIES TO ENHANCE MEMORY BASED BRAIN-RESEARCH*. Focus on Exceptional Children, Vol. 32 (2). Retrieved from http://www.sc-boces.org/english/IMC/Focus/Memory_strategies2.pdf
6. Bauer, J. and Kenton, J. (2005). *Toward Technology Integration in the Schools: Why It Isn't Happening*. Journal of Technology and Teacher Education, 13(4), 519-546. Retrieved from <http://www.editlib.org/p/4728>
7. Bennet, A. and Bennet, D. (2008). *The Human Knowledge System: Music and Brain Coherence*. The Journal of Information and Knowledge Management Systems, Vol. 38 (3). Retrieved from http://www.monroeinstitute.org/assets/journal_archives/journal2009summerfall.pdf
8. Bennet, P. 2003. *Abnormal and clinical psychology: An introductory textbook*. Philadelphia: Open University Press.
9. Berkeley. (n.d.) *Causality*. University of Berkeley, California. Retrieved from <http://sekhon.berkeley.edu/papers/causality.pdf>
10. Billington, E. and DiTommaso, N. M. (2003). *Demonstrations and applications of the matching law in education*. Journal of Behavioral Education, Vol. 12, 91-104.
11. Bocchino, R. (1999). *Emotional Literacy: To Be a Different Kind of Smart*. California: SAGE Publications.
12. Blaikie, N.W.H. (2003). *Analysing quantitative data: from description to explanation*. London: SAGE.

13. Bluestein, J. (2013). *Stress and the Brain*. Dr. Jane Bluestein Instructional Support Services, Inc. Retrieved from <http://janebluestein.com/2013/stress-and-the-brain/>
14. Brandsford, J.D., Brown, A.L. and Cocking, R.R. (2001). *How people learn: Brain, mind, experience and school*. Washington D.C.: National Academy Press.
15. Brooks, J.G. and Brooks, M.G. (1999). *In Search of Understanding: The Case for Constructivism*. Alexandria, VA: ASCD.
16. Brunye, T.T., Taylor, H.A., and Rapp, D.N. (2007). *Repetition and Dual Coding in Procedural Multimedia Presentations*. APPLIED COGNITIVE PSYCHOLOGY. Wiley Inter Science. DOI: 10.1002/acp.1396. Retrieved from http://ase.tufts.edu/psychology/spacelab/pubs/brunye_taylor_rapp_acp_inpress.pdf
17. Bulgren, J. A., Deshler, D. D. and Schumaker, J. B. (1997). *Use of a recall enhancement routine and strategies in inclusive secondary classes*. Learning Disabilities Research and Practice, 12(4), 198–208.
18. Buzan, T. and Buzan B. (2003). *The mind map book*. BBC Worldwide Ltd. London: The Bath Press.
19. Campbell, D. (2009). *The Mozart Effect*. New York: Harper Collins.
20. Cane, G and Nummela, R. (1990). *The Triune Brain*. Retrieved from <http://www.buffalostate.edu/orgs/bcp/brainbasics/triune.html>
21. Chen, I. (n.d.). *Behavioral Theories*. Retrieved from <http://viking.coe.uh.edu/~ichen/ebook/et-it/behavior.htm>
22. Cilliers, C. D. (2010). *Education Psychology (Cognitive Education) 769*. SUN Media, Faculty of Education, University of Stellenbosch.
23. Clark, D. (2009). *Suggestopedia*. Learning and Performance Glossary. Retrieved from <http://www.nwlink.com/~donclark/hrd/glossary/s.html>
24. Darby, S. (2003). *Learning Theories in the Classroom: Behaviourism*. Retrieved from http://www.did.stu.mmu.ac.uk/cme/Student_Writings/ProfStudies/SueDarby.html
25. De Jager, M. (2006). *Mind Moves: Removing barriers to learning*. Linden: The BG Connexion (Pty) Ltd.
26. Department of Basic Education. (2011a). *REPORT ON THE ANNUAL NATIONAL ASSESSMENTS OF 2011*. Retrieved from

<http://www.education.gov.za/LinkClick.aspx?fileticket=1U5igeVjiqg%3dandtabid=424andmid=1831>

27. Department of Basic Education. (2011b). *Strategic Plan 2011 – 2014*. Retrieved from <http://www.education.gov.za/LinkClick.aspx?fileticket=%2F%2BBILaBJ7ak%3Dandtabid=80andmid=585>
28. Department of Basic Education. (2012). *REPORT ON THE ANNUAL NATIONAL ASSESSMENTS OF 2012*. Retrieved from <http://www.education.gov.za/LinkClick.aspx?fileticket=YyzLTOk5IYU%3dandtabid=819andmid=2294>
29. Department of Basic Education. (2013a). *REPORT ON THE ANNUAL NATIONAL ASSESSMENTS OF 2013*. Retrieved from <http://www.education.gov.za/LinkClick.aspx?fileticket=Aiw7HW8ccic%3dandtabid=36andmid=2514>
30. Department of Basic Education. (2013b). *Grade 6 Mathematics in English. Book 1*. Pretoria: D.B.E.
31. Department of Education. (1997): *Quality education for all. Overcoming barriers to learning and development*. Report of the National Commission on Special Needs in Education and Training (NCSNET), National Committee on Education Support Services (NCESS). Retrieved from http://conferences.ufs.ac.za/dl/Userfiles/Documents/00001/642_eng.pdf
32. Deshler, D.D., Schumaker, J.B., Lenz, B.K., Bulgren, J.A., Hock, F.H., Knight, J. and Ehren, B.J. (2001) *Ensuring Content-Area Learning by Secondary Students with Learning Disabilities*. *Learning Disabilities Research and Practice Journal*, 16(2), 96-108. Retrieved from www.maase.pbworks.com/f/CEoverarticle.pdf
33. De Souza, L.O and Van Eeden, E. S. (2013). *Clear-cut to high-tech: History teaching and learning support material (TLSM) drawing on information and communication technology (ICT)*. *Cielo: Yesterday and Today*, n. 4. North-West University. Retrieved from <http://www.scielo.org.za/pdf/yt/n4/n4a05.pdf>
34. Dror, I. (2013). *Cognitive Technology*. 2013 Yearbook of Science and Technology. McGraw-Hill.

35. Duffy, T.M. and Cunningham, D.J. (1996). *Constructivism: Implications for the design and delivery of instruction*. In D.H. Jonassen (Ed.), *Educational communications and technology*. 170-199. New York: Simon and Schuster Macmillan.
36. Edwards, A. (2012). *New Technology and Education: Contemporary Issues in Education Studies*. London: Continuum International Publishing Group.
37. Ertmer, P. A. and Newby, T.J. (1993). *Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective*. *Performance Improvement Quarterly*, Vol. 6 (4): 50-72. Retrieved from <http://portal.ou.nl/documents/84590/84945/Ertmer+and+Newby+%281993%29.pdf>
38. Feuerstein, R. (1990). *The theory of structural cognitive modifiability*. In B.Z. Presseisen (Ed.), *Learning and thinking styles: Classroom Interaction*. Washington, DC: National Education Association. 68-134.
39. Florian, L. (n.d.). *USES OF TECHNOLOGY THAT SUPPORT PUPILS WITH SPECIAL EDUCATIONAL NEEDS*. McGraw-Hill Education. Retrieved from <https://www.mheducation.co.uk/openup/chapters/033521195X.pdf>
40. Forrester, D. and Jantzie, N. (n.d.). *Learning Theories*. Retrieved from http://www.acs.ucalgary.ca/%7Egnjantzi/learning_theories.htm
41. Gardner, J. (2006). *Cognitive Behaviour Protocol #17. Executive Dysfunction*. CCIA/Assessment and Clinical Services. July 2006, First Edition.
42. Gibson, J.J. (1978). *THE ECOLOGICAL APPROACH TO THE VISUAL PERCEPTION OF PICTURES*. *Leonardo*, Vol. 11, 227-235. Great Britain: Pergamon Press Ltd. Retrieved from www.thehangman.com/teaching-files/ccc/gibson.pdf
43. Gill, M. (2010). *Introduction to Suggestopedia: Pocket Therapist Guide* [Kindle DX]. Pandora Publishing: Chicago. Retrieved from www.amazon.com
44. Goodyer, L.D. (1997). *THE APPLICATION OF THE BRIGHT START COGNITIVE CURRICULUM (SELF-REGULATION) FOAT-RISK PUPILS*. Masters dissertation. Johannesburg: RAU. Retrieved from https://ujdigispace.uj.ac.za/bitstream/handle/10210/7531/L.D.%20GOODYER_1997_MA.pdf?sequence=1
45. Gokhale, A. (2012). *Effectiveness of Computer Simulation for Enhancing Higher Order Thinking*. *Journal of Industrial Teacher Education*. Vol. 33. (4). Virginia Teach Digital

Library and Archive. Retrieved from <http://scholar.lib.vt.edu/ejournals/JITE/v33n4/jite-v33n4.gokhale.html>

