EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)-DRIVEN PEDAGOGY ON PERFORMANCE OF GRADE 12 GEOMETRY ORDINARY LEVEL LEARNERS IN THE OMUSATI EDUCATIONAL REGION, NAMIBIA

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ABSTRACT

Mathematical skills and knowledge are crucial for the attainment of Sustainable Development Goals (SDGs) -Goal 4 and the Namibian Vision 2030. In spite of the important role that Mathematics plays in the development of national economy, there has been poor performance in the subject at national examination level in many countries globally (Ali, 2013; Karue, & Amukowa, 2013), including Namibia (Haimbodi, 2012; Naukushu, 2011; Mateya, 2008). The Omusati Education region in Namibia is one of the regions characterized by poor performance in Grade 12 Mathematics Namibia Senior Secondary Certificate Ordinary (NSSCO) level. The Namibian Mathematics curriculum comprises many topics, one of which is Geometry. The Examiners' reports highlighted that questions on Geometry are poorly answered every year (DNEA, 2011, 2012, 2013, 2014). The objectives of this study were to investigate the effects of ICT-driven pedagogy on learners' Geometry performance and to determine the Experimental Group's perception level toward ICT-driven pedagogy.

This study was informed by Bruner's (1960) Constructivist Theory to explain effects of Information and Communication Technology (ICT)-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners. The study used Understanding by Design teaching approach to explain Geometrical concepts. Further, the Technology Acceptance Model (TAM) and Theory of flow Cognitive

Absorption (CA) were adopted as conceptual frameworks to test for learners' perceptions toward ICT-driven pedagogy.

This study used sequential explanatory research design, a mixed research design approach; using non-equivalent pre-test and post-test quasi-experimental design and a survey. Cluster random sampling was used to select a sample of 176 Grade 12 learners from two purposively selected secondary schools in the Omusati Education region. The Experimental School had a *Geometers' Sketchpad* software while the Control School did not. The Experimental Group (N=88) were taught Geometry topics (geometrical terms, relationships, angle properties and symmetry) using the ICT-driven pedagogy for two weeks. Meanwhile, the Control Group (N=88) was taught the same content using a traditional approach (chalkboard and textbook). Data were collected in two phases; first the two groups wrote a pretest then after two weeks intervention the post-test was conducted straightaway. In addition, the questionnaire was administered immediately after the post-test to the Experimental Group. The data were analysed using the *Statistical Package for Social Sciences* (SPSS) software.

Mann-Whitney U (non-parametric) test was used to test for significant difference between the Control and Experimental Groups since unequal variance was assumed after using Levene's test (ρ-value = $0.027 < \propto = 0.05$). The findings of the study revealed that, at 95% confidence level ρ=0.004; Mann-Whitney U test = 2 914.500,

there was a statistically significant difference between the two groups in terms of learner performance on Geometry topics. This implies that the use of ICT-driven pedagogy improved learners' performance. From the analysis of TAM constructs, the study found that 70.8% of the Experimental Group held positive perception toward ICT-driven pedagogy whereby a higher percentage were females (43.1%) than males (27.7%). Positive attitude toward ICT-driven pedagogy by learners translated into learners encouraging for the adoption of ICT-driven pedagogy.

Further, this study found a weak association $(x^2 = 3.426;\ \rho = 0.180 > \alpha = 0.05)$ between gender and perception levels; a strong association between performance in Geometry topics and perception level $(x^2 = 0.758;\ \rho = 0.685 > \alpha = 0.05)$. It can therefore be concluded that perception toward ICT-driven pedagogy has a link on performance in Geometry topics. Furthermore, a very weak negative correlation between gender and performance in the post-test on Geometry topics (r = -0.122;$\rho = 0.052 > 0.05$) was found which implies that performance is not determined by whether a learner is male or female and vice versa.

Based on the findings of this study, it was recommended that Mathematics teachers should be encouraged to use ICT-driven pedagogy when teaching Geometry in order to improve learners' academic achievement. Furthermore, schools that are equipped with ICT facilities should be encouraged to secure GSP software in order to enhance teaching and understanding of Geometry topics.

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DEDICATION

To my siblings and my mother Viviane Shikonekeni, to my son Tonata Justice Haimbodi, and to Nuuyoma SS class of 2013 Mathematics Higher Level Group, with all your encouragement, continuous support and positive attitudes, there has always been light at the end of the tunnel. This is dedicated to you.

DECLARATION

I, Leena Ngonyofi Kanandjebo, declare hereby that "**EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)-DRIVEN PEDAGOGY ON PERFORMANCE OF GRADE 12 GEOMETRY ORDINARY LEVEL LEARNERS IN THE OMUSATI EDUCATIONAL REGION, NAMIBIA**" is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

…………………… [signature]   Date: ………………………..

Leena Ngonyofi Kanandjebo

LIST OF ACRONYMS

ICT	Information and Communication Technology
MDGs	Millennium Development Goals
NDP 4	National Development Plan 4
NIED	National Institute for Educational Development
NSSCO	Namibia Senior Secondary Certificate Ordinary
DNEA	Directorate of National Examinations and Assessment
EMIS	Education Management Information System
UNAM	University of Namibia
NUST	Namibia University of Science and Technology
TFU	Teaching for Understanding
UbD	Understanding by Design
PbL	Project-based Learning
GSP	Geometer’s Sketchpad
TAM	Technology Acceptance Model
CA	Cognitive Absorption
SSCED	Social Studies Center for Educator Development

NAEP	National Assessment of Educational Progress
FCAT	Florida Comprehensive Assessment Test
PU	Perceived Usefulness
PEOU	Perceived Ease of Use
ATU	Attitude Toward use
BI	Behaviour Intentions

CHAPTER 1: INTRODUCTION

This chapter introduces a study on the Effects of Information and Communication Technology (ICT)-driven pedagogy on the performance of Grade 12 Geometry Ordinary level learners in the Omusati Education region, Namibia. This chapter begins with presenting the orientation of the study, elaborates the research problem, and aims of the study. It further, presents the research questions, hypothesis and the significance of the study. The limitations of the study and delimitation are discussed under Section 1.6 and Section 1.7 respectively, followed by the last section with the definition of terms used in the study.

1.1 Orientation of the study

One of the most important school subjects in the curriculum, Mathematic, is considered as a basis of all learning, with other subjects deriving their concepts from it (Ali, 2013). Mathematics is seen by many people as an essential and core subject for scientific, technological and economic development (Umameh, 2011; Mbugua, Kibet, Muthasa, & Nkonke, 2012). It is also considered as a basic entry requirement for any of the esteemed courses, such as medicine, architecture and engineering, among other degree programmes. In addition, it is not only an important subject for individuals' in terms of acquiring an academic qualification at school or college, but it also prepares individuals for the future, regardless of career choice (Davies, & Hersh, 2012). Mathematical skills and knowledge are essential for the attainment of the Sustainable Development Goals (SDGs) – Goal 4 (United Nations (UN), 2015), and as Charles-Ogan (2014) noted, these are needed to bring about sustained development in agriculture, education, gender equality and health.

Mathematics is also important for the attainment of Vision 2030, a presidential initiative, which highlighted the need to strengthen the teaching of Mathematics, Science and technology at all levels (Government of the Republic of Namibia, 2004). In the National Development Plan 4 (NDP 4), the Namibian government recommended that centres of excellence be accessible to all, with exceptionally high standards and requirements, and should be developed in the fields, such as Mathematics (Government of the Republic of Namibia, 2013). Thus, the teaching of Mathematics was believed necessary for the development of a dynamic knowledge-based economy society. This steered the policy reform for Mathematics to become a compulsory subject for every learner in Namibian schools (National Institute for Educational Development (NIED), 2010).

In spite of the important role that Mathematics plays in many fields of work, there has traditionally been poor performance in the subject at national examination level in some countries globally (Ali, 2013; Karue, & Amukowa, 2013); some of the contributory factors being poor teaching methods, lack of proper instructional materials and lack of learners' involvement when teaching (Ali, 2013; Karue, & Amukowa, 2013; Haimbodi, 2012; Naukushu, 2011; Mateya, 2008).

The Namibian Mathematics curriculum comprises of many topics, including Geometry which is taught from primary to secondary grades. It is regarded as "… a unifying topic to the entire Mathematics curriculum and it is a rich source of visualization for arithmetical, algebraic, and statistical concepts" (Idris, 2009, p.94). Themes covered under Geometry at the senior secondary phase include geometrical terms and relationships, geometrical constructions, symmetry, angle properties and locus. However, performance in Geometry has been poor with Idris (2009) and Myers (2009) pointing out that little regard has been given to how well the learners understand geometrical concepts.

The national average pass rate in Grade 12 Mathematics Namibia Senior Secondary Certificate (NSSC) Ordinary level is 30.2%, 39%, 38.8%, 40.8%, 41.5%, 40.19 and 40.16%, in 2008, 2009, 2010, 2011, 2012, 2013 and 2014 (Directorate of National Examinations and Assessment (DNEA, 2008, 2009, 2010, 2011, 2012, 2013, 2014). The Omusati Education region is one of those characterised by learners' poor performance in Mathematics at Ordinary level. Table 1 shows the statistics of Grade 12 Mathematics in the National Senior Secondary Certificate (NSSC) Ordinary level over the seven-year period in Omusati Education region.

Table 1: Grade 12 Mathematics NSSC Ordinary level Statistics for Omusati Education region

Year	Total number of learners	% Symbol A – D	% Symbol E-G	% Ungraded (U)
2008	1686	41.5	52.2	6.3
2009	1781	38.5	55.6	5.9
2010	2150	40.6	53.3	6.1
2011	2540	42.1	52.6	5.3
2012	2539	49.9	46.2	3.9
2013	2907	49.8	46.5	3.7
2014	2969	47.8	49.4	2.9
Average		**44.3**	**50.8**	**4.9**
Total:		→	**55.7**	

(Source: DNEA, 2008, 2009, 2010, 2011, 2012, 2013, 2014)

Table 1 indicates that over the period of seven years (2008-2014), an average of more than half (55.7%) obtained no-passing symbols; of which, 50.8% of the learners achieved between E-G and 4.9% were ungraded (U) (EMIS, 2014). However, it should be noted that the Ministry of Education, Arts and Culture has no guidelines with a description of what is a pass or fail. Therefore, a learner’s legibility to be admitted for further studies at universities was used as reference. The universities require a total of 25 points in five subjects and a pass of a C symbol in Mathematics for admission in science related courses. In addition EMIS (2014) documented that on average only about 44.3% of the learners scored passing symbols (A* - D) in Mathematics for the past five years, as Table 1 shows. These performances in Mathematics NSSC Ordinary level raise many questions on what can be done to improve the percentage of passing symbols.

Examiners' reports on NSSC Ordinary level Mathematics stated that teachers should concentrate on teaching topics that proved to be difficult to learners, such as Geometry (DNEA, 2011, 2012, 2013, 2014), as questions on Geometry were the worst answered every year. The DNEA (2011, p.3) report indicated that "learners could not recognise properties of triangles, quadrilaterals and circles as related to line and order of rotational symmetry". Another report stated that, "learners were not able to recognise and use geometrical shapes and terms like isosceles, trapezium, kite and many more" (DNEA, 2012, p.2). A more recent report indicated that, questions on the line of symmetry and order of rotational symmetry were being poorly answered (DNEA, 2014). The reports support Mateya's (2008) study, which found that although learners at Grade 12 level were familiar with some of the geometric shapes, most learners had a weak conceptual understanding of geometric concepts, not knowing their properties and hardly able to make basic informal deductions. Therefore, the focus of this study was on three of the five Geometry topics in the Mathematics NSSCO curriculum, namely, geometrical terms and relationships, symmetry and angle properties.

Information and Communication Technology (ICT) has been used to deliver instruction in some countries around the world, such as Malaysia (Myers, 2009) and USA (Idris, 2009). Namibia, like other countries, has identified ICT as one of the tools that could be used to enhance instruction in the classroom. According to the Ministry of Education (2005, 2006), the National ICT Policy for Education and Tech/Na! Implementation Plan were developed in order to ensure ICT implementation in schools. The National ICT policy outlined six overall educational goals concerning ICT in education; two of the six overall goals that formed the basis of this study are as follows (Ministry of Education, 2005, p.4):

- Broaden access to quality educational services for learners at all levels of the education system and set specific criteria and targets to help classify and categorise the different development levels of using ICT in education.