46. Gray, A. (1995). *The Road to Knowledge is Always Under Construction: A Life History Journey of Constructivist Teaching*. Unpublished Master Thesis, University of Saskatchewan. Retrieved from http://www.google.co.za/url?sa=t&drct=j&dq=andescrc=sandsource=webandcd=1andved=0CB4QFjAA&url=http%3A%2F%2Fecommons.usask.ca%2Fbitstream%2Fhandle%2F10388%2Fetd-11032011-105727%2FGray-Audrey_sec_1995.pdf&ei=K6ciVlfzMc2M7AaBwYDwCg&usg=AFQjCNGXJlKMXOnrfTeMU_XN3Xku_648LA
47. Green, D. (2002). *From Theory to Practice: Behaviorist Principles of Learning and Instruction*. The Office for Teaching and Learning Newsletter. Dec 2002, Vol. 7, (2). Detroit: Wayne State University. Retrieved from <http://www.otl.wayne.edu/pdf/newsltr/dec02.pdf>
48. Haberkorn, J. (n. d.). *Cognitivist and Behaviorist Teachers*. Retrieved from <http://www.scribd.com/doc/229298929/Cognitivist-and-Behaviorist-Teachers>
49. Hand, J.D. (1984). *Split-brain theory and recent result in brain research: Implications for the design of instruction*. Intus News/Nuus. Vol 8. (2).
50. Hannafin, M. J. and Land, S. M. (1997). *The foundations and assumptions of technology-enhanced student-centered learning environments*. Journal of Instructional Science, Vol. 25. 167-202.
51. Hasselbring, T.S. and Williams Glaser, C.H. (2000). *The use of Computer Technology to Help Students with Special Needs*. The future of Children. CHILDREN AND COMPUTER TECHNOLOGY. Volume 10, No. 2. Retrieved from <http://famielstogetherinc.com/wp-content/uploads/2011/08/COMPUTERTECHNEEDS.pdf>
52. Heafner, T. (2004). *Using Technology to Motivate Students to Learn Social Studies*. Contemporary Issues in Technology and Teacher Education. Vol. 4. No. 1, 42-53. Retrieved from <http://www.citejournal.org/articles/v4i1socialstudies1.pdf>
53. Heppner, P.P., Kivlighan, D.M. and Wampold, B.E. (1998). *Research design in counselling*. Belmont: Wadsworth Publishing Company.

54. Hergenhahn, B.R. and Olson, M.H. (2001). *"An Introduction to Theories of Learning"*. New Jersey: Prentice-Hall, Inc.
55. Higgins, S. (2003). *Does ICT Improve Learning and Teaching in Schools?* A BERA Professional User Review. British Educational Research Association. Retrieved from <http://learning.wales.gov.uk/docs/learningwales/publications/121122ictlearningen.pdf>
56. Hokanson, B and Hooper, S. (2000). *Computers as cognitive media: examining the potential of computers in education*. *Computers in Human Behaviour*, 537-552.
57. Hopson, M. H., Simms, R.L. and Knezek, G. A. (2001). *Using a Technology-Enriched Environment to Improve Higher-Order Thinking Skills*. *Journal of Research on Technology in Education*. Vol. 34 (2).
58. Hornby, A.S, Cowie, A.P. and Gimson, A.C. 1983. *Oxford Advanced Learner's Dictionary of Current English*. Oxford: Oxford University Press.
59. Huysamen, G.K. (1994). *Methodology for social and behavioural sciences*. International Johannesburg: Thomson Publishing (Pty) Ltd.
60. Jackson, R.R. (2011). *How to motivate reluctant learners*. Alexandria, Virginia: ASCD.
61. Jensen, E. (2005). *Teaching with the brain in mind*. (2nd Ed). Alexandria, Virginia: ASCD.
62. Jonassen, D. H. (1994). *Technology as Cognitive Tools: Learners as Designers*. IT Forum, Paper # 1, Pennsylvania State University. Retrieved from <http://itforum.coe.uga.edu/paper1/paper1.html>
63. Jonassen, D. H, Carr, C and Yueh, H. (1998). *Computers as Mindtools for Engaging Learners in Critical Thinking*. *TechTrends*, Vol. 43. (2). Retrieved from http://www.siue.edu/education/techready/5_Software_Tutorials/5_AncillaryPages/Mindtools.pdf.
64. Jonassen, D. H. and Reeves, T. C. (1996). *Learning with technology: Using computers as cognitive tools*. *Handbook of Research for Educational Communication and Technology*, New York: Simon and Schuster Macmillan. 693-724.
65. Johnson, J. (2010). *Designing with the mind in mind: Simple guide to Understanding User Interface Design Rules*. [Kindle DX]. Burlington: Morgan Kaufmann Publishers, Elsevier Inc. Retrieved from Amazon.com
66. Johnson, W. (1998). *How to boost your child's brain power*. Retrieved from <http://www.findarticles.com/cf 0/m1264/n4v29/21003410/p1/article.jhtml>

67. Johnson, A.P. (2002). *A short guide to action research*. Boston: Allyn and Bacon.
68. Jones, M. (2013). *216 Cape Schools go no-fee*. Independent Online. Retrieved from http://www.iol.co.za/lifestyle/family/kids/216-cape-schools-go-no-fee-1.1609769#Ur_ybrSsaSo
69. Jooste, Z.C, Press, K, Slamang, M and Smuts, C. (2012). *Study and Master Mathematics, Grade 6*. Cape Town: Oxford University Press.
70. Jordan, A., Carlile, O. and Stack, A. (2008). *Approaches to Learning - A Guide For Teachers*. McGraw-Hill Education: Berkshire, U.K. Retrieved from http://www.principals.in/uploads/pdf/CurriculumDesignPlanning/Jordan_Approaches_to_Learning_0335226701.pdf
71. Kay, A. (1990). *User Interface: a personal view*. In Laurel. B. (Ed.) *The art of human-computer interface design*, 191-201.
72. Keesee, G.S. (2011). *Learning Theories*. Retrieved from <http://teachinglearningresources.pbworks.com/w/page/19919565/Learning%20Theories>
73. Kibler, J. (2014). *Cognitive Disequilibrium*. Springer Reference. Retrieved from <http://www.springerreference.com/docs/html/chapterdbid/179877.html>
74. Kinsella, K. (1995). *Understanding and empowering diverse learners in ESL classrooms*. In Reid, J.M. ed. *Learning styles in the ESL/EFL classroom*. Boston: Heinle and Heinle, 170-194.
75. Kommers, P.A, Jonassen, D.H and Mayes, T.M. (1992). *Cognitive Tools for learning*. Heidelberg, Germany: Springer-Verlag.
76. Kotze, Y. (2008). *Instructional Design Workshop for Educators*. Pretoria: Eduzine
77. Kozma, R. B. (1991). *Learning With Media*. *Review of Educational Research*, Vol. 61 (2), 179-211.
78. Kozulin, A and Presseisen, B. Z. (1995). *Mediated Learning Experience and Psychology Tools: Vygotsky's and Feuerstein's Perspectives and a Study of Student Learning*. *Educational Psychologist*, Vol. 30 (2), 67-75.
79. Kramer, D. (1999). *O.B.E. Teaching Toolbox. O.B.E. Strategies, tools and techniques for implementing Curriculum 2005*. Florida Hills: Vivlia Publishers and Booksellers.

80. Kulik, J. (2003). *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. Arlington, Virginia: SRI International.
Retrieved from
http://www.sri.com/policy/csted/reports/sandt/it/Kulik_ITinK-12_Main_Report.pdf
81. Lajoie, S.P. and Derry, S.J. (1993). *Computers as cognitive tools*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
82. Learning Reviews. (2013). *iMindMap Basic*. Retrieved from
<http://www.learningreviews.com/learning-tools/graphic-organizers/imindmap-basic.html>
83. LeDoux, J (1994). *Emotion, memory, and the brain*. Scientific American, Vol. 270 (6), 50-57.
84. Lee, P.U., Klippel, A and Tappe, H. (2003). *The Effect of Motion in Graphical User Interfaces*. In Butz et al. (Eds.): Smart Graphics 2003, LNCS 2733, 12–21.
Berlin : Springer-Verlag.
85. Lee, Y-H., Waxman. H., Wu, J.-Y., Michko, G., and Lin, G. (2013). *Revisit the Effect of Teaching and Learning with Technology*. Educational Technology and Society, 16 (1), 133–146.
86. LeFever, M. D. (2004). *LEARNING STYLES: REACHING EVERYONE GOD GAVE YOU TO TEACH*. Colorado Springs, USA: David. C. Cook Publishers.
87. Le Grange, L. (2009). *Reliability, validity and educational research*. Educational Research. Faculty of Education. University of Stellenbosch.
88. Levin, J.A, Riel, M.M, Miyake, N and Cohen, M. (1987). *Education on the electronic frontier: Tele-apprentices in globally distributed educational contexts*. Contemporary Education Psychology, Vol. 12, 254-260.
89. Levine, M. (2002). *A Mind at a Time. How Every Child Can Succeed*. London, UK: Simon and Schuster Inc.
90. Lewis, D.K. (2001). *Counterfactuals*. Mal den, Mass: Wiley-Blackwell.
91. Lombard, K and Grosser, M. (2008). *Critical thinking: are the ideals of OBE failing us or are we failing the ideals of OBE?* South African Journal of Education. Vol. 28, (4).
Retrieved from http://www.scielo.org.za/scielo.php?pid=S0256-01002008000400007&script=sci_arttext

92. Lozanov, G. (1978). *Suggestology and Outlines of Suggestopedia*. New York: Gordon and Breach.
93. MacArthur, C. A. (1999). *OVERCOMING BARRIERS TO WRITING: COMPUTER SUPPORT FOR BASIC WRITING SKILLS*. University of Delaware, Newark, Delaware, USA. Retrieved From [http://ncset.uoregon.edu/ncset_media/refbase/Marilyn%20papers/MacArthur 1999Barriers.pdf](http://ncset.uoregon.edu/ncset_media/refbase/Marilyn%20papers/MacArthur%201999Barriers.pdf)
94. MacLean, P.D. (1990). *The triune brain in evolution: Role in paleocerebral functions*. New York: Plenum Press.
95. Mahoni D. (2010). *Latin Translations, Latin Grammar and other Translations*. Lat-Dict, An online Latin Dictionary. Retrieved from <http://www.latin-dictionary.net/info/word/10830.html>
96. Martin-Stanley, B.L and Martin-Stanley, C. R. (2007). *Constructivism and Technology: Strategies for Increasing Student Learning Outcomes*. University of Wisconsin-La Crosse. Retrieved from <http://www.nssa.us/journals/2007-29-1/2007-29-1-15.htm>
97. Mayer, R.E and Moreno, R. (2002). *Aids to computer-based multimedia learning*. Learning and Instruction Journal. Vol. 12, 107-119.
98. Mayfield Clinic. (2013). *Neurons*. Retrieved from <http://www.mayfieldclinic.com/PE-AnatBrain.htm#VDaT6BaCUTA>
99. McCoy, L.P. (1996). *Computer-Based Mathematics Learning*. Journal of Research on Computing in Education, Vol. 28 (4), 438-460.
100. McKeown, S. and McGlashon, A. (2012). *Brilliant Ideas for Using ICT in the Inclusive Classroom*. [Kindle DX]. Routledge: Oxon. Retrieved from Amazon.com.
101. McLeod, G. (2003). *Learning Theory and Instructional Design*. TLC, Durham Technical Community College. Volume 4, Fall 2003. Available from http://courses.durhamtech.edu/tlc/learningmatters/learning_theory.pdf
102. McLeod, S. (2007). *Behaviorist Approach*. Simply Psychology. Retrieved from <http://www.simplypsychology.org/behaviorism.html>
103. McMillan and Schumacher. (1993). *Research Education, a conceptual introduction*. New York: Harper Collins College Publishers.

104. McNay, E.C., McCarty, R.C. and Gold, P.E. (2001). Fluctuations in brain glucose concentration during behavioural testing: Dissociations between brain areas and blood. *Neurobiology of Learning and Memory*. Volume 75(5), 325-337.
105. Mitchell, A and Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London, U.K: The Learning and Skills Development Agency. Retrieved from <http://dera.ioe.ac.uk/5270/1/041529.pdf>
106. Morrison, Gary R. (2010) *Designing Effective Instruction*. (6th Ed). John Wiley and Sons.
107. Mouton, J. (1996). *Understanding social research*. Pretoria: Van Schaik.
108. National Science and Technology Forum. (2014). *NATIONAL SCIENCE AND TECHNOLOGY FORUM (NSTF) WORKSHOP PROCEEDINGS – EDUCATION IN SOUTH AFRICA: IS ICT THE ANSWER?* Retrieved from <http://www.nstf.co.za/ShowProperty?nodePath=/NSTF%20Repository/NSTF/files/Workshops/2014/ICTproceedings.pdf>
109. Ndlovu, N. S and Lawrence, D. (2012). *The quality of ICT use in South African classrooms*. In *Strategies to Overcome Poverty and Equality Conference*. 3-7 September 2012. Cape Town: University of Cape Town.
110. Nicholson, J. A, Nicholson, D. B. and Valacich, J. S. (2007). *COMPUTER-MEDIATED LEARNING: LEVERAGING TECHNOLOGY ATTRIBUTED TO ENHANCE LEARNING OUTCOMES*. Proceedings of the AIS SIG-ED IAIM 2007 Conference.
111. Noeth, R.J and Boris, B.V. (2004). *Evaluating the Effectiveness of Technology in Our Schools*. ACT Policy Report. ACT, Inc. Retrieved from http://www.act.org/research/policymakers/pdf/school_tech.pdf
112. Nyaumwe, L. J and Mtetwa, D. K. (2001). *Developing a cognitive theory from student teachers' post-lesson reflective dialogues on secondary school mathematics*. *South African Journal of Education*. Vol. 31, 145-159.
113. O'Brien, R. (1998). *An Overview of the Methodological Approach of Action Research*. University of Toronto. Retrieved from <http://www.web.ca/~robrien/papers/arfinal.html>
114. O'Donnel, L. (1999). *Music and the Brain*. Music Power. Retrieved from <http://www.moodelevatingmusic.com/articles/article-music-and-brain.pdf>

115. Olivier, M.S. (2009). *Information Technology Research. A practical guide for Computer Science and Informatics*. (3rd Ed). Pretoria: Van Schaik.
116. O'Neill, G and McMahon, T. (n.d.). *STUDENT–CENTRED LEARNING: WHAT DOES IT MEAN FOR STUDENTS AND LECTURERS?* University College Dublin, 27-36. Retrieved at http://www.aishe.org/readings/2005-1/oneill-mcmahon-Tues_19th_Oct_SCL.pdf
117. Ong, W.J. (1982). *Orality and literacy: The technologizing of the word*. New York: Routledge.
118. Openstax. (2014). *How neurons communicate*. Rice University. Retrieved from <http://cnx.org/contents/185cbf87-c72e-48f5-b51e-f14f21b5eabd@9.45:182/Biology>
119. Ormrod, J. E. (2008). *Educational Psychology Developing Learners*. Pearson Merrill Prentice Hall, 384-386.
120. Ornstein, A.C and Hunkins, F.P. (1988). *Curriculum-Foundations, principles and issues*. (2nd Ed). Boston: Allyn and Bacon.
121. Oxford University Press. (2012). *Definition of suggest in English*. Oxford University Press. Retrieved from <http://www.oxforddictionaries.com/definition/english/suggest>
122. Ozden, M. and Gultekin, M. (2008). *The Effects of Brain-Based Learning on Academic Achievement and Retention of Knowledge in Science Course*. Electronic Journal of Science. Vol. 12 (1). Retrieved from <http://ejse.southwestern.edu/article/download/7763/5530>.
123. Paget, R.J. (2006). *The role of music in learning*. p. 5. Retrieved from <http://www.baatltd.com/newsletters/The%20Role%20of%20Music%20in%20Learning.pdf>
124. Paine, T. (2010). *The Triune Brain*. Image retrieved from <http://otheralternaterealities.com/Brain.aspx>
125. Pan African Research Agenda. (2008-2011). *The Pedagogical Integration of Information and Communications Technologies*, South Africa (PanAf). Database retrieved at <http://www.oecd.org/site/progresskorea/44128865.pdf>
126. Papert, S. (1980). *MINDSTORMS Children, Computers, and Powerful Ideas*. Basic Books, Inc., Publishers: New York

127. Papert, S and Harel, I. (1991). *Constructionism*. Ablex Publishing Corporation. Chapter 1 of the book as an essay. Retrieved from [http://www.papert.org/articles/Situating Constructionism .html](http://www.papert.org/articles/Situating%20Constructionism.html)
128. Pashler, H., McDaniel, M., Rohrer, D and Bjork, R. (n.d.). *Learning Styles. Concepts and Evidence*. A Journal of the Association for Psychological Science. Retrieved from http://www.montana.edu/teachlearn/documents/mar7_Pashlerarticle.pdf
129. Pea, R. D. (1985). *Beyond amplification: Using the computer to reorganize mental functioning*. Educational Psychologist Vol. 20(4), 147-182.
130. Pham, H. (2011). *Theory-Based Instructional Models Applied in Classroom Contexts*. Literacy Information and Computer Education Journal (LICEJ), Vol. 2 (2), June 2011. Retrieved from <http://www.infonomics-society.org/LICEJ/Theory-Based%20Instructional%20Models%20Applied%20in%20Classroom%20Contexts.pdf>
131. Piaget, J. and Cook, M. T. (1952). *The origins of intelligence in children*. New York: International Universities Press, INC. Retrieved from http://www.pitt.edu/~strauss/origins_r.pdf
132. Poplin, M. (1988). "The reductionist fallacy in learning disabilities: Replicating the past by reducing the present." Journal of Learning Disabilities: Vol. 21 (7), 404
133. Prensky, M. (2001). *Digital Natives, Digital Immigrants*. On the Horizon, MCB University Press, Vol. 9 (5), October 2001.
134. Princeton University. (2014). *Gestalt psychology*. CC-BY-SA. Retrieved from http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Gestalt_psychology.html
135. Pritchard, A. (2009). *WAYS OF LEARNING. LEARNING THEORIES AND STYLES IN THE CLASSROOM*. (2nd Ed.). London: Routledge.
136. Ragasa, C. Y. 2008. *A comparison of Computer-Assisted Instruction and the Traditional Method of Teaching Basic Statistics*. Journal of Statistics Education. Vol. 16, (1).
137. Rogers, P.L. (2002). *Designing Instruction for Technology – Enhanced Learning*. Hershey, U.S.A.: Idea Group Publishing.
138. Rossouw, L. (1995). *Die optimalisering van die leerpotensiaal van die skoolbeginner*. Unpublished D.Ed Thesis. Pretoria: University of South Africa.