- Leverage ICT to assist and facilitate learning for the benefit of all learners and teachers across the curriculum.

In Namibia, the emphasis of ICT in education is directed toward its pedagogical use, that is to facilitate and assist in the teaching and learning process at all levels of the education system (Ministry of Education, 2005). Although ICT use in education has been acknowledged by the Namibian government; Simasiku and Simataa (2012) in their analysis of the status quo of ICT in the Namibian education sector stated that ICTs have not been thoroughly applied in classroom practices. Ngololo, Howie and Plomp (2012) have attested to this, whilst Losanda (2012) argued that ICT is applied to a lesser extent in Mathematics in Namibian schools and Ngololo et al. (2012) found that schools made limited use of ICT for pedagogy and there is a need to develop classroom-related ICT resources.

There are several ICT driven pedagogies, of which Teaching for Understanding (TFU) (Blythe, 1997), Understanding by Design (UbD) (Wiggins and McTighe, 2005), and Project-based Learning (PbL) (Moursund, 1999) are the most common approaches used in delivering instruction. This study used UbD from Wiggins and McTighe (2005), since it focuses on deliberately planning the learning experience, instruction and acceptable evidence of competency in the outcomes and results (assessment). From the perspective of UbD teaching approach, teaching should focus on understanding the learning content through designing more effective learning content and assessments (Wiggins, & McTighe, 2005). Learners should be taught using pictures, symbols and concrete objects for them to be able to recognise, observe and identify their properties (Bruner, 1960). In addition, Geometer's Sketchpad (GSP) can be used to improve learners' performance in Geometry (Myers, 2009).

1.2 Statement of the problem

Grade 12 learners in the Omusati Education region, Namibia; have been performing poorly in Mathematics as shown in Table 1, with 55.7% of the learners obtaining no-passing symbols and 44.3% (less than fifty percent) obtaining passing symbols. Passing symbols are necessary for admission to UNAM and NUST Mathematics related-degree courses. The Examiners' report on assessment does not indicate the problems experienced by learners, item by item but rather as a theme, leaving out much details on learners' competencies. However, the reports indicated that Geometry is one of the topics in the Mathematics NSSCO syllabus in which learners perform poorly (DNEA, 2011, 2012, 2014). The Examiners' reports specifically pointed out that, learners proved to have problems in geometrical terms and relationships, symmetry and angle properties.

Studies conducted by Idris (2009) and Myers (2009) on GSP and Geometry performance pointed out that GSP can be used to improve performance in Geometry. In Namibia however, only two studies (Losanda, 2012; Mateya, 2008) were conducted on the teaching of secondary school Mathematics using ICT. These studies did not use GSP as an intervention. Losanda (2012) researched teachers' perceptions on the use of spreadsheets and Algebra programmes as curriculum materials for high school Mathematics whilst a related study by Mateya (2008) used Van Hiele Theory to analyse Geometrical conceptualisation of Grade 12 learners. There is no study conducted in

Namibia that has focused on the Grade 12 learners' performance in Geometry at NSSC Ordinary level using ICT-driven pedagogies to address the problem of poor performance. Consequently, this study aims at investigating the effects of Understanding by Design (UbD) on Geometry (geometrical terms and relationships, angle properties and symmetry) performance of Grade 12 Mathematics NSSC Ordinary level learners in the Omusati Education region.

1.3 Research questions

Against the background presented above, this study was guided by the following research questions:

1. What is the effect of using UbD teaching approach on Geometry performance of Grade 12 learners at the NSSC Ordinary level in the Omusati Education region?

2. What are the perceptions (*levels)* of the Experimental Group on the use of UbD teaching approach using GSP?

3. What is the association between perception levels, performance and gender of learners?

1.4 Hypothesis

The following hypothesis will be tested:

H_o: There is no significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods.

H_1: There is a significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods.

1.5 Significance of the study

It was anticipated that the research findings from this study might shed light on the benefits of the use of UbD teaching approach as well as inform educators on learners' perceptions toward the ICT-driven pedagogy. In addition, the findings of this study may exist as a source of literature in this area and provide valuable insight into the successful teaching of Geometry using ICT. The study might also inform practitioners about the appropriate teaching strategies to utilise in order to enhance understanding of Geometrical terms and relationships, angle properties and symmetry.

1.6 Limitations of the study

The following were the limitations of this study:

The responses to the instrument which sought to determine the perception level of the Experimental Group were to be ticked on a Likert scale. Some learners might have ticked without necessarily reading the items of the scale. Such responses could have misinformed the researcher on the perceptions (*levels)* of the Experimental Group toward the use of UbD teaching approach using GSP.

1.7 Delimitations of the study

The research focussed on Mathematics Grade 12 learners at two selected secondary schools with in the Omusati Education region, because the GSP software was only available at one school in the region.

1.8 Definition of terms

Key terms used in this thesis should be understood as follows:

(a) **Geometry topics** refer to the three themes taught in this study, i.e., geometrical terms and relationships, geometrical, symmetry and angle properties. Geometry and Geometry topics were used interchangeably and had a similar meaning.

(b) **Geometers' Sketchpad (GSP)**, according to Myers (2009), is a dynamic Geometry software programme that allows learners and educators to create and manipulate shapes and to study Geometry in greater detail. In this study GSP is defined the same way.

(c) **Geometry Ordinary level learners** refer to the Grade 12 learners who were taught the three Geometry topics.

(d) **ICT-driven pedagogy** refers to the teaching approach that involves the use of technological tools to either deliver the learning content or assist with teaching the learning content (Roblyer, Edwards, and Havriluk, 2010). In the context of this study ICT-driven pedagogy refers to the teaching using UbD approach, GSP, Khan Academy and YouTube videos.

(e) **Information and Communication Technology (ICT)** refers to all the technologies used for the handling and communication of information and their use specifically in education (Ministry of Education, 2005). In the context of this study, ICT refers to technologies such as GSP software, YouTube and Khan Academy videos that were used to deliver instructions in order to improve teaching and learning.

(f) **NSSC Ordinary level** is defined as the Namibia Senior Secondary Certificate core and extended level.

(g) **Perceptions** are recognition and interpretation of sensory information and actions in response to these stimuli (Cherry, 2014). In this study, perceptions refer to the learners' attitudes (positive, negative or neutral) toward ICT-driven pedagogies.

(h) **Performance** is the academic accomplishment of a given task measured against pre-defined known standards of accuracy, completeness and speed (Cobb, 2005). In this study it refers to the Geometry test scores or marks of Grade 12 Mathematics learners in the Omusati Education Region.

(i) **Performance ruling** in this study refers to pass or fail in the pretest and posttest.

The next section reviews the literature related to this study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature related to the study and is divided into three parts. The first part of Part A reviews literature that addressed Research Question 1 and begins with discussing Bruner's Constructivist Theory, to explain the effects of ICT-driven pedagogies in learners' Geometry performance. Bruner advocated that the use of visual activities with computer programme is an essential component in helping learners to see how concepts apply to real-world situations and thereby enhance their understanding on the subject content. The second part of Part A presents traditional teaching approach; then followed ICT-driven pedagogy, i.e. the Understanding by Design (UbD) teaching approach, to understand content delivery and assessment through the two processes of UbD Backward design process and Facets of Understanding respectively. The explanation of these concepts is followed by research studies that used UbD and ICT-tools such as GSP and videos as a content delivery tool and their effects on learners' performances.

Part B focuses on literature that addressed Research Question 2 and Research Question 3. The first part of Part B presents two models, namely, Technology Acceptance Model (TAM) and Cognitive Absorption (CA) and how they relate to one another. These models focus on individuals' attitudes and behaviours toward ICT; thus were used as a lens to interpret learners' perceptions towards ICT-driven pedagogies. The second part of Part B discusses research findings on learners' perceptions. Further, the contents of Part A and B are consolidated in the conceptual framework of this study (Part C). Finally, the conclusion of this Chapter is presented in Part D.

PART A: Literature on Research Question 1

2.2 Bruner's Constructivist Theory

Bruner's Constructivist Theory stipulates that learners are active problem-solvers and capable of exploring 'difficult subjects' provided that the learning content is structured and presented in sequential order (Bruner, 1960). Bruner refers to the structure of knowledge as a relationship among factual elements and teaching and learning techniques. Thus, structure implies various teaching mechanisms that will enable the learners most readily to grasp the learning content.

Bruner (1960) believes that children go through three stages of intellectual development:

1. *Enactive stage* - Refers to learning through actions. This goes in line with McLeod (2008), for whom knowledge largely takes the form of motor responses. Learners may be able to perform a physical task better than describing the same task that has just been presented.

2. *Iconic stage* - Refers to the use of pictures or models. It is vital that teachers use diagrams and illustrations to accompany verbal information.
3. *Symbolic stage* - Refers to the development of the ability to think in abstract terms. Knowledge is mostly in the form of arbitrary words, mathematical symbols and other symbol systems (McLeod, 2008).

Bruner (1960) recommended the combined use of three modes of representation of learning, that are, concrete, pictorial and symbolic, which will lead to more effective learning and good performance in school subjects. He added that instruction should incorporate relevant learning materials that will facilitate interest towards learning. Thus, when pictures and/or symbols are used in the presentation of the learning content, most of the learners' senses are involved and so improve learners' understanding.

Constructivists view learning as a process that occurs "when an individual constructs both mechanisms for learning and his or her own unique version of knowledge, coloured by background, experiences, and aptitudes" (Roblyer, 2006, p.37). According to Retallick, Cocklin and Coombe (1998), constructivism transforms learners from passive recipients of knowledge to active learners in the learning process, in most cases guided by the teacher. Learners construct their knowledge actively rather than just absorbing it from the teacher or the textbook. Learners generate new knowledge through activities, experiences, and experiments. In addition, Rogers (2003) stated that the primary goal of the Constructivist Learning Theory is to help learners to learn how to learn.

In terms of technology, Bruner's Constructivist Theory advised that, teachers should use videos to equip learners with basic skills (Uriarte, & Uriarte, 2013). This will broaden their understanding of certain topics and motivate them to learn, which will in turn lead to better performance. Teachers should provide opportunities for learners to construct new knowledge and meaning from authentic experiences (Uriarte, & Uriarte, 2013).

In addition, Bruner (1960) emphasised that education should develop symbolic thinking of learners. Therefore, the use of GSP and other ICT tools can be used in teaching Geometry to enable a learner to grasp Geometry concepts with ease.

2.3 Traditional Teaching methods

The traditional or the conventional method of teaching is a teacher-centred approach, where the teacher plays an active role and the student passive role in the learning process (Tumba, Chinda, & Andeyarka, 2014). It is also referred to as the "chalk and talk" method of teaching (Jackson, 2012). Traditional teaching lesson presentation involves the use of discussions and explanations using a chalkboard. Based on the study conducted by Keùan and Çaliùkan (2013) on the effect of learning Geometry topics with Geometer's sketchpad;

the researchers used Wilcoxon signed-rank test to examine the difference between the scores of retention test and post-test of the group that was taught using traditional methods. Further, Keùan and Çaliùkan (2013) found traditional method to have had effects on retention and performance ($z = 0.402$; $\rho > 0.05$). Learners who were taught using traditional methods performed poorly compared to those that were taught using GSP. In this study, a traditional teaching method was used to teach the Control group.

2.4 ICT-driven Pedagogy: Understanding by Design (UbD)

The UbD framework was developed by Wiggins and McTighe (1998) as a planning framework to guide curriculum, assessment and instruction. It focuses on teaching for understanding through designing more effective learning content and assessments. This framework capitalises on assessment tasks which learners should use to construct new knowledge and those that require an extended time to complete (Marzano, Pickering, & McTighe, 1993). Anwaruddin (2013) supports Marzano et al.'s (1993) claim that assessment tasks that require an extended time, deepen learners' understanding since they are actively engaged. Consequently, these assessment tasks will increase learners' motivation and interest level in subjects.

UbD places more emphasis on teachers as designers of learning, and works within the standards-driven curriculum to help them clarify learning goals, devise revealing assessments of learners' understanding, and craft effective and engaging learning activities (McTighe, & Wiggins, 2012). Under this framework, learning outcomes and assessment are gathered before specifying instructional procedures in order to enhance learners' understanding during lesson presentation (Anwaruddin, 2013). McTighe and Wiggins (2012) stated that UbD calls for collaborative learning, use of technology and other teaching approaches in order to design, share, and critique learning content. It differs from conventional thinking about teaching and learning as it emphasises the use of a backward design process (Social Studies Center for Educator Development (SSCED), 1999). In this study, the Experimental Group was taught using the UbD approach.

This study used the UbD lesson plan format in preparation of the lessons and assessment to test the Experimental Group's understanding of Geometrical concepts. Learners in both groups were encouraged to be active learners in order to enhance their understanding during lessons and to collaborate in order to share ideas (Johnson, Johnson, & Holubec, 2008) during class activities.

The next section discusses UbD backward design, which is a road map to instruction and assessment design.

2.4.1 UbD Backward design process

The backward design process is a plan and checklist to guide the design of instruction and assessment, beginning with how to achieve the desired results of instruction rather than the planning process through activities, materials, or textbook content (SSCED, 1999). Wiggins and McTighe (2003) argued that the process uses curriculum as a means to an end, centring on the idea that the design process should begin with identifying the desired results then work backwards to develop instruction rather than the traditional approach of defining topics to be covered. UbD backward design consists of three stages, as show in Figure 1.

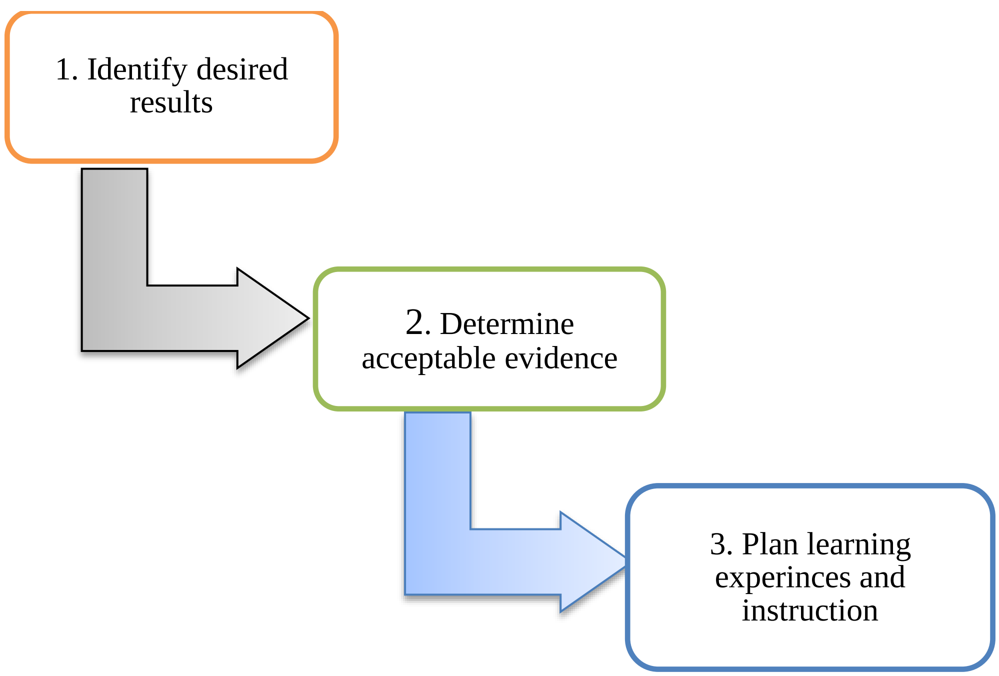

Figure 1: *Stages of the UbD "Backward" Design process (Wiggins and McTighe, 2003)*

Stage 1: Identify Desired Results

At this stage, objectives that learners should know by the end of the unit in measurable terms are clearly specified. Based on the learning objectives in the syllabus, teachers identify the main ideas that learners should understand and essential questions they should ask in order to foster understanding and transfer of learning. In addition, the desired objectives should be stated in a question format. Answering key questions deepens learning and helps learners achieve the desired understanding. Wiggins and McTighe (1998) stated that understanding-driven objectives should begin with one or more of six facets of understanding, i.e., explanation, interpretation, application, perspective, empathy and self-knowledge (see Section 2.3.2). In addition, teachers should prioritise content knowledge so that the most essential and enduring ideas are given more attention.

Stage 2: Determine Acceptable Evidence

At this stage, teachers should present the evidence that was used to determine whether learners have understood the learning content. They should state the forms of assessment that were used to determine that the learners have acquired the knowledge, understanding, and skill to answer questions and their progress should be constantly monitored. Wiggins and McTighe (2003) stated that the following type of assessment tools can be used: tests and quizzes with constructed-response, reflective assessment such as self-evaluation activities, peer response groups, performance tasks and projects to allow learners independent application of knowledge to real-life events.

Stage 3: Plan Learning Experiences and Instruction

In the final stage, teachers need to plan what is to be taught and the sequence of teaching and learning experiences that will equip learners to develop and demonstrate the desired understanding. In planning learning activities, teachers should consider the 'WHERETO' elements, which is an acronym for; **W**here the work is heading; **H**ook learners through engaging and provocative entry points; **E**xplore the subject in depth and equip learners with required knowledge and skills to perform successfully on final tasks; **R**ethink with learners the ideas and answers as learners rehearse and revise; and **E**valuate results and develop action plans through self-assessment of results (Wiggins, & McTighe, 1999, p.5). Stage 3 describes all learning experiences and instructional procedures that enable learners to achieve the curricular goals (Anwaruddin**,** 2013; Wiggins, & McTighe, 2011; Tomlinson & McTighe, 2011).

In this study the ideas from the UbD concept in the above discussed stages, were adopted as a guide for lesson planning. Due to time constraints and minimal availability of learning facilities at the Experimental school, the researcher could not accommodate all the ideas proposed under each stage. However, the lesson plan format comprising all the three stages' sub-headings (Stage 1: Identify Desired Results; Stage 2: Determine Acceptable Evidence and Stage 3: Plan Learning Experiences and Instruction were used (see Appendix I).

The next section looks at facets of understanding, which were used as indicators of understanding. The facets of understanding were used in the pre-test and post-test.

2.4.2 Facets of Understanding

The facets of understanding form a guide to the development of performance tasks in order to determine whether learners have developed understanding of the intended instruction. McTighe (2004) stated that the facets serve as indicators of how understanding is revealed and thus provide guidance as to what kind of assessments is to be used. According to Wiggins and McTighe (1998) the six facets of understanding are:

1. **Explain** - This is what a learner is expected to provide thoroughly and justify accounts of phenomena, facts, and data. The learners should state the learning content in their own words and teach others.

2. **Interpret** - Learners should provide translations, revealing historical or personal dimension to ideas and events; make subjects personal or accessible through images, anecdotes, analogies, and models.

3. **Apply** - Effectively use and adapt what they know in diverse contexts.

4. Demonstrate **perspective** - Recognise different point of view and see the wider picture.

5. **Empathize** - Find value in what others might find odd, alien, or implausible; perceive sensitively on the basis of prior indirect experience.

6. **Self-knowledge** - Perceive personal style, prejudices, projections, and habits of mind that both shape and impede our own understanding; so that learners are aware of what they do not understand and why understanding is so hard.

In this study, the following concepts: Explain, Apply and Perspective were used in lesson planning and designing test questions to promote deep and critical thinking in learners. The next sub-section looks at studies based on ICT-driven Pedagogy.

2.5 Study based on ICT-driven Pedagogy

Wenglinsky (1998) used UbD teaching approach and National Assessment of Educational Progress (NAEP) achievement data to investigate the relationship between the various uses of technology and achievement in Mathematics of U.S Grade 8 learners. In Wenglinsky's (1998) study knowledge and skills were taught in the context of helping learners to achieve the desired understanding and to thoughtfully apply their knowledge to authentic problems. Wenglinsky (1998) found a significant relationship between the NAEP test scores and the use of technology that focused on mathematical projects, problems and simulations that promoted application of knowledge and higher order thinking. He also found that when computers were used for higher-order thinking skills, learners performed better and so suggested that teachers focus on using computers to apply higher order skills learned elsewhere in class. Hence, in this study, ICT tools such as GSP and videos were used to promote higher-order thinking skills, i.e. deeper understanding through the use of visuals and geometrical proofs. Learners were tested on whether they had achieved higher order thinking skills through discussion questions, lesson presentation and using post-test results.

Ogdol and Lapinid (2013) used UbD lesson plan in order to develop learners' mathematical understanding on linear equations in two variables; the study also investigated learners' perceptions of their skills and proficiency before and after the implementation of the UbD lesson plan. UbD lesson plan was validated by eleven professional teachers. The study was carried out in a heterogeneous class of 40 learners in a private laboratory school in Manila. Learners were assessed using written exercises and performance task. The data was analysed using z-statistic. After the implementation of the UbD lesson plan, the researcher found UbD unit plan or the backward curriculum to have led to the development of above 70% learners' mathematical understanding. The researchers also found that UbD positively affected leaners' perceptions which lead to better performance in the subject content. Therefore, Ogdol and Lapinid (2013) recommended the employment of the Understanding by Design framework in teaching Mathematics at all levels of learning. Although, Ogdol and Lapinid's (2013) study did not incorporate technology their study findings assisted in explaining the effectiveness of the UbD approach.

2.6 Effects of GSP on academic performance

The first study conducted in Namibia on Geometry was qualitative in nature, by Mateya (2008) using Van Hiele' Theory in order to analyse geometrical conceptualisation of Grade12 learners. Mateya (2008) found that most of the learners had a weak conceptual understanding of geometric concepts and the majority could competently operate below Level 3 of the Van Hiele Theory. Further, Mateya (2008) recommended that the teaching and learning of Geometry should involve more hands-on activities that would enhance learners' conceptual understanding of geometric concepts. Furthermore, correct spelling and pronunciation of geometrical terms should be used at all times. In addition, Mateya's findings were used to inform the development of the first lesson plan with respect to how the learners understood the geometrical concepts (Appendix I) as required to achieve the basic competencies stated in the syllabus.

Another study was carried out by Idris (2009) on the impact of using Geometers' Sketchpad (GSP) on Malaysian learners' achievement and Van Hiele Geometric thinking. The researcher used GSP and the Van Hiele Theory to describe and identify stages that learners went through as they moved from a holistic perception of geometric shapes to a refined understanding of geometric proof. The study had 32 learners as an Experimental group and 33 as a Control group, and before the intervention, the researchers found no statistically significant difference between the pre-test Geometry performances of the Control and

Experimental group. After intervention, Idris (2009) found a statistically significant difference ($\alpha = 0.05, t = 0.788, \bar{x} = 19.65$ and $p = 0.02$) between post-test Geometry performances of learners who had been taught using GSP and those who were not. Further, in the posttest, the Control group exhibited a mean of 13.08 whilst the Experimental group had a mean of 19.65. Idris (2009) recommended the use of Geometers' Sketchpad as an effective tool in teaching and learning Geometry at secondary school level.

A similar study was conducted by Myers (2009) using GSP and Florida Comprehensive Assessment Test (FCAT) to investigate the effect of technology on Grade 10 learners' achievement in Geometry, interaction with gender and socio-economic status and their Van Hiele levels. Myers' (2009) study found a significant difference between the Control and Experimental groups at the $\alpha = .05$ level of significance, $\rho = .001$. The researcher recommended the use of technology (particularly GSP) since the software enhanced understanding and improved learners' Mathematics test scores.

It must be noted that, the Van Hiele Theory was not used directly in this study, but the findings obtained in the studies described in this section helped in the understanding of the achievement levels of Grade 12 learners. Besides, the significant level of $\alpha = 0.05$, which indicates an improvement in performance using GSP, which was used as a benchmark for the present study.

Although, the main ICT tool used in this study was GSP; YouTube and Khan Academy videos were also used minimally to enhance understanding of Geometrical concepts.

The effects of YouTube and Khan Academy videos are discussed in the next section (2.7).

2.7 Effects of videos on academic performance

Video presentation is a form of technology for visually representing information in order to illustrate concepts (Perry, 2013). It can help learners understand concepts and improve academic achievement. A study conducted at Southeast Ohio by Perry (2013) on the effects of visual media on achievement and attitude on rural secondary school Biology learners, the researcher found that the use of visual media could strengthen understanding, especially of abstract processes that are hard for one to visualise. The concept of using videos in Biology was purposefully borrowed for use in this study to investigate whether the use of videos coupled with GSP in Geometry would have the same effect on learners' performance.