139. Rochelle, J. M., Pea, R. D., Hoadley, C. M., Gordon, D. N. and Means, B. M. (2000). *Changing how and what children learn with computer-based technologies*. Children and Computer Technology. Vol. 10 (2), 76. Available from: http://halshs.archivesouvertes.fr/docs/00/19/06/10/PDF/A103_Roschelle_etal_01_Packard.pdf
140. Roda, C. (n.d.). *Human attention and its implications for human-computer interaction*. Retrieved at http://interruptions.net/literature/Roda-Human_Attention_in_Digital_Environments11.pdf
141. Rostami, K. and Khadjooi, K. (2010). *The implications of Behaviorism and Humanism theories in medical education*. Gastroenterology and Hepatology From Bed To Bench, Vol. 3 (2), 65-70. Retrieved from <http://journals.sbmu.ac.ir/ghfbb/index.php/ghfbb/article/view/81>
142. Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
143. Salomon, G., Perkins, D and Globerson, T. (1991). *Partners in Cognition: Extending Human Intelligence with intelligent Technologies*. Proceeding of the 24th International Congress of Psychology (Vol. 4). American Educational Research Association.
144. Schacter, J. (1990). *The Impact of Education Technology on Student Achievement*. Santa Monica, California: Milken Exchange on Education Technology.
145. Scheiderman, B and Plaisant, C. (2010). *Designing the User Interface. Strategies for Effective Human-Computer Interaction*. (5th Ed). Boston: Pearson
146. Shen, J. (2013). *How Nerve Signal Work*. Image retrieved from <http://blog.bufferapp.com/why-practice-actually-makes-perfect-how-to-rewire-your-brain-for-better-performance>
147. Semenov, A. (2005). *INFORMATION AND COMMUNICATION TECHNOLOGIES IN SCHOOLS. A HANDBOOK FOR EDUCATORS*. UNESCO.
148. Shaffer, D and Kipp, K. (2014). *Developmental Psychology: Childhood and Adolescence*. (9th Ed.) Cengage Learning. California: Belmont.
149. Shield, G. (2012). *A Critical Appraisal of Learning Technology Using Information and Communication Technologies*. Journal of Technology Studies. Retrieved from

- <http://scholar.lib.vt.edu/ejournals/JOTS/Winter-Spring-2000/shield.html>
150. Siemens, G. (2002). *Instructional Design in ELearning*. Retrieved from <http://www.elearnspace.org/Articles/InstructionalDesign.htm>
 151. Shim, J. E and Li, Y. (2007). *Cognitive Tools in the classroom. Applications of Cognitive Tools in the Classroom*. The University of Georgia. Retrieved from http://projects.coe.uga.edu/epltt/index.php?title=Cognitive_Tools_in_the_classroom
 152. Sigelman, C.R. and Rider, E.A. (2003). *Lifespan human development*. Belmont. Wadsworth.
 153. Smith. B. and McCulloch, P. (2014). *Inclusive Technologies Assisting Students with Learning Difficulties and Disabilities*. Spectronics. Retrieved from <http://www.spectronicsinoz.com/article/inclusive-technologies-assisting-students-with-learning-difficulties-and-disabilities/>
 154. Smith, D.P.J. (1993). *Navorsingsontwerp en metodes van navorsing*. Johannesburg: RAU.
 155. Smith, G. S and Hardman, J. (2014). *The impact of computer and mathematics software usage on performance of school leavers in the Western Cape Province of South Africa: A comparative analysis*. International Journal of Education and Development using Information and Communication Technology. Vol. 10 (1), 22-40.
 156. Sorensen, E. K., and Ó Murchú, D. (Eds.) (2006). *Enhancing Learning Through Technology*. [Kindle DX]. Hershey, PA: Idea Group Publishing. Retrieved from Amazon.com.
 157. Sotto, E. (2007). *When Teaching Becomes Learning: A Theory and Practice of Teaching*. (2nd Ed.), London: Continuum.
 158. Sporns, O. (2011). *Networks of the brain*. Massachusetts: Massachusetts Institute of Technology.
 159. Sprenger, M. (2005). *How to Teach so Students Remember*. Alexandria, VA: ASCD.
 160. Sprenger, M. (2010). *Brain-based Teaching in the Digital Age*. Alexandria, VA: ASCD.
 161. Stavredes, T. (2011). *Effective online teaching: Foundations and strategies for student success*. San Francisco: John Wiley and Sons

162. Surgenor, P. (2010). *Teaching toolkit. How Students learn*. 2. UCD Teaching and Learning. Retrieved from www.ucd.ie/teaching
163. Surgenor, P. (2010). *Teaching toolkit. How Students learn*. 3. UCD Teaching and Learning. Retrieved from <http://www.ucd.ie/t4cms/UCDTLT0018.pdf>
164. Sutoo, D and Akiyama, K. (2004). *Music improves dopaminergic neurotransmission: demonstration based on the effect of music on blood pressure regulation*. National Centre for Biotechnology Information, U.S. National Library of Medicine: Bethesda, USA. Abstract retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/15246862>
165. Swanepoel, C. (2009). *A comparison between the views of teachers in South Africa and six other countries on involvement in school change*. South African Journal of Education. Vol. 29, 461-474.
166. Swann, J. and Pratt, J. (2003). *Educational Research in Practice: Making Sense of Methodology*, London: Continuum.
167. Swanson, H.L. and Deshler, D. (2003). *Instructing Adolescents with Learning Disabilities: Converting a Meta-Analysis to Practice*. Journal of Learning Disabilities. Vol. 36 (2), 124– 135. Retrieved from <http://www.wce.wvu.edu/Depts/SPED/Forms/Kens%20Readings/reading/Readings/comprehension/instructing%20adolescents.pdf>
168. Tapscott, D. (2009). *Growing Up Digital: How the Net Generation Is Changing Your World*. [Kindle Edition]. New York: McGraw Hill
169. Taylor-Powell, E. (1996). *Analyzing Quantitative Data*. Cooperative Extension Publications. University of Wisconsin. Madison, U.S.A. Retrieved from <http://learningstore.uwex.edu/assets/pdfs/g3658-6.pdf>
170. Tinio, V.L. (n.d.). *ICT in Education*. United Nations Development Programme, Bureau for Development Policy. New York, U.S.A. Retrieved from <http://www.eprimers.org> and <http://www.apdip.net>.
171. Vygotsky, L. S. 1978. *Mind in society: The development of higher psychological processes* Cambridge, MA: Harvard University Press.
172. Wagner, M.J, and Tilney, G. (2012). *The Effect of “Superlearning Techniques” on the Vocabulary Acquisition and Alpha Brainwave Production of Language Learners*. TESOL Quarterly Vol. 17 (1), 5–17.