According to studies (Adams, 2010, Pearson, Dorrian, & Litchfield, 2011) carried out with college students on video use, it was found that teaching using videos can improve learners' performance. In a study by Kay and Kletskin (2012) on evaluating the effectiveness of problem-based video podcasts designed to improve Mathematics readiness for first year university students in Canada; the researchers found that students who utilised podcasts found them to be useful and their performance in Mathematics has improved.

Unlike the above studies, a study conducted at a university in Pennsylvania by Gönül and Solano (2013) on innovative teaching found Khan Academy videos to have no significant effect on learners' examination scores. The researchers used online homework and Khan Academy video exercises known as 'skill-sets' on linear equations, numbers and operations, percentages, solving for unknown variables just to mention but a few in order to investigate whether Khan Academy videos contributed positively to performance in exams. The study consisted of 102 undergraduate students and the data was analysed by calculating the mean and standard deviation.

It is worth mentioning that, the above studies were carried out on college students, the findings were applied to secondary level learners with an aim of understanding the effect videos might have on learners' Geometry performance. In this study, videos on Geometry were used during lesson presentation in order to enhance learners' understanding of geometrical proofs and concepts.

The following section discusses the theoretical framework that informed this study in terms of learners' perceptions of ICT-driven pedagogies.

PART B: Literature on Research Question 2 and Research Question 3

2.8 Technology Acceptance Model (TAM)

TAM places emphasis on the behaviour of an individual towards the use of ICT. According to Park (2009), TAM is one of several widely used models and it has shown great potential in explaining and predicting individuals' beliefs toward ICT. It postulates that a user's adoption of the new ICT tools is determined by that user's Intention to Use (ITU) them, which in turn is related to the user's beliefs about them (Chandra, Theng, O'Lwin, & Foo, 2009). TAM is built on two fundamental elements, which are: Perceived Usefulness and Perceived Ease of Use (Al-Adam, Al-Adam, & Smedley, 2013).

Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) signify attitudes and behavioural intention to accept technology. PEOU can be defined as the degree to which an individual believes that using a particular technology would be free of effort, meanwhile PU is defined as the degree to which an individual believes that using a particular technology would enhance his/her performance (Davis, 1989). Consequently, the more an individual perceives the technology as easy to use or useful, the greater the chances he/she is willing to adopt or recommend it be used. Dahawy and Kamel (n.d.) agree that the easier the technological tool was used, the more it was adopted and the more it was being used to communicate information. Individuals are more likely to have a positive attitude on the use of a new technology if they perceive that it is easy to use and it is useful. Figure 2 shows the relationship between elements of TAM.

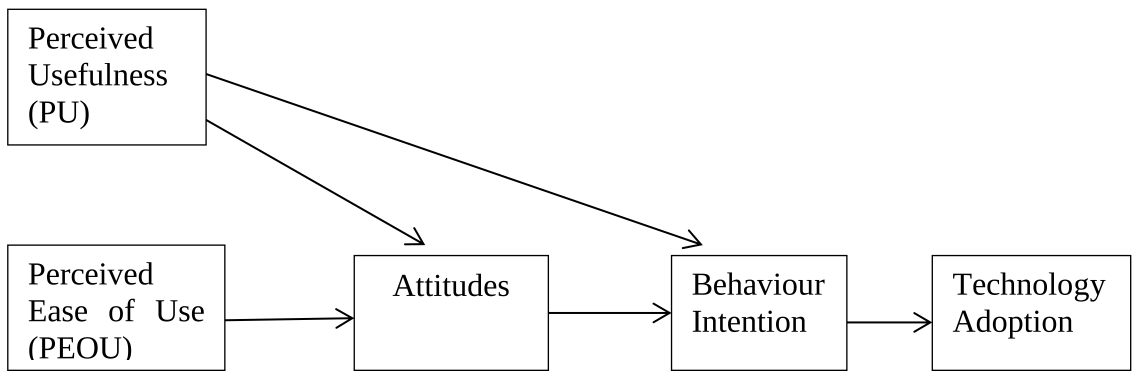

Figure 2: *Technology Acceptance Model (Adopted from Davis, Bagozzir,& Warshaw,1989)*

Figure 2 show that PU and PEOU jointly predict attitudes on using technology adoption. PU also influences the user's Behavioural Intentions (BI). An individual's actual use of technology is influenced directly or indirectly by the user's Behavioural Intentions (BI), Attitude Toward Use (ATU), Perceived Usefulness of the technology and Perceived Ease of technology Use (Park, 2009; Davis, 1989). Furthermore, a higher level of PU results in positive Attitudes Toward Use (ATU) of technology, and PEOU can directly determine Attitudes Toward Use (ATU).

In order to further clarify and heighten understanding of learners' perceptions toward ICT-driven pedagogies and what drives their usage intentions, Cognitive Absorption Theory was used, as discussed as follows:

2.9 Cognitive Absorption

The Cognitive Absorption (CA) is a concept of TAM. CA is a state of deep involvement in an activity with the use of ICT. Raafat and Bahli (2005) noted that CA represents a form of intrinsic motivation which involves three streams, namely: 1) trait of absorption (state of deep attention), 2) Theory of flow (concentration and attitudes), and 3) concept of engagement (intrinsic interest and curiosity).The trait of absorption describes an individuals' state of deep attention, when he/she is totally absorbed with the event being experienced. Csikszentmihalyi (1990) describes the Theory of Flow as a state in which people are so involved in an activity, such as in the lesson or class exercise that nothing else seems to matter. This is characterized by the individual's sense of intense concentration and a feeling of being in complete control of what he/she is doing. The Theory of Flow helps in understanding learners' technology interactions and their perceptions on it. The concept of engagement encompasses the dimensions of intrinsic interest, curiosity, and attention without necessarily feeling that one is in control. When the elements (streams) of CA are positive, learners are likely to have a positive perception toward technology, and this will lead to better performance in schools (Raafat, & Bahli, 2005).

The present study adopted the Theory of Flow, developed by Csikszentmihalyi (1990) in explaining learners' perceptions when engaged in an activity that is appropriately challenging their skill level. This often results in immersion and concentrated focus on a task, in turn producing deep learning and high levels of personal satisfaction. When that happens an individual is likely to have positive perceptions towards ICT. In this state of being, learners are motivated by inherent enjoyment of the challenges provided by the activity and are subsequently more productive and happier. A higher level of flow is capable of conferring value to the online experience, which will positively influence attitudes toward ICT use (Finneran, & Zhang, 2005). This experience could also be true for other ICT tools, such as GSP.

Some studies have used TAM to predict learners' perceptions toward technology adoption and acceptance (Martínez-Torres, Toral, Barrero, Gallardo, Arias, & Torres, 2008; Al-Adam et al., 2013). Some studies were carried out in Africa (Ondiek, 2001; Venter, Van Rensburg, & Davis, 2012), although at universities, where the resources were abundant, they are discussed below to relate how they have enhanced teaching and learning with ICT in Africa and in the world. Some studies discussed were carried out in other subjects area such as English since there is a close relationship between methods of learning in English and Mathematics (Li, &Wang, 2013); and Biology because Mathematics is related to all sciences (National Research Council, 2013). The studies discussed are relevant to Namibia as an African country and ICT infrastructure development is similar; with Namibia being ranked 78th out of 115 countries ahead of Uganda, Nigeria, Mali, Mozambique and

Zimbabwe (Isaacs, 2007). Further, studies on ICT-driven pedagogy and Mathematics in Namibia are non-existent. Some literatures discussed were carried from other parts of the world, especially the developed countries in order to obtain a worldwide view. Section 2.10 discusses TAM based studies.

2.10 TAM based studies

A study by Al-Adam et al. (2013) explored students' factors that impact on the acceptance of e-learning using TAM in Jordanian universities. A questionnaire was distributed to a sample of 107 foreign language students, using regression analysis; the researchers found that PEOU had a significant effect on PU and Attitudes Toward Use (ATU). They also found that PU had a significant effect on Intentions to Use (ITU), hence they concluded that TAM can be employed as a useful theoretical base to predict and understand individuals' intentions to use e-learning. PEOU and PU both influence an individual's perceptions.

In another study, Venter, Van Rensburg and Davis (2012) used TAM in a survey study to examine drivers of Learning Management System (LMS) use in a South African open and distance learning institution. The sample consisted of 213 fourth-year business students and found that high level Perceived Usefulness (PU) and Perceived Ease Of Use (PEOU) contributed to positive usage behaviour (Spearman's rho, $r = 0.720, 0.491 > 0.4$) at $\rho = 0.001$. Venter et al. (2012) also found a slight significant difference between the technology adoption and attitudes toward technology use, implying a high percentage of positive responses on PEOU and PU results in positive behaviour usage.

In a different study, Martínez-Torres et al. (2008) exposed students to web tools in practical and laboratory teaching at a University in Spain. The researchers used TAM to examine the acceptance of web-based e-learning tools used in practical and laboratory teaching and found that successful use of web-based tools depended primarily on a user's behaviour. They concluded that TAM was useful in predicting student intention to use e-learning and PEOU did not posit a significant influence in or intention towards e-learning tool usage.

The three studies discussed above attested TAM as a useful theoretical base to explain and predict learners' perceptions toward technology. In this study TAM was used in order to determine learners' perception levels toward ICT-driven pedagogy. Further, Spearman's rho obtained by Venter et al. (2012) was used as a benchmark to explain learners' PEOU, PU and behaviour intentions on the use of ICT-driven pedagogy.

2.11 Perceptions of learners on ICT-driven pedagogy

Instructions delivered and/or learned through ICT tools are perceived by many authors as significant in improving teaching and learning (Passey, Rogers, Machell, McHugh, &

Allaway, 2003; Hartsell, Herron, Fang, & Rathod, 2010; Banyard, Underwood, Kerlin, & Stiller, 2011). The use of ICT tools in classrooms instils a sense of responsibility in learners, making them realise their role in education and helping them understand difficult concepts. Passey et al. (2003) argued that the use of ICT has a positive impact on the motivational level of learners in school subjects and on learners' perceptions toward subjects and schooling, thus influencing them to perform well in school subjects. In addition, Slouti and Barton (2007) argued that the use of ICT in teaching and learning has a positive impact on learners' perceptions of Mathematics, and it accounts for better performance.

Perceptions are an important aspect in social judgments, behaviours and the decision-making process. They can either be negative, positive or neutral. In a study carried out by Idris (2009) on the impact of using GSP on Malaysian learners' achievement and Van Hiele Geometric thinking, using a 5 point Likert scale; Idris (2009) determined perceptions of learners towards the use of GSP. Most of the learners showed positive perceptions and felt that GSP made them comfortable learning Mathematics.

In another study, by Omollo, Indoshi and Ayere, (2013) on attitudes of learners toward the use of ICT in the implementation of Biology curriculum, calculated the mean, standard deviation and t-test in order to establish the perception levels of learners. A mean score of 3.5 and above was interpreted to denote a positive attitude, between 2.5 and 3.5 neutral and below 2.5 negative. The study found that learners had a positive attitude towards the use of ICT, however no significant difference was found between gender and attitude ($\propto = 0.05, t = -1.138$). Learners' attitudes are one of the determinant factors for the use of ICT approaches in teaching and learning. This study adopted the mean scores (see Section 3.11 under Methodology) obtained in Omollo et al. (2013) in order to categorise learners' perceptions of ICT-driven pedagogy.

Studies on perceptions and gender are discussed in the next section.

2.12 Perceptions on ICT-driven pedagogy and Gender

In a study conducted by Wasike, Michael and Joseph (2013), on the impact of perceptions on performance in Mathematics of female students in secondary schools in Kenya; the researchers found that female students' good performance was due to their positive perceptions. On the contrary, Barkatsas, Kasimatis and Gialamas, (2009) carried out an investigation on students' attitudes toward technology using Multiple Correspondence Analysis and Test Value (Valuer Test) in order to analyse their attitudes toward technology and, their interaction with achievement and gender. The learners were secondary school students from state co-educational schools in Athens, Greece. Barkatsas et al. (2009) found boys to have more positive attitudes (Absolute value, ($|V|$) = -5.13) toward the use of technology in Mathematics than the girls. It was also found that at $\alpha = 0.05$ high achievement in Mathematics was associated with a strong positive attitude to learning it with technology ($|V|$ = 3.68); and low level of Mathematics achievement was associated with a negative attitude to learning Mathematics with technology ($|V| \leq 1.96$).