173. Watkin, N. (2006). *Using ICT to promote Independent Learning ICT, Engagement and Quality Learning*. The Education Forum. Retrieved from <http://educationforum.ipbhost.com//index.php?showtopic=7136>
174. Watson, J. B. (1913). *Psychology as the behaviorist views it*. *Psychological Review*, Vol. 20, 158-178.
175. Waxmen, H. C., Lin, L. and Michko, G. M. (2003). *A Meta-Analysis of the Effectiveness of Teaching and Learning With Technology on Student Outcomes*. Learning Point Associates.
176. Webster, J. and Hackley, P. (1997). *Teaching Effectiveness in Technology-Mediated Distance Learning*. *Academy of Management Journal*. Dec 1997. Vol. 40 (6), 1282-1309. Retrieved from <http://ed334s2011.wikispaces.com/file/view/Teaching+Effectiveness+in+Technology-Mediated+Distance+Learning.pdf>
177. Weegar, M.A and Pacis, D. (2012). *A Comparison of Two Theories of Learning -- Behaviorism and Constructivism as applied to Face-to-Face and Online Learning*. E-Leader Manila. National University San Diego, CA, U.S.A. Retrieved from <http://www.g-casa.com/conferences/manila/papers/Weegar.pdf>
178. Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics*. Princeton, New Jersey. Educational Testing Services.
179. Wheldall, K. and Glynn, T. (1988). *Contingencies in Contexts: a behavioural interactionist perspective in education*. *Educational Psychology*, Vol. 8 (1/2), 5 – 18.
180. Wickens, C. D and McCarly, J.S. (2008). *Applied Attention Theory*. Boca Raton, U.S.A: CRC Press.
181. Wichman, F.A, Sharpe, L.T and Gegenfurter, K.R. (2002). *The Contributions of Color to Recognition Memory for Natural Scenes*. *Journal of Experimental Psychology*, American Psychological Association, Inc. *Learning, Memory, and Cognition* 2002, Vol. 28 (3), 509 –520.
182. Wilkens, L.O. and Spears, A. (n.d.). Overview of brain-based learning. TeachandLearn.net. Retrieved from <http://vcampus.uom.ac.mu/teachertraining/unit%204/2.pdf>

183. Wood, D. (1992). *How children think and learn. The social contexts of cognitive development*. Cambridge, Massachusetts: Blackwell.
184. Woollard, J. (2010). *Psychology for the classroom: Behaviourism*. London, New York: Routledge.
185. Wright, J. (2012). Motivation. Proceedings from the CCSE Conference. Intervention Central. Retrieved from http://www.fehb.org/CSE/CCSEConference2012/wright_CCSE_Conference_Breakout_Motiv_Students_15_Mar_2012.pdf
186. Yin, R. K. (1994). *Case Study Research: Design and Methods*. London: Sage.

Appendix 1 – Teaching slides



Decimals


Grade 6

Slide nr. 1

What is a decimal number?

A Decimal Number (based on the number 10) is a number that contains a **Decimal Point**.

To understand decimal numbers you must first know about **Place Value**



When we write numbers, the **position** (or "**place**") of each number is important.


[Place Value Lesson Video.](#)

★ Do page two in your working document.

Slide nr. 2

In the number 327:

- the "7" is in the **Units** position, meaning just 7 (or 7 "1's")
- the "2" is in the **Tens** position, meaning 2 tens (or twenty)
- And the "3" is in the **Hundreds** position, meaning 3 hundreds.



As we move left, each position is **10 times bigger!**

From Units, to Tens, to Hundreds
.....and.....

As we move right, each position is **10 times smaller!**

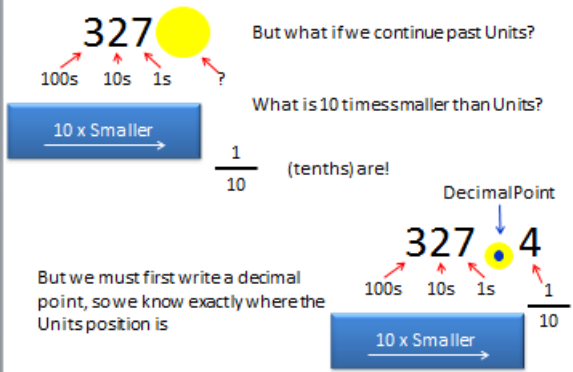
From Hundreds, to Tens, to Units

★ Do page 3 & 4 in your working document.

Slide nr. 3

But what if we continue past Units?

What is 10 times smaller than Units?

$$\frac{1}{10} \text{ (tenths) are!}$$


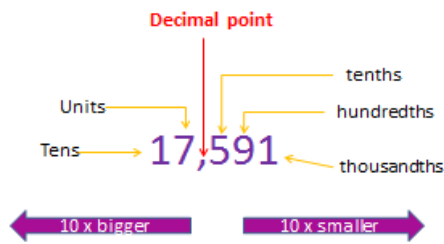
But we must first write a decimal point, so we know exactly where the Units position is

This is "Three Hundred Twenty Seven and 4 tenths"

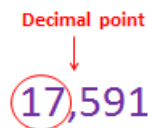
We usually just say "three hundred twenty seven point four"

Slide nr. 4


Now we can continue with smaller and smaller values, from tenths, to hundredths, to thousandths and so on. Look at the example below!



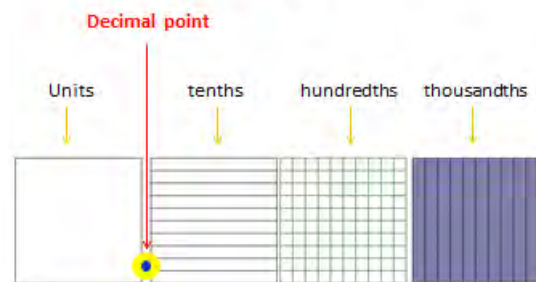
Our Decimal System lets us write numbers as large or as small as we want, using the decimal point. Numbers can be placed to the left or right of a decimal point, to indicate values greater than one or less than one.



The number left of the decimal point is a **whole number**

 Do page 5 -7 in your working document.

Here is another way of looking at decimals....



Slide nr. 5

Slide nr. 6

The real definition of a decimal...

decimal

The word "Decimal" really means "based on 10"
(This word originates from the Latin word "decima" meaning "a tenth part")

A **decimal number** usually means there is a **Decimal Point**.

Why do we need decimal points?

To represent non-whole numbers.

There are decimals because of fractions.
Decimals are converted fractions.

A decimal shows a number less than one.

TO SHOW REMAINDERS

Decimals are used in situations which require more precision than whole numbers can provide.

What is the important issue?

You need to know your **place values!**

You need to know it



Watch this video.....

[Decimal Place Value Video.](#)

Slide nr. 7

Slide nr. 8

How do we read or say
(pronounce)
decimal numbers?

523

This number will read as....
"five hundred twenty-three"

(Notice that we don't say "and twenty-three!")
We're saving the big "and" for the decimal point!

5.2
five and two tenths
(Because it's really $2 \times \frac{1}{10}$)

Let's look at the number
57.49.....

PLACE VALUE AND DECIMALS													
millions	hundred thousands	ten thousands	thousands	hundreds	tens	ones	and	tenths	hundredths	thousandths	ten-thousandths	hundred thousandths	millionths
					5	7	.	4	9				

You will read this number as.....

Fifty seven and forty nine hundredths.

But.....

It can also be read as.....

Fifty seven point four nine.

[How to read a decimal Video.](#)

[Do page 8 in your working document.](#)

Slide nr. 9

Slide nr. 10

Other ways to write and
talk about decimals.....

You could think of a decimal number as a Decimal Fraction.

A Decimal Fraction is a fraction where the denominator (the bottom number) is a number such as 10, 100, 1000, etc. (in other words a power of ten),

$\frac{23}{10}$ Will be written as 2,3

$\frac{1376}{100}$ Will be written as 13,76

Writing decimals in
expanded notation.

Remember your place values as they will help you to write your decimal number in expanded notation!

First label your place values.

1648,375
1000 100 10 1 1/10 1/100 1/1000

Write your expanded notation.

$1 \times 1000 + 6 \times 100 + 4 \times 10 + 8 \times 1 + 3 \times \frac{1}{10} + 7 \times \frac{1}{100} + 5 \times \frac{1}{1000}$
Whole numbers decimal numbers

This is where the decimal point will be!



[Do page 9 in your working document.](#)

Slide nr. 11

Slide nr. 12

Converting fractions to decimals.

The following fractions are easy to convert as you just need to look at the decimal places.

$$\frac{3}{10} = 0.3 \quad \text{tenths}$$

$$\frac{17}{100} = 0.17 \quad \text{hundredths}$$

$$\frac{5}{100} = 0.05 \quad \text{hundredths}$$

$$\frac{323}{1000} = 0.323 \quad \text{thousandths}$$

$$\frac{47}{1000} = 0.047 \quad \text{thousandths}$$

$$\frac{9}{1000} = 0.009 \quad \text{thousandths}$$

13

What about a fraction like $\frac{1}{5}$?

If we can turn the denominator into a 10 or 100 or 1000 (a power of 10), then it is easy!

How do we do it?

$$\frac{1}{5} \times \frac{2}{2} = \frac{2}{10} = 0.2$$

Let's do another one:

$$\frac{3}{25} \times \frac{4}{4} = \frac{12}{100} = 0.12$$

One more:

$$\frac{5}{8} \times \frac{125}{125} = \frac{625}{1000} = 0.625$$



Do page 10 & 11 in your working document.

14

Slide nr. 13

Slide nr. 14

To add decimals, follow these steps:

- Write down the numbers, one under the other, with the decimal points lined up
- Put in zeros so the numbers have the same length
- Then add normally, remembering to put the decimal point in the answer

Example: Add 1.452 to 1.3

Line the decimals up:

$$\begin{array}{r} 1.452 \\ + 1.3 \end{array}$$

"Pad" with zeros:

$$\begin{array}{r} 1.452 \\ + 1.300 \end{array}$$

Add:

$$\begin{array}{r} 1.452 \\ + 1.300 \\ \hline 2.752 \end{array}$$

15

To subtract decimals, follow these steps:

- Write down the numbers, one under the other, with the decimal points lined up
- Put in zeros so the numbers have the same length
- Then subtract normally, remembering to put the decimal point in the answer

Example: Subtract 0.3 from 1.1

Line the decimals up:

$$\begin{array}{r} 1.1 \\ - 0.3 \end{array}$$

"Pad" with zeros:

$$\begin{array}{r} 1.10 \\ - 0.3 \end{array}$$

Subtract:

$$\begin{array}{r} 1.10 \\ - 0.3 \quad \hline 1.07 \end{array}$$

16

Slide nr. 15

Slide nr. 16

To multiply decimals, follow these steps:

- Multiplying decimals start with normal multiplying and ignoring the decimal points.
- Then the trick is to make sure the answer has **as many decimal places as the two original numbers combined.**

Example: Multiply 0.3 with 213

$$0.3 \times 2.13 = 0.639$$
$$\begin{array}{r} 2.13 \leftarrow 2 \\ \times 0.3 \leftarrow +1 \\ \hline 0.639 \leftarrow 3 \\ \hline \end{array}$$

How to multiply decimals animation.

17

Bibliography


- Department of Basic Education. 2013. *Grade 6 Mathematics in English*, Book 1. D.B.E. Pretoria
- Jooste, Z.C, Press, K, Slamang, M & Smuts, C. 2012. *Study & Master Mathematics, Grade 6*. Oxford University Press. Cape Town.
- Information obtained from:
 - <http://www.mathsisfun.com/worksheets/decimals.php>
 - <http://www.coolmath.com/prealgebra/02-decimals/>
- Graphics obtain from:
 - http://www.mathgoodies.com/cd/Album/images/ss_place_value_chart.html
 - <http://megamindacademy.com/adding-decimal-numbers/>
 - <http://www.mathsisfun.com/numbers/decimals-multiplying-animation.html>

18

Slide nr. 17

Slide nr. 18

Appendix 2 – Learner Workbook designed in MS Power Point.



Decimal working document

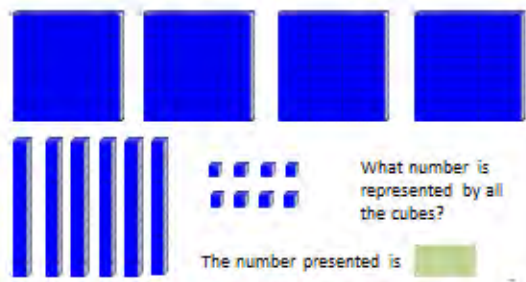
Done by
Grade 6

Slide nr. 1

Place Value House

Move all the cubes into the correct place value holders.

Hundreds	Tens	Units



What number is represented by all the cubes?

The number presented is

(Click on the green block to type an answer)

Slide nr. 2

Type what each digit's position (place value) is.

(Click on the block and start typing the words)

--	--	--	--

4327

Slide nr. 3

Type what each digit's position (place value) is.

(Click on the block and start typing the words)

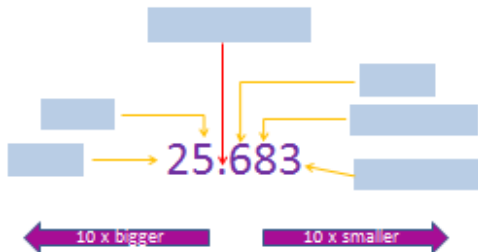
--	--	--	--	--

90257

Slide nr. 4

Give the place values for the following numbers.

(Click on the coloured block to start typing the words)

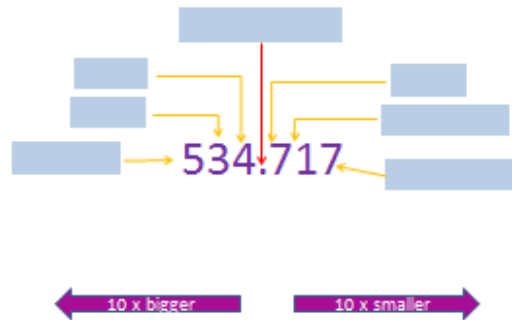


5

Slide nr. 5

Give the place values for the following numbers.

(Click on the coloured block to start typing the words)

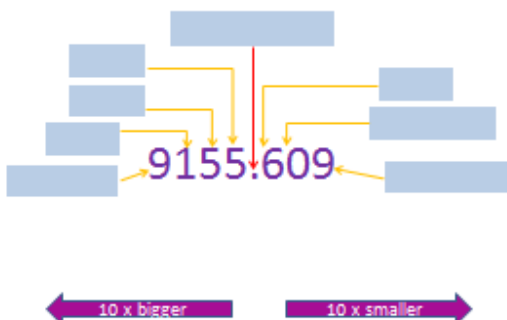


6

Slide nr. 6

Give the place values for the following numbers.

(Click on the coloured block to start typing the words)



7

Slide nr. 7

How do we read decimal numbers?

523

This number will read as...

"five hundred twenty-three"

(Notice that we don't say "and twenty-three!")

We're saving the big "and" for the decimal point!

Write the following numbers in words.

(Click on the coloured block's border to start typing. The cursor will automatically move down to give you more typing space if there isn't enough space in the line!)

12,5 =

505,16 =

1445,505 =

8

Slide nr. 8

Write your expanded notation for the following numbers.

$$\square | 10 \ 100 \ 1000 \times + \frac{1}{100} \ \frac{1}{10} \ \frac{1}{1000}$$

Copy and paste the above to assemble your expanded notation. Click on the blue block's line to type the number value.

Example: 523.12

523.12 =

$$\boxed{5} \times 100 + \boxed{2} \times 10 + \boxed{3} \times 1 + \boxed{1} \times \frac{1}{10} + \boxed{2} \times \frac{1}{100}$$

25.13 =

123.456 =

6.155 =

11

Slide nr. 9

Turn the following fractions into decimals.

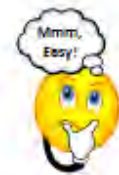
$$\frac{3}{10} = \square$$

$$\frac{7}{100} = \square$$

$$\frac{335}{1000} = \square$$

$$\frac{5}{10} = \square$$

$$\frac{173}{1000} = \square$$



12

Slide nr. 10

Turn the following fractions into decimals

$$\frac{2}{5} \times \frac{\square}{\square} = \frac{\square}{\square} = \square$$

$$\frac{1}{25} \times \frac{\square}{\square} = \frac{\square}{\square} = \square$$

$$\frac{3}{4} \times \frac{\square}{\square} = \frac{\square}{\square} = \square$$

$$\frac{3}{8} \times \frac{\square}{\square} = \frac{\square}{\square} = \square$$

$$\frac{100}{250} \times \frac{\square}{\square} = \frac{\square}{\square} = \square$$

11

Slide nr. 11

Learn the following to know it by heart!



halves

$$1/2 = 0.5$$



thirds

$$1/3 = 0.333$$

$$2/3 = 0.666$$



fourths

$$1/4 = 0.25$$


$$2/4 = 0.5$$

$$3/4 = 0.75$$


12

Slide nr. 12


Fifths



fifths



eights




tenths

$1/5 = 0.2$	$1/8 = 0.125$	$1/10 = 0.1$
$2/5 = 0.4$	$3/8 = 0.375$	$2/10 = 0.2$
$3/5 = 0.6$	$5/8 = 0.625$	$3/10 = 0.3$
$4/5 = 0.8$	$7/8 = 0.875$	$4/10 = 0.4$
		$5/10 = 0.5$
		$6/10 = 0.6$
		$7/10 = 0.7$
		$8/10 = 0.8$
		$9/10 = 0.9$

Slide nr. 13

Turn the following fractions into decimals



Click behind the '=' to type your answer!

$1/5 =$

$2/5 =$

$3/5 = 0.3$

$4/5 =$

$7/5 =$

Slide nr. 14

Add the following decimals.

Remember the following:

- Write down the numbers, one under the other, with the decimal points lined up.
- Put in zeros so the numbers have the same length.
- Then add normally, remembering to put the decimal point in the answer.

Add: $+$ $+$ $+$

5.1, 6 and 3.74 \rightarrow 5.1 6 3.74

3.25, 0.075 and 5 \rightarrow 0.075 5 3.25

Slide nr. 15

Subtract the following decimals.

Remember the following:

- Write down the numbers, one under the other, with the decimal points lined up.
- Put in zeros so the numbers have the same length.
- Then subtract normally, remembering to put the decimal point in the answer.

Subtract: $-$ $-$

6 and 3.74 \rightarrow 6 3.74

5 and 3.25 \rightarrow 3.25 0.075

Slide nr. 16

Multiply the following decimals.