In another study conducted by Mubeen, Saeed and Arif (2013), correlation coefficient was used in order to determine the attitudes of secondary school boys and girls toward Mathematics and academic achievement in Mathematics. At $\propto = 0.05$, the researchers found statistical significant correlation ($r = 0.32, \rho = 0.1946$) between attitude scores and Mathematics performance of girls meanwhile boys were not significant ($r = 0.13, \rho = 0.1946$). This implies that female learners performed better compared to male learners. Mubeen et al. (2013) also found no statistical significant relationship between attitude towards Mathematics and academic performance and found no significant relationship between gender and academic performance. According to Mubeen et al. (2013), this was because in principle, both females and males produce exactly the same scientific knowledge provided that adequate rigour is undertaken in scientific inquiry.

In a Kenyan study, Ondiek (2010) found a significant relationship between learners' gender and attitude towards Mathematics. The study involved 205 learners selected from various secondary schools within Eldoret Municipality. The study found that 93.7% of the boys had a positive attitude towards Mathematics compared with 59.5% girls. The implication is that, there is a tendency for girls to be negatively inclined towards Mathematics and a likelihood of lower performance of girls in Mathematics in comparison to the boys (Ondiek, 2010). This indicates also how attitudes affect performance.

The information from the studies discussed above was adapted in the construction of the questionnaire in order to investigate learners' perceptions on ICT-driven pedagogy. Further, it was essential for this study to explore the results on whether female or male leaners would perform better after taught using ICT-driven pedagogy.

It was of utmost importance for this study to adopt a conceptual framework that encompassed all the major issues discussed above. The section that follows presents the conceptual framework on which this study was based.

PART C

2.13 Conceptual framework of this study

The study adopted Bruner's (1960) Constructivist Theory, Technology Acceptance Model (TAM) (Davis, 1989) as well as on the Theory of Flow Cognitive Absorption (CA) which is a concept of TAM (Csikszentmihaly, 1990). Constructivist-based learning environments are characterised by problem-solving activities, provision of stimulating learning environments, cooperative learning and the promotion of learning through exploration (Roblyer, Edwards, & Havriluk, 2010). Constructivists believe that knowledge is not transmitted but constructed in an individual's mind by participating in certain experiences. Bruner’s (1960) Constructivist Theory states that learning is an active process in which learners construct new ideas or concepts based upon existing knowledge. According to Bruner (1960), the learning content should be structured in considerable detail that enables learners to easily grasp the information.

UbD teaching approaches was drawn from learning theories that focus on transformational learning (Clayton, 2011). UbD supports authentic tasks and calls for teaching for understanding, with emphasis on problem-based learning and the use of pictorial and symbolic activities. TAM focuses on an individual’s perceived ease of use and perceived use, meanwhile the Theory of flow focuses on the learners’ satisfaction and attitudes as discussed earlier. Therefore, if the level of flow is high and teachers are applying UbD teaching approach which is based on Bruner’s Constructivist Theory ideas, learners might perform better in school subjects.

Bruner’s Constructivist Theory was used to explain the effects of UbD approach to the performance of learners in learning Geometry while TAM and the Theory of flow was used to explain learners’ perceptions toward ICT driven pedagogies.

Figure 3 shows the model of the conceptual framework of this study which was adopted and adapted.

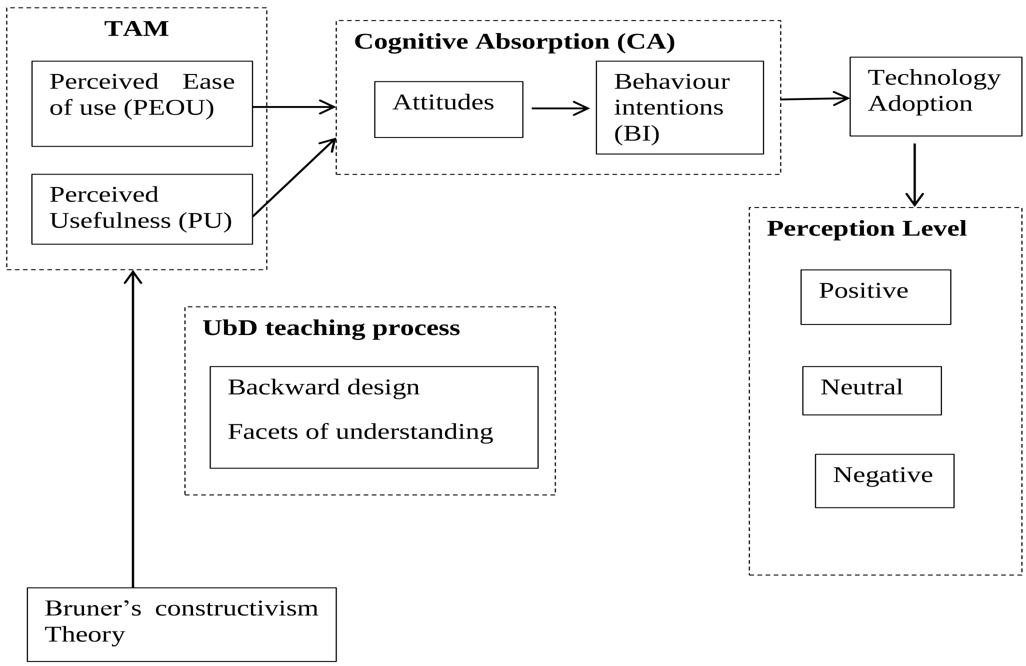

Figure 3: *Conceptual Framework based on TAM and UbD. (Adapted from TAM (Davis, 1989) and UbD (Wiggins, & McTighe, 1998))*

PART D

2.14 Conclusion

This chapter presented the development of the conceptual framework from the literature. The first section (Part A) covered Bruner's Constructivist views on the effects of teaching and learning with technology, followed by UbD teaching approach, UbD Backward design process and facets of understanding which are used as assessment objectives. Part A was concluded with research findings that were carried out on academic performance and ICT driven teaching strategies in other parts of the world. The second section (Part B) looked at the TAM and cognitive absorption that explain learners' perceptions toward ICT adoption in teaching. Part B also discussed learners' perceptions toward GSP and learning. Literature revealed that studies on ICT-driven pedagogy and Mathematics in Namibia are non-existent; in addition literature on UbD is limited in the developing countries. Thus, literatures from other parts of the world were used as a basis to explain effects of ICT-driven pedagogy on the performance and to understand learners' perceptions toward ICT-driven pedagogy in Namibia.

Literature presented shown that the use of GSP incorporated in UbD teaching approach leads to better performance in school Mathematics. In addition, perceptions of learners toward ICT depend on two concepts, i.e., perceived ease of use and perceived usefulness. The next chapter discusses the methodology used to collect data for this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The main focus of this chapter was to describe the methods that were used in the study to collect and analyse the data. First, it discusses the research design and how the research site and study learners were selected. It further explains the instruments, methods used in collecting data from the sample and the pilot study to test the research instruments. The data analysis procedures and research ethics were also discussed.

3.2 Research design

This study used sequential explanatory research design, a mixed research design; using non-equivalent pretest-posttest quasi-experimental designs and a survey. In a nonequivalent pretest-posttest Control group design, intact classrooms were used (Gay, Mills & Airasian, 2009) since the classes were already grouped and were used as they are in the respective existing schools.

3.3 Population

The population of the study comprised Grade 12 learners taking Mathematics NSSC Ordinary level in the Omusati Education region. There are about 15 secondary schools in the Omusati Education region with a total of about 3000 learners enrolled for Mathematics NSSC Ordinary level.

3.4 Sample and sampling procedures

Two schools were purposefully selected on the basis that one had Geometers' Sketchpad software while the other school did not. Cluster random sampling was used to select the sample of participating classes.

At each school, two Grade 12 Mathematics NSSC Ordinary level classes were randomly selected to form a cluster. School A had a computer laboratory and Geometers' Sketchpad (GSP) software. It served as an Experimental Group on the basis that it had GSP software. A cluster at School A consisted of two Experimental classes which were referred to as Group E, with a total of 88 learners, each class had 44 learners.

Meanwhile, School B was a Control group. It had no GSP software and had four classes. Each class had 44 learners, which in total made 176 learners. A cluster at School B consisted of two Control classes, which were referred to as Group C, with a total of 88 learners, each class had 44 learners.

3.5 Research instruments

The following research instruments were used.

3.5.1 Mathematics pre-test and post–test

Pre-test and post-test questions were set up by adapting Mathematics NSSC Ordinary level past question papers on geometrical terms, relationships, angle properties and symmetry. The pre-test and post-test were aimed at testing learners' knowledge and understanding on Geometry topics before and after the intervention respectively. The total marks of each test were twenty-five (25). The questions were categorised based on Geometry topics (geometrical terms, relationships, angle properties and symmetry).

3.5.2 Questionnaire

The questionnaire consisted of two sections. Section A was designed to identify demographic attributes of the respondents, such as gender and age. Section B covered perceptions of learners toward ICT-driven pedagogies. It consisted of four sub-sections, as follows: Perceived ease of use (PEOU), Perceived usefulness (PU), Attitude toward Use (ATU), and Behavioural Intention (BI). All constructs were measured on a five-point Likert-type scales, from 1= *undecided* to 4 = *strongly agree*.

3.6 Instructional material

The Control and Experimental groups were taught separately the same topics of Geometry which were: geometrical terms and relationships, angle properties and symmetry. In the Namibia Senior Secondary Certificate (NSSC) Ordinary level syllabus, the objectives are listed under Geometrical terms and relationships, angle properties and symmetry, as follows (NIED, 2010):

- use and interpret the geometrical terms: point, line, parallel, intersecting, bearing, right angle, acute, obtuse and reflex angles, perpendicular, similarity, congruence
- use and interpret vocabulary of triangles, quadrilaterals, circles, polygons and simple solid figures, including nets

- calculate unknown angles using the following geometrical properties (reasons may be required but no formal proofs):

(a) angles at a point

(b) angles on a straight line and intersecting straight lines

(c) angles formed within parallel lines

(d) angle properties of triangles and quadrilaterals

(e) angle properties of regular polygons

(f) angle in a semi-circle

(g) angle between tangent and radius

(h) angle properties of irregular polygons

(i) angle at the centre of a circle is twice the angle at the circumference

(j) angles in the same segment are equal

(k) angles in opposite segments are supplementary

- recognise line and rotational symmetry (including order of rotational symmetry) in two dimensions
- recognise properties of triangles, quadrilaterals and circles directly related to their symmetries
- use the following symmetry properties of circles:

  - equal chords are equidistant from the centre
  - the perpendicular bisector of a chord passes through the centre of a circle
  - tangents from an external point are equal in length

In addition, Khan Academy and YouTube videos on Geometry were made available.

3.7 Pilot study

The pilot study was designed to gather information on the appropriateness of the research instruments and other administrative logistics prior to the conducting of the main study, in order to improve its quality and efficiency (Lancaster, Dodd, & Williamson, 2004). It helped in refining the instruments in order to ensure that appropriate and relevant information was collected. In addition, piloting helps the researcher to become familiar with the administration of the instruments, the learners and how best to analyse the information obtained (Gay et al., 2009). The pilot study was carried out at School A since it was the only school in the region that had GSP, and on class Z, which was not part of the sample. It would have been too expensive to the researcher to move learners from a different school which is about 20 km from School A to be part of the pilot study. All learners at School A had never been exposed to GSP software. The researcher assumed that these Grade 12 learners had the same characteristics as the learners.

Class Z was randomly picked from the seven Mathematics classes at School A and had 40 learners. A pre-test was administered to them thereafter learners were randomly separated into two groups, i.e., Experimental and Control group. Each group consisted of 20 learners. Both groups were taught the same topic. The Experimental group was taught Geometry topics using ICT driven pedagogy while the Control group was taught using traditional teaching approaches. The post-test was then administered to both groups after the lessons. The questionnaire was then administered to the Experimental group.

The first problem discovered was that the total marks in the post-test, was 5 marks more than the pre- test. Some questions on angle properties were removed so that the two tests would weigh an equal number of marks in the main study. Another problem detected was in the post-test Question 3, testing knowledge on geometrical constructions. This question was removed since the topic on Geometrical constructions was not part of the scope of this study.