Remember the following:

- Write down the numbers, one under the other, with the decimal points lined up.
- Put in zeros so the numbers have the same length.
- Then subtract normally, remembering to put the decimal point in the answer.



Multiply:

$$0.3 \times 5 = \begin{array}{r} 0.3 \\ \times 5 \\ \hline \end{array}$$



$$1.2 \times 2.4 = \begin{array}{r} 1.2 \\ \times 2.4 \\ \hline \end{array}$$



27

Congratulations,
you have completed your
work!



Please **save** your
workbook before you exit
the programme!

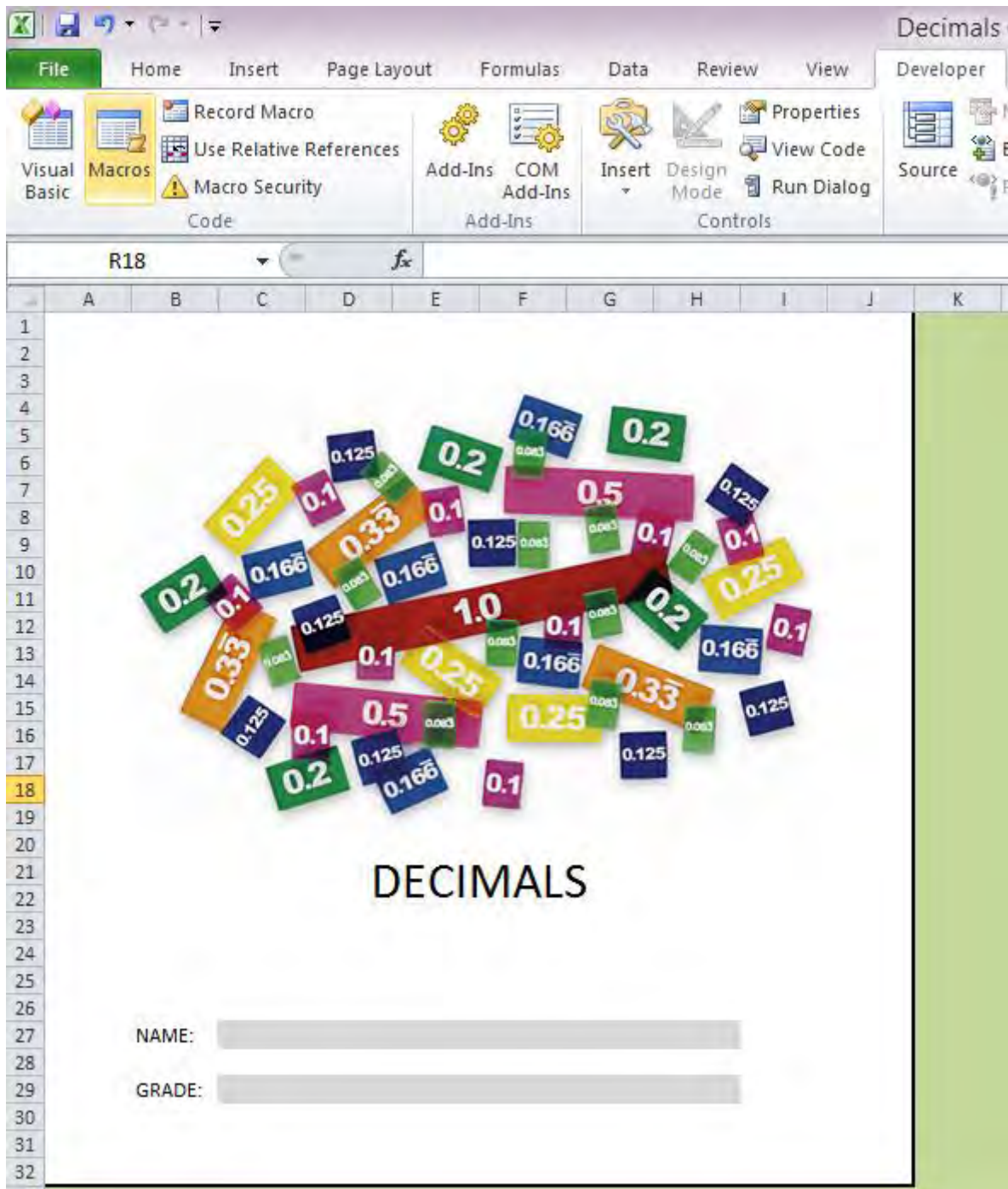
28

Slide nr. 17

Slide nr. 18

Appendix 3 - The pre-test

Front page sheet:



The screenshot shows a Microsoft Excel spreadsheet with the following content:

- Worksheet Name:** Decimals
- Formulas Bar:** R18
- Grid:** Columns A-K, Rows 1-32.
- Content:**
 - A collection of colorful cards with decimal numbers: 0.1, 0.2, 0.25, 0.33, 0.5, 1.0, 0.125, 0.166.
 - The word **DECIMALS** centered below the cards.
 - Input fields for **NAME:** and **GRADE:** at the bottom.

Test page sheet Section A:

File Home Insert Page Layout Formulas Data Review View

Clipboard Font Alignment

L16

ANSWER THE FOLLOWING QUESTIONS

SECTION A

Click the or inside the scroll down box to find possible answers. Click on the answer of your choice.

1. What is the tenths digit in the number 43.765?
2. For the number 36.2495, what is the place value of the digit 9?
3. For the number 2 367.981 where do you find the largest digit?
4. Which of the following numbers has 5 in the thousandths place?
5. What is the tenths digit in the number 356.812?
6. For the number 489.6327, where do you find the smallest digit?
7. Which of the following numbers has a 4 in the hundredths place?
8. Which number place has the value of 90 in the number 3599.99?

Test page sheet Section B:

H58

SECTION B

Type your answer inside the coloured block.

9. Deca- means [input box] (Type in words)

10. Centi- means..... [input box] (Type in words)

11. Milli- means..... [input box] (Type in words)

12. The number $\frac{1}{2}$ is a [input box] fraction

13. The number 3.2 is a [input box] fraction

14. What is the decimal fraction of the following:

a. $\frac{1}{2}$ [input box]

b. $\frac{1}{4}$ [input box] [input box]

c. $\frac{3}{4}$ [input box]

15. What will the decimal fraction be for the following statements?

a. $1 \div 2 =$ [input box]

b. $2 \div 4 =$ [input box]

c. $3 \div 4 =$ [input box]

d. $5 \div 5 =$ [input box]

16. Type the numbers represented by the expanded notation.

a. $50 + 4 + \frac{1}{10} =$ [input box]

b. $5 + \frac{5}{10} =$ [input box]

c. $300 + 30 + 3 + \frac{3}{10} =$ [input box]

Test page sheet Section C:

The image shows a Microsoft Word document with the following content:

80 SECTION C

81

82 Click the or inside the scroll down box to find possible answers. Click on the answer of your choice.

83

84 17. Which relationship sign will make the equations true?

85

86 a. 1 0.5

87

88 b. 0.5 5

89

90 c. $2\frac{1}{2}$ 2.5

91

92 d. 0.1 $\frac{1}{10}$

93

94 e. 0.3 3.0

95

96 SECTION B

97

98 Do the calculations and type you answer inside the coloured block.

99

100 18. $3.3 + 2.5 =$

101

102 19. $.32 - 2.7 =$

103

104

105 *You are done with your work. Please save and exit this program.*

106

107

108

Pre-test answer and formula sheet:

Examples:

The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E
1					
2		QUESTION:		FORMULA	
3					
4	1.	3			
5		4			
6		6			
7		5			
8		7			
9					
10				0	
11					
12	2.	9 tenths			
13		9 hundredths			
14		9 thousandths			
15		9 ten-thousands			
16					
17					0
18					
19	3.	In the Thousands place			
20		In the Units place			
21		In the tenths place			
22		In the hundredths place			
23					
24					0
25					
26	4.	5 003.256			
27		576.835			
28		89.0527			
29		31.8605			
30					
31					0
32					

File Home Insert Page Layout Formulas Data					
Clipboard		Font			
Cut Copy Paste Format Painter		Calibri	11	A ⁺ A ⁻	
		B <i>I</i> <u>U</u>			
D135		fx =SUM(D133/30*100)			
A	B	C	D	E	
105	17c.	=			
106		<			
107		>			
108					
109					0
110					
111	17d.	=			
112		<			
113		>			
114					
115					0
116					
117	17e.	=			
118		<			
119		>			
120					
121					0
122					
123	18.	5.8			0
124					
125	19.	5.61			0
126					
127					
128					
129					
130					
131					
132					
133	Total				0 /30
134					
135	Final Mark				0
136					

Appendix 4 - The post-test

Front page sheet:

The image shows a screenshot of a Microsoft Excel spreadsheet. The ribbon at the top includes 'File', 'Home', 'Insert', 'Page Layout', 'Formulas', 'Data', and 'Review'. The 'Home' ribbon is active, showing options for 'Clipboard' (Cut, Copy, Paste, Format Painter) and 'Font' (Calibri, 11, Bold, Italic, Underline, Text Color, Background Color). The active cell is AF3, containing the formula f_x . The worksheet grid shows columns A through K and rows 1 through 42. The worksheet content is as follows:

DECIMALS
GRADE 6

(Click on the coloured block to type the needed info)

NAME:

GRADE:


Test page sheet Section A:

Decimals Assessment 3 - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer


Calibri 11 A A Wrap Text
B I U Merge & Center % .00 .00
Font Alignment Number

B C D E F G H I J K L M N O



DECIMALS

GRADE 6



INSTRUCTIONS:

- 1) Click on the ▼ when there is a to see the possible answers. Then click on the answer of your choice.
- 2) Where there is a coloured block, click inside the block and type your answer.