3.8 Validity

This study relied on face, content and constructs validity procedures to establish whether the instruments measured what they were supposed to measure (Cohen, Manion, & Morrison, 2011). In order to measure face and content validity of the research instruments, they were assessed by the experts in the research content area at University of Namibia and Namibian secondary schools. The purpose was to avoid unclear questions, vocabulary and sentence structures that might be too difficult, poorly constructed items, improper arrangements of items and ambiguous test items which were inappropriate for the outcomes being measured. Construct validity was assessed by teachers at both Schools A and B, by the Head of Department (HoD) of Mathematics and Science at School A and by Mathematics lecturers at the University of Namibia: Oshakati Campus. According to Gay et al. (2009), having a second evaluator enhances the reliability of the instruments and controls instrumentation as a threat to validity, which reflects the lack of consistency in measuring instruments. Lesson plans (Appendix I) that were used during teaching were given to the HoDs and Mathematics teacher at School A for validation.

3.9 Reliability

The scores from the pilot study were used to test for reliability of the version of TAM constructs in the Namibian context using Cronbach alpha(α). The reliability of learners' questionnaire was determined by the use of Cronbach's alpha formula for internal consistency of the instruments. Cronbach alpha of 0.7 and above ($\alpha \geq 0.7$) was accepted in this study in line with Gay's (1987, p.234) recommended threshold. In this study, alpha formula was selected as the appropriate method because the questionnaire involved a rating of scale with five options.

The results from the pilot study yielded an alpha level of above 0.7 (0.791; 0.772; 0.701; and 0.733) on all TAM constructs, as the coefficient of above 0.7 (0.791; 0.772; 0.701; and 0.733) on all TAM constructs, as the coefficient of reliability of the questionnaire as shown in Table 2**.**

Table 2: Cronbach alpha of TAM constructs

Constructs	Number of items	Cronbach Alpha
Perceived ease of use (PEOU)	6	.791
Perceived usefulness (PU)	6	.772
Attitude toward use (ATU)	3	.701
Behaviour intentions (BI)	4	.733

The alpha values obtained in Table 2, were high enough to consider the instruments as reliable since they were above the recommended threshold of 0.70 (Gay, 1987).

3.10 Data collection procedures

The researcher obtained the class lists of Grade 12 learners' names for each class from the teachers at each school. The two participating classes were randomly selected from the Grade 12 classes. The researcher explained the purpose of the study and let the learners sign the consent form in order to participate in the study. Mathematics pre-test was administered to the two groups the day before the commencement of teaching and the results of the individual learners were recorded for analysis. Teaching was carried out for two weeks on school days during the afternoon, from 14:00 – 15:00 to avoid disruptions of normal teaching schedule of the school. The post-test was conducted immediately after completion of the two weeks of teaching. The teaching process was video-taped. In addition, the questionnaire was administered immediately after the post-test to the Experimental group in order to investigate this group's perception levels towards the use of the ICT-driven pedagogy.

The next section discusses how the data were collected from each class group.

3.11 Understanding the teaching for the two participating class groups

The teaching at School A and B are discussed below to illustrate how the data were collected from each class group. Both schools where the class groups were selected had a computer laboratory and comparable characteristics namely: hostel accommodation for learners, fields of study and teacher-learner ratio.

3.11.1 Intervention using ICT-driven pedagogy: Experimental group

The Experimental group was based at School A and used ICT tools, namely, Khan Academy and *YouTube* videos on Geometry topics and GSP. The experimental group was taught using Understanding by Design (UbD) teaching approach. The introduction to each topic was sequenced in the following order based on the UbD backward design: Second, the researcher gave a copy of the lesson objectives; this informed learners of what was expected from them after the lesson presentation.

Stage 1: Objectives that learners should know by the end of the unit, in measurable terms, were clearly specified in a question format so as to deepen learning and help them achieve the desired understanding. The following facets of understanding were used: explanation, interpretation, application, perspective, empathy and self-knowledge. The ICT-driven pedagogy that was used to deliver the content was stated.

Stage 2: The forms of assessment i.e post-test and class exercises; that were used to determine that the learners had acquired the knowledge, understanding, and skill to answer questions were stated. The activities involved such as investigating geometric objects, proofs and properties to deepen learners' understanding of geometric concepts.

Stage 3: Geometrical objects, proofs, and angle properties were explained using GSP software for 25 minutes. Leaners were also shown Khan Academy videos and YouTube videos on Geometry in order to enhance understanding. The videos lasted for a maximum of 5 minutes. The teacher summed-up by stating the desired understanding required from the presentation.

All the five lessons, each were 40 minutes long. Furthermore, all learners in the Experimental group had access to internet and resources such as quizzes and videos throughout the period of teaching. The classes took place after hours from 14h00 to 15:00 for two weeks.

3.11.2 Traditional teaching method: The Control group

The learners in the Control group were based at School B and taught using traditional modes of teaching such as explanations, demonstrations on the chalkboard, discussions with teacher and using a textbook. The lessons lasted for 40 minutes and the learning objectives were stated prior to each lesson to create levels of expectations for learning. The classes took place at 14:00 to 15:00 for two weeks on school weekdays.

3.12 Data Analysis

The data was analysed using the Statistical Package for Social Sciences (SPSS) software. First, the normality of the test scores was assessed using Shapiro-Wilk test. In order to determine whether the pre-test and post-test scores data were normally distributed before running further statistical tests (Cohen et al., 2011). Intra-group comparisons were made in each group using Paired sample t-test in order to compare the Mathematics pre-test results to the post-test results. Furthermore, Levene's t-test was carried out at a significance level $\propto = .05$ in order to determine if the two groups i.e. the Control and Experimental group have about the same or different amounts of variability (Cohen et al., 2011). Thereafter, a Mann-Whitney U (non-parametric) test was used to test for significance between the Control and Experimental post-test scores since the variance between the two groups was assumed to be unequal (Cohen et al., 2011). Since there were no national standard Grade descriptors for Senior Secondary phase in Namibia, the Omusati Regional level Grade descriptors were used as a benchmark. In this study a score of 50% and above on the post-test was considered as a pass. Meanwhile, below 49% was considered as a fail (Omusati Education Directorate, 2011).

A total of 19 Likert-type items were used to determine learners' perception levels toward ICT-driven pedagogy by calculating the mean scores on the attitudinal scale. To achieve this, numerical scores were assigned to five response options given to each item on the attitude scale in the questionnaire. For positively stated items, the score values were assigned as follows: *Strongly Agree* (SA) = 5, *Agree* (A) = 4, *Undecided* (UD) = 3, *Disagree* (D) = 2 and *Strongly Disagree* (SD) =1. However, for the negatively stated items, the scoring was reversed and scores assigned as follows: SA = 1, A = 2, UD = 3, D = 4 and SD = 5 (Gay et al., 2009). Further, frequency count and percentage were computed for each section of the questionnaire (PE, PEOU, BI and ATU). The responses that indicated *strongly agree* and *agree* were added together to denote that learners had agreed on the particular statement while responses that indicated *strongly disagree* and *disagree* were added to denote that learners had disagreed on the particular statement. The perception levels were categorized as positive, neutral and negative (Gay et al., 2009). In order to establish learners' perception levels, a mean score of 3.5 and above was interpreted to denote a positive attitude, between 2.5 and 3.5 neutral and below 2.5 negative (Omollo et al., 2013).

Further, the Chi- square (x^2) was calculated to determine the significant difference between the statistically generated value and the observed value (Cohen et al., 2011). In this study, Chi-square was used to determine whether there was an association between males and females in the Experimental group and their perception levels and between learners' performance versus their perceptions. In addition, the mean score of the learners' responses was used to perform cross tabulation between gender versus perception levels, and learners' performance versus their perceptions in order to determine whether those who had passed had negative or positive perception towards ICT-driven pedagogy (UbD and ICT tools) and whether they were male or female. Later, bi-variance cross-tabulation was carried out in order to establish the link between gender, perception and performance on the post-test.

3.13 Ethical considerations

First, the researcher obtained ethical clearance from UNAM Research and Publications Office to proceed with the study. Second, the researcher sought permission from the Permanent Secretary of the Ministry of Education, Director of the Omusati Educational Region and two school (School A and School B) principals to conduct the study. Learners participating in the study were informed about the purpose and objectives of the study for them to participate voluntarily. In addition, learners were asked to sign consent forms (Appendix G) since all lessons were video-taped. Moreover, learners' attendance record was kept although they could withdraw at any time without any negative consequences. Furthermore, the names of the learners were not revealed and each participant was assigned a code. They were assured that the information obtained from them would be for research purposes only and would be treated with utmost confidentiality.

CHAPTER 4: PRESENTATION OF RESULTS AND DISCUSSION OF FINDINGS

4.1 Introduction

The chapter presents the results and discussion of the findings of the data collected from the pre-test and post-test and questionnaire in an attempt to answer the research questions. The results section is divided into two parts; Part A, aimed at answering Research Question 1, and Part B aimed at answering Research Question 2 and Research Question 3. The biographical information of learners was presented first, following the presentation of data on the effects of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners. Under Part A, a test for normality and descriptive statistics were carried out, followed by intra-group comparisons of Control and Experimental groups and comparison between the Experimental and Control group.

In Part B, perceptions of learners toward ICT-driven pedagogy are presented. First, TAM constructs were analysed in order to establish learners' technology acceptance before determining their perception levels following an analysis of learners' perception levels. Further, the relationship between gender, perception level and performance was analysed in order to understand the associations between gender, perception levels and performance. The conclusion of this chapter is presented under Section 4.3.

4.2 Presentation of results

This section presents the results of the study.

4.2.1 Biographical information of learners

A sample of 176 learners taking Mathematics at Ordinary level from two schools (School A and School B) in the Omusati Education region, participated in this study. This is shown in Table 3 and Table 4.

School A

Table 3: Gender of learners at School A (Experimental Group, Group E) (N=88)

Gender	Frequency	Percentages (%)
Female	51	58.0
Male	37	42.0
Total	88	100.0

Table 3 above, shows the distribution of learners at School A in terms of gender. School A consisted of two Experimental classes, Group E, with 88 learners. 58% of Group E learners were females and 42% were males.

School B

Table 4: Gender of learners; School B: Control group (Group C) (N=88)

Gender	Frequency	Percentages (%)
Female	48	54.5
Male	40	45.5
Total	88	100.0

Table 4 above indicates that the Control group had a total of 88 learners who participated in the study. Of the total number of learners (88), 54.5% of Group C learners were females. When the total females and males figures from Tables 3 and 4 are combined, most learners in the study were females, with a total percentage of 56% (N = 99) while 44% (N = 77) were males.

PART A

4.2.2 The effects of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners

In order to determine the effects of UbD and GSP on performance of Grade 12 Geometry Ordinary Level learners in the Omusati Education region, two types of tests were administered, i.e. pre-test and a post-test. The learners' scores on the pre-test and post-test for the two groups were recorded for analysis.

The pre-test was conducted in order to determine whether the class groups were at the same level of understanding, so that the degree of change occurring in the post-test of the Experimental group can be attributed to the treatment given (Gay et al., 2009). Test for normality (Section 4.2.2.1) was conducted on the pre-test and post-test scores (Appendix L) to determine if further statistical tests could be conducted.

4.2.2.1 Test for Normality

The normality of the test scores was assessed using the Shapiro-Wilk test, because it has the ability to handle large sample size and is the most powerful normality test (Keskin, 2006) at significance level $\propto = 0.05$ (Cohen et al., 2011). This was done in order to determine whether the pre-test and post-test scores data were normally distributed before running the statistical tests.

The following hypotheses were tested:

H_0: *The test scores are normally distributed.*

H_1: *The test scores are not normally distributed.*

Table 5: Tests of Normality of pre-tests and post-test scores

Data	Group	Total N	Test Statistics	Asymptotic sig (2-sided test)
Pre-test scores	*Control*	88	0.979	0.159
	Experimental	88	0.979	0.002
Post-test scores	*Control*	88	0.988	0.576
	Experimental	88	0.968	0.027

Table 5 shows that, the ρ −values of the Shapiro – Wilk test (ρ = 0.002; 0.027) for the Experimental group's pre-test and post-test scores were less than 0.05, thus the null hypothesis were rejected. This means that the test scores of the Experimental group deviated from a normal distribution.

However, in both cases of the pre-test and post-test scores of the Control group was normally distributed because the ρ-values of the Shapiro - Wilk test ($\rho = 0.159; 0.576$) were greater than 0.05 (ρ> 0.05). Hence, we fail to reject the null hypothesis. Furthermore, the test scores of the Control group were normally distributed while the Experimental group's test scores were not normally distributed.

Parametric tests were carried out for both groups to test for significance since each group sample had more than 15 learners (Kothari &Warner, 2007). All parametric and non-parametric tests were conducted at 95% confidence level. Descriptive statistics was carried out first, as shown in Table 6, 7, 8 and 9.

Table 6: Mean, Standard deviation and other statistics of the pre-test for the Experimental group

	Group	Descriptive		Statistics
Pre-test scores of learners	**Experimental**	Mean		13.78
		95% Confidence Interval for Mean	Lower Bound	13.08
			Upper Bound	14.48
		Variance		10.930
		Std. Deviation		3.306
		Minimum		3
		Maximum		19
		Range		16
		Skewness		-0.776

Table 6 shows that the mean interval of the pre-test scores for the Experimental group lays between 13.08 and 14.48. The pre-test minimum score of the Experimental group was 3, the highest learner scored 19 and the difference (range) between the highest score and lowest score was 16. The pre-test scores for the Experimental group were negatively skewed (-0.776). This implies that the extreme scores were at the lower end of the distribution. Most (62) learners did well on the pre-test and only few (26) scored low marks.

Figure 4 clearly shows a graphical distribution of the test scores of the Experimental group.

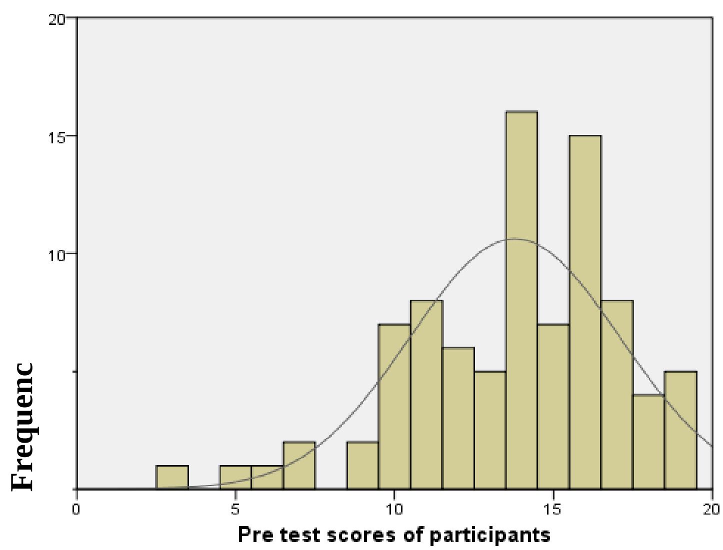

Figure 4: *Experimental group pre-test scores*

The descriptive statistics of the Control group pre-test scores are shown in Table 7.

Table 7: Mean, Standard deviation and other statistics of the pre-test for the Control group

	Group	Descriptive		Statistics
Pre-test scores of participant	**Control**	Mean		13.73
		95% Confidence Interval for Mean	Lower Bound	13.10
			Upper Bound	14.35
		Variance		8.683
		Std. Deviation		2.947
		Minimum		7
		Maximum		22
		Range		15
		Skewness		0.147

Table 7 shows that the Control group's average performance lays between 13.10 and 14.35. The highest score was 22 and the minimum score was 7. The difference (range) between the highest score and lowest was 15. Further, Figure 5 shows that pre-test scores of the Control group were positively skewed (0.147) which means that most (55) of the learners in the Control group scored less than 15 marks out of 25 marks, but a few (33) scored above 20 marks out of the total (25).

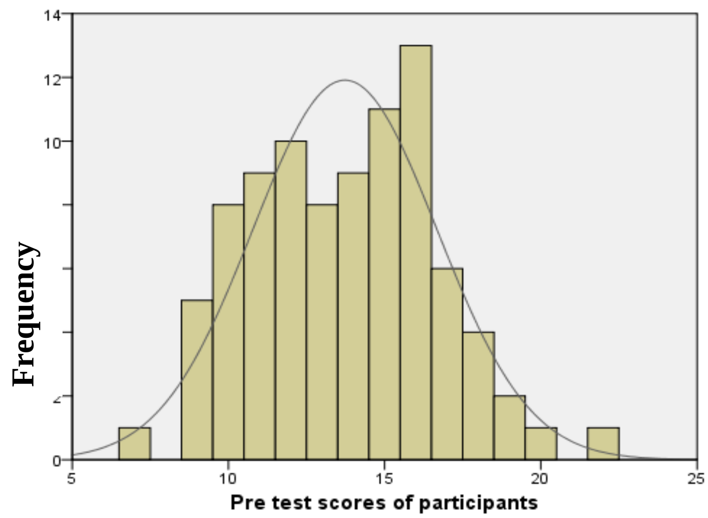

Figure 5: *Control group pre-test scores*

In addition, the pre-test results showed that the standard deviation of the Experimental group of 3.306 was higher than the Control group (2.947). Table 6 and 7 also indicate that there was more variability among the Experimental group (10.930) than among the Control group (8.683). This is because the scores of the Experimental group were unevenly distributed. It is clear from Figure 4 and 5 that there was a higher cluster of scores around 14 and 16.

The tables (Table 8 and Table 9) that follow show the descriptive statistics after the intervention.

Table 8: Mean, Standard deviation and other statistics of the post-test for the Experimental group

	Group	*Descriptive*		*Statistics*
Post-test score of learners	**Experimental**	Mean		15.32
		95% Confidence Interval for Mean	Lower Bound	14.74
			Upper Bound	15.90
		Variance		7.507
		Std. Deviation		2.740
		Minimum		10
		Maximum		21
		Range		11
		Skewness		-0.105

Table 8 shows that the mean interval at 95% confidence level of the post-test scores for the Experimental group lays between 14.74 and 15.90. The minimum score on the post-test of the Experimental group was 10 and the highest score was 21.

However, the mean (15.32) for the Experimental group obtained in this study was less than the mean (19.65) obtained in Idris' (2009) study. The difference in the mean could be attributed to the time factor with respect to data collection. Idris (2009) collected data over ten weeks more than the two weeks for this study. It might also be attributed to the low teacher-learner ratio (1:32), which was less than in the current study (1:44). There might be other contributing factors, such as teaching environment, technological advancement in Malaysia, learners' academic intelligence and level of difficulty of the test items that might have affected the results of this study.

Additionally, the post-test scores for the Experimental group were negatively skewed, as shown in Figure 6, which implies that most learners in the Experimental group had scored high marks on the post-test and only a few scored low marks. This might be because the UbD teaching approach was used together with GSP and to a lesser extent the videos, which according to Wellingsky (1998) have the capability of promoting higher-order thinking skills, i.e., deeper understanding through the use of visuals and geometrical proofs. The hands-on activities that were used during lessons promoted application of knowledge, active participation and involvement of learners in lessons, which might have led to better performance on the post-test.

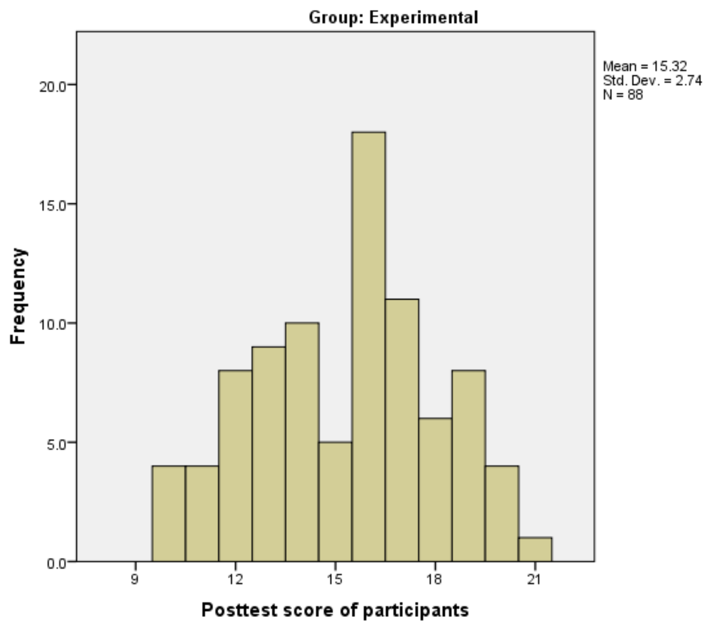

Figure 6: *Experimental group post-test score*

Table 9: Mean, Standard deviation and other statistics of the post-test for the Control group

	Group	*Descriptive*		*Statistics*
Post-test score of learners	**Control**	Mean		13.81
		95% Confidence Interval for Mean	Lower Bound	13.02
			Upper Bound	14.59
		Variance		13.836
		Std. Deviation		3.720
		Minimum		4
		Maximum		23
		Range		19
		Skewness		-0.124

Table 9 shows that the mean interval at 95% confidence level of the post-test scores for the Control group lays between 13.02 and 14.59. The minimum score on the post-test of the Control group was 4 and highest score was 23. However, the mean score (13.81) obtained by the Control group in this study was higher than the mean score of 13 exhibited by the Control group in Idris's (2009) study. The higher mean score in this study's Control group could be attributed to the different test items that were used and different set of learners. It is worth noting that this study was similar to Idris (2009) since both studies used GSP and investigated its effect at $\alpha = 0.05$.

Similar to the post-test scores of the Experimental group, the Control group post-test scores were negatively skewed, as shown in Figure 7, which implies that most learners in this group scored high marks on the post-test and only a few scored low marks.

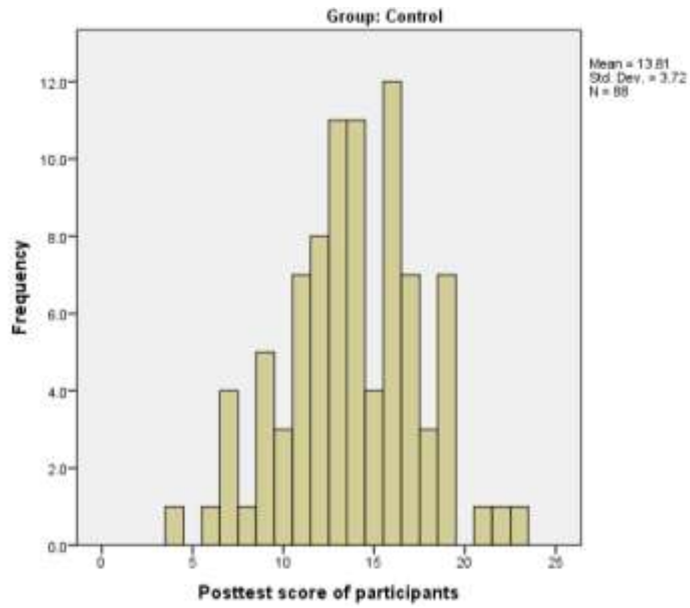

Figure 7: *Control group post-test scores*

Overall, the standard deviation on the post-test of the Experimental group was 2.740, which seems lower than that of the Control group’s 3.720. This showed more variability among the scores of the Control group than among the Experimental group. This might be because most of the Control group learners did not score very high marks. As shown in Figure 7, there was a higher cluster of scores around 13, 14 and 16.

However, it is also worth noting that, the mean score of the Experimental group had increased more after the intervention (from 13.78 to 15.32) than that of the mean of the Control group (from 13.73 to 13.81). The increase in the Experimental group’s performance could be attributed to the intervention in which essential questions that stimulate understanding were asked, assessment was planned and carried out during lessons. As Perry (2013), Myers (2009) and Idris (2009) state, ICT-driven pedagogy has the potential for enhancing learners' conceptual understanding of Geometrical concepts and could improve academic achievement.

4.2.2.2 Intra-group comparisons of Experimental group

This subsection presents the results of the comparison between the pre and post-test scores of the two groups, Experimental and Control group, in order to compare performances of each, before and after the intervention. Primarily, a paired t-test was carried out to compare the pre-test and post-test scores of the Experimental group. Table 10 presents the paired samples t-test results of the Experimental group.

Table 10 : Intra-group comparisons (Paired Samples t-test): Experimental Group

Group		**T**	**Df**	**Sig. (2-tailed)**
Experimental	*Pre-test scores of learners - Post-test score of learners*	-3.837	87	0.000

Table 10 shows that at α = 0.05 and df = 87, the value of $t = -3.837$and the $\rho - value = 0.00$. These results indicate that the mean score of the Experimental group on the Mathematics pre-test and post-test were statistically significantly different. The difference can be attributed to the UbD teaching approach and ICT tools specifically GSP that was used in delivering the Geometry content. This is because, UbD teaching approach incorporated with ICT tools had the potential of strengthening understanding of learners on Geometry topics (geometrical terms and relationships, angle properties and symmetry) and this significantly increased learners' achievement (Ogdol & Lapinid, 2013; Wellingsky, 1998; Myers, 2009).