SECTION A

QUESTION 1: How would you describe a decimal number?

QUESTION 2: Which number is a decimal number based on?

QUESTION 3: Why is a decimal point used in a decimal number?

Test page sheet Section B:

Questions 4-5

Decimals Assessment 3 - Microsoft

Insert Page Layout Formulas Data Review View Developer

Calibri 11 A⁺ A⁻ Wrap Text

at Painter **B** *I* U Merge & Center

Font Alignment Number

SECTION B

QUESTION 4:

Give the **values** of the following digits in the numbers below:

a) the '9' in the number 1587.39

b) the '2' in the number 321.048

c) the '8' in the number 8920.765

d) the '3' in the number 58.1543

e) The fourth digit in 888.88

QUESTION 5:

Give the **place values** of the following digits in the numbers below:

a) the '6' in the number 256.83

b) the '3' in the number 5000.35

c) The first digit in 5550.55

d) the '0' in the number 233.107

e) The last digit in 842.267

Test page sheet Section B:

Questions 6-7

Decimals Assessment 3 - Microsoft

File Home Insert Page Layout Formulas Data Review View Developer

Calibri 11 A A

Font Alignment Number

QUESTION 6:

The type the decimal number given by the words into the coloured blocks:

a) Fifteen and five hundredths.

b) One thousand and one tenth.

c) Two hundred sixteen and 8 thousandths

QUESTION 7:

Turn the following fractions into decimals (Type your answer into the coloured blocks):

a) $\frac{5}{10}$ f) $\frac{1}{2}$

b) $\frac{3}{100}$ g) $\frac{1}{4}$

c) $\frac{123}{1000}$ h) $\frac{2}{3}$

d) $\frac{1}{3}$ i) $\frac{1}{8}$

e) $\frac{3}{4}$ j) $\frac{1}{10}$

Test page sheet Section B:

Question 8 - 9

Decimals Assessment 3 - Microsoft

Insert Page Layout Formulas Data Review View Developer

Calibri 11 A A

Painter B I U Font Alignment Merge & Center General Number

QUESTION 8:

Expanded notation (Type the correct digit into the blue block).

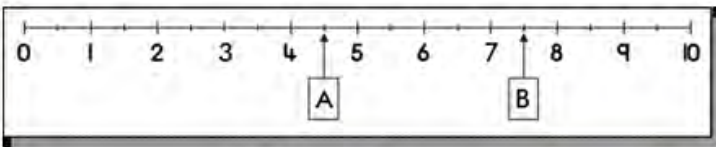
a) $523.12 = \square \times 100 + \square \times 10 + \square \times 1 +$
 $\square \times \frac{1}{10} + \square \times \frac{1}{100}$

b) $35.805 = \square \times 10 + \square \times 1 + \square \times \frac{1}{10} +$
 $\square \times \frac{1}{100} + \square \times \frac{1}{1000}$

c) $1050.33 = \square \times 1000 + \square \times 100 + \square \times 10 +$
 $\square \times 1 + \square \times \frac{1}{10} + \square \times \frac{1}{100}$

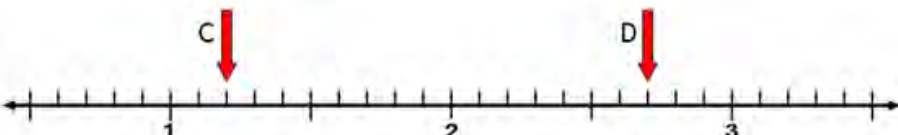
QUESTION 9:

This number line is marked in halves. Which decimal numbers do the arrows point to?



a) A = b) B =

Which decimal numbers do the arrows point to? (Remember the number line is marked fifths!)



c) C = d) D =

Test page sheet Section B:

Questions 10 – 13b

Decimals Assessment 3 - Micros

Insert Page Layout Formulas Data Review View Developer

Calibri 11 A⁺ A⁻ B I U % .00 .00

Font Alignment Number

QUESTION 10:

Type each decimal number in ascending order in the blocks below:

2	0,2	1	2,5	0	1,5	1,25	1,75
---	-----	---	-----	---	-----	------	------

Answer:

--	--	--	--	--	--	--	--

QUESTION 11:

Which relationship sign will make the equations true?

a) $\frac{1}{4}$ 0,75

b) $\frac{1}{2}$ 0,5

c) 0,6 0,1

d) 24 2,4

QUESTION 12:

Adding decimals

Solve the following problems. Click inside the coloured block to type your answer.
Use a separate sheet of paper to do your calculations.

a) 0,3 + 1,25 + 16,5 =

b) 12,7 + 6,35 + 3,22 =

QUESTION 13:

Subtracting decimals

Solve the following problems. Click inside the coloured block to type your answer.
Use a separate sheet of paper to do your calculations.

a) 21,35 - 18,76 =

b) 8,31 - 2,7 =

Test page sheet Section B:

Questions 14 – 15d

QUESTION 14:

Multiplying decimals

Solve the following problems. Click inside the coloured block to type your answer.
Use a separate sheet of paper to do your calculations.

- a) $3,6 \times 4$
- b) $4,5 \times 1,3$

QUESTION 15:

Decimal word problems

Solve the following problems. Click inside the coloured block to type your answer.
Use a separate sheet of paper to do your calculations.



A movie ticket cost R25,50. What is the cost of 9 tickets? (Remember to add the 'R' for 'Rand' to answer!)

The answer is

- b) Some children from Sunlands travelled by air. Group one travelled 1264km to Johannesburg and a second group travelled 1271,38 km to Durban.



How far did both groups travel to their destinations?

The answer is km

How far did they travel altogether when they arrived back in Cape Town?

The answer is km

- c) David has 5 litres of apple juice. He gives Shafeeq 0,7 litre. How much juice does he have left?



The answer is litres

- d) What is the total mass of the containers in the picture?

The answer is kg



Test page sheet Section B:

Questions 15e

Decimals Assessment 3 - Micros

Insert Page Layout Formulas Data Review View Developer

Calibri 11 A⁺ A⁻ B I U Wrap Text Merge & Center General % $\leftarrow 0$ $\rightarrow 0$


Font Alignment Number

f_x

C D E F G H I J K L M N

e) Snowy the cat has eight kittens. The picture on the right show their masses. Which mass is the heaviest?

The answer is kg



Kitten	Mass (kg)
1	0.333
2	0.213
3	0.305
4	0.41
5	0.313
6	0.5
7	0.215
8	0.47

Well done!
You have finished your work. Make sure to **save** your work before you close this program.

Pre-test answer and formula sheet:

Examples – Drop down list answers and formula:

Question 1 - 4

	A	B	C	D	E
1	ANSWERS			SCORE	
2					
3	QUESTION 1				
4	A decimals number is a number that consist of many values.				
5	A decimal number is a number that contains a Decimal Point.				
6	A decimal number is a number that is the same as a fraction.				
7					
8				0	
9					
10	QUESTION 2				
11	5				
12	100				
13	10				
14					
15				0	
16					
17	QUESTION 3				
18	A decimal point separates the place values.				
19	We use a decimal point to show exactly where the Units position is.				
20	A decimal point helps us to write a decimal number in the correct way.				
21					
22				0	
23					
24	QUESTION 4a				
25	900				
26	9				
27	90				
28	9/10				
29	9/100				
30	9000				
31					
32				0	

Pre-test answer and formula sheet:

Examples – Drop down list answers and formula:

Question 15a – 15e

The screenshot shows an Excel spreadsheet titled "Decimals Assessment 3". The ribbon includes File, Home, Insert, Page Layout, Formulas, Data, Review, View, and Developer. The formula bar displays $=SUM(D346/40*100)$. The spreadsheet data is as follows:

	A	B	C	D	E
324					
325	QUESTION 15a				
326	0				
327				0	
328					
329	QUESTION 15b				
330	0			0	
331	0			0	
332					
333					
334	QUESTION 15c				
335	0				
336				0	
337					
338	QUESTION 15d				
339	0				
340				0	
341					
342	QUESTION 15e				
343	0				
344				0	
345					
346			TOTAL	1,25 /40	
347					
348					
349			PERSENTAGE:	3,125 %	
350					
351					