4.2.2.3 Intra-group comparison of the Control group

This sub-section presents the results of a paired t-test that was carried out to compare the pre-test and post-test scores of the Control group (See Table 11).

Table 11: Intra-group comparisons (Paired Samples Test): Control group

Group		**T**	**Df**	**Sig. (2-tailed)**
Control	*Pre-test scores of learners – Post-test score of learners*	-0.184	87	0.854

Table 11 shows that at 95% confidence interval ($\propto = 0.05$) and $df = 87$, the value of $t = -0.184$ and ρ −value was = 0.854. The $\rho - value > \propto$ (0.05), this shows that there was no statistical significant difference between the Control groups' pre-test scores and post-test scores. Although, there was a difference in the means between the pre-test ($\bar{x} = 13.73$) and post-test ($\bar{x} = 13.81$) as noted on the descriptive statistics (Tables 7 and 9), the difference was statistically insignificant. Consequently, this implies that the traditional teaching method employed to teach Geometry topics (geometrical terms and relationships, angle properties and symmetry) at School B, seemed not to have made a significant difference to the performance of learners at that school.

Based on the findings under Sections 4.2.2.1 and 4.2.2.2 it was apparent that ICT-driven pedagogy, specifically UbD and GSP software, might have contributed to the significant difference attained. The outcome supports the study conducted by Myers (2009) who used GSP to investigate the effect of technology on Grade 10 learners' achievement in Geometry, interaction with gender and socioeconomic status and their Van Hiele levels. Furthermore, the findings of this study coincided with those of Idris (2009), who looked at the impact of using Geometers' Sketchpad (GSP) on Malaysian learners' achievement and Van Hiele Geometric thinking.This study did not use Van Hiele Theory but used the results of the two studies to measure the impact achieved in the current study.

On the one hand, both studies (Myers, 2009 and Idris, 2009) used GSP with an extension of Van Hiele Theory to categorise the impact levels. On the other hand, the current study used GSP and UbD as a teaching approach to enhance content delivery, and yet delivered significant results. Further, the findings concur with Wellingsky (1998) that the use of UbD together with ICT tools in teaching and assessment lead to better performance. Furthermore, the findings of this study concur with those of Ogdol and Lapinid (2013) who found that using the UbD backward approach can enhance up to above 70% learners' Mathematical understanding. The present study and that of Wellingsky (1998) found ICT tools with UbD to have a positive effect on performance.

It is apparent from the findings, that GSP and videos fused with UbD can boost understanding of Geometrical concepts, since they assisted with explaining Geometrical shapes and concepts that were difficult for the learners to visualise in their minds.

4.2.2.4 Comparison of pre-test and post-test scores between the Experimental and Control groups

This sub-section presents a comparison between the Experimental group and Control group test scores. The Experimental group and Control group pre-test scores were compared in order to determine if the two groups of learners were comparable in ability before the intervention. Levene's t-test was used to determine if they had about the same or different amounts of variability between scores (Cohen et al., 2011). The table below presents Levene's t-test and t-test for Equality of Means calculations carried on the pre-test scores:

Table 12: Independent Samples Test of the pre-test for the Control and Experimental group

Type of test		**Levene's Test for Equality of Variances**	**t-test for Equality of Means**		
		Sig.	*T*	*Df*	*Sig. (2-tailed)*
Pre-test scores of learners	*Equal variances assumed*	.620	.120	174	.904
	Equal variances not assumed		.120	171.747	.904

Table 12 shows that the t-test for the pre-test on Geometry topics with the degree of freedom, $df = 174$, ρ-value = 0.620 for Levene's test is greater than $\propto = 0.05$, which indicates that equal variances is assumed. The ρ (sig. (2 tailed)) = 0.904 > 0.05; thus at 95% confidence level implies that there was no significant difference in the mean performance of the Experimental pre-test and Control group pre-test. Thus, the Control group and Experimental group could be said to have been equivalent at the beginning of the intervention. Therefore, the two groups of learners were comparable in ability. Consequently, the degree of change occurring in the post-test results of the treatment group would be attributed to the treatment (Gay et al., 2009; Cohen et al., 2011). This implies that the change in the Experimental Group's scores might be is due to ICT tools and UbD teaching approach.

In addition, in order to determine whether a significant difference existed between the scores of the Control and Experimental group, the following hypothesis was tested:

$\boldsymbol{H_0}$: *There is no significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods.*

$(H_0 : \mu_{Control} = \mu_{Experimental})$.

$\boldsymbol{H_1}$*: There is a significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods.*

$(H_1 : \mu_{Control} \neq \mu_{Experimental})$.

Table 13 presents the Levene's t-test and t-test for Equality of Means calculation for the post-test scores.

Table 13: Independent Samples Test of the post-test for the Control and Experimental group

Type of test		**Levene's Test for Equality of Variances**	**t-test for Equality of Means**		
		Sig.	*T*	*Df*	*Sig. (2-tailed)*
Post-test score of learners	*Equal variances assumed*	.027	3.069	174	.002
	Equal variances not assumed		3.069	159.936	.003

The t-test for the post-test on Geometry topics with the degree of freedom, $df = 174$, ρ-value = 0.027 for Levene's test is less than $\propto = 0.05$. This indicates that the variances are unequal in both groups. Since equal variance was not assumed, a Mann-Whitney U (non-parametric) test was used to test for significance. Table 14 shows the statistics.

Table 14: Independent-Samples Mann-Whitney U test of the post-test for the Experimental group

Total N	*Test Statistic*	*Asymptotic sig.(2-sided test)*
176	2 914.500	0.004

Now, since the ρ -value = $0.004 < 0.05$, the null hypothesis was rejected. Therefore, at 95% confidence level there was a significant difference in the Geometry topics post-test performance of the Experimental and Control group.

The findings of this study support Idris (2009) and Myers (2009) in that the use of GSP as a teaching tool lead to better performance of learners in Geometry. GSP and videos acted as visual teaching aid that assisted with simplifying explanations of nonfigurative geometrical concepts and proofs of geometrical properties. The results concur with Ogdol and Lapinid (2013) that the use of UbD unit lesson plan contributes to better understanding in Mathematics. The results were also consistent with those of Wenglinsky (1998), who looked at the impact of UbD and technology on the learners' performance in Mathematics. Wenglinsky (1998) did not use GSP nor focus on Geometry but his study used computers and UbD as a teaching approach in order to enhance learners' performance in Mathematics. However, this study used technology, GSP and UbD, to enhance the teaching of Geometry (branch of Mathematics). Wenglinsky (1998) reported that the use of technology and UbD ideas in teaching

Mathematics has a significant effect on learners' performance, because it allows learners to be active learners during lessons. Further, UbD teaching approach allows practical application of Geometry which instils motivation in learners as they would know the reason why a certain concept is introduced to them (McTighe, & Wiggins, 2012).

Significant difference in performance between the Experimental group and the Control group might be attributed to the use of ICT-driven pedagogy which Bruner's (1960) Constructivism Theory advocated in the three stages of intellectual development. Bruner (1960) argues that instruction in the use of three modes of representation, i.e., concrete, pictorial and symbolic, leads to more effective learning and good performances in subjects. In this study, pictures and symbols were used to explain Geometrical terms, symmetry and angle properties. Further, the findings of this study support those of the study conducted by Perry (2013) on the effects of visual media on achievement of Biology learners. Perry (2013) found that the use of visual media can strengthen understanding since it simplifies abstract concepts and this improves learners' academic achievement. The concept of using videos in Biology was purposefully borrowed to be used in this study to investigate whether the use of videos coupled with GSP in Geometry would have the same effect on learners' performance. The videos lasted for a less than 5 minutes. Further, this study's findings correspond to with those of Pearson and Litchfield (2011), Adams (2010) and Kay and Kletskin (2012) and showed, that videos can improve learners' performance in Mathematics. However, the findings of this study do not support the study conducted by Gönül and Solano (2013) that used Khan

Academy videos for a semester to investigate its effect on Business courses learners' academic performance. Though the latter was not conducted on Geometry it did use Khan Academy videos.

The results of this study suggest a positive effect of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners compared to traditional teaching methods.

PART B

4.2.3 Perceptions of learners toward ICT-driven pedagogy

In addition, to the examination of effects of ICT-driven pedagogy on Geometry learners' performance, this study sought to find out the perception levels of the Experimental group toward ICT-driven pedagogy. A five point Likert scale questionnaire was used to measure the Experimental group's perceptions after the intervention. The Experimental group consisted of 88 learners, but only 82% (72) of the Experimental group responded on the PEOU and PU statements questionnaire, since some of the learners dropped after the treatment. Further, only 63% (55) of the learners in the Experimental group answered the ATU and BI statements. Some of the learners in the Experimental group were disqualified since they did not answer all the questions and some had more than one response to one statement.

4.2.3.1 Analysis of TAM constructs

Learners' perceptions were measured based on their responses on the four TAM constructs, Perceived ease of use (PEOU), Perceived usefulness (PU), Attitudes toward use (ATU) and Behaviour intentions (BI). TAM constructs were analysed in order to establish learners' technology acceptance before determining their perception levels. The total number of learners having the same opinions on the same item was calculated as a percentage of the total sample. The responses that indicated *strongly agree (5)* and *agree (4)* were added together to denote that learners had agreed on the particular statement and, the responses that indicated dis*agree (3)* and *strongly disagree (2)* were added together to denote that learners had disagreed on the particular statement. The results of these constructs are presented in the same order. Table 15, 16, 17 and 18 presents the analysis of each TAM construct.

Table 15 presents the frequency and percentages of learners' responses on PEOU.

Table 15: Perceived ease of use (PEOU)

TAM constructs	Strongly agree (SA)		Agree (A)		Total (SA +A)		Disagree (D)		Strongly Disagree (SD)		Total (SD+D)		Un-decided		Total Learners	
	F	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***
ICT-driven pedagogy is learner friendly.	32	44.4	32	44.4	**64**	**88.8**	4	5.6	0	0	**4**	**5.6**	4	5.6	72	100
My interaction with GSP and other ICT tools (videos and internet) is clear and understandable.	30	41.7	36	50	**66**	**91.7**	6	8.3	0	0	**6**	**8.3**	0	0	72	100
Learning to use GSP and other ICT tools would be easy for me.	35	48.6	31	43.1	**66**	**91.7**	4	5.6	0	0	**4**	**5.6**	2	2.8	72	100
I think it would be easy to be become skilful at using GSP and other ICT tools.	41	56.9	26	36.1	**67**	**93**	5	6.9	0	0	**5**	**6.9**	0	0	72	100
I find that the process of teaching and learning using ICT driven pedagogy was clear, understandable and straightforward.	40	55.6	25	34.7	**65**	**90.3**	5	6.9	0	0	**5**	**6.9**	2	2.8	72	100
ICT tools are difficult to use	2	2.8	27	37.5	**29**	**40.3**	36	50	6	8.3	**42**	**58.3**	1	1.4	72	100

(F = frequency)

Table 15 shows that, 88.8% of learners believed ICT-driven pedagogy was learner friendly. The majority (91.7%) expressed the view that their interaction with GSP and other ICT tools (videos and internet) was clear and understandable. The majority (91.7%) also stated that learning to use GSP and other ICT tools would be easy for them. The highest percentage of learners (93%) indicated that it would be easy to become skilful at using GSP and other ICT tools, whilst 90.3% felt that the process of teaching and learning using ICT driven pedagogy was clear, understandable and straightforward. In addition, half (58.3%) of the learners disagreed that ICT tools were difficult to use.

Table 16 presents the frequency and percentages of learners’ responses on PU.

Table 16: Perceived usefulness (PU)

TAM constructs	Strongly agree		Agree		Total (SA+A)		Disagree		Strongly Disagree		Total (D+SD)		Un-decided		Total learners	
	F	%	*F*	%	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*
ICT-driven pedagogy helped me in understanding the topic better.	36	50	32	44.4	**68**	**94.4**	2	2.8	1	1.4	**3**	**4.2**	1	1.4	72	100
ICT-driven pedagogy helped me visualize.	15	20.8	43	59.7	**58**	**80.5**	9	12.5	2	2.8	**11**	**15.3**	3	4.2	72	100
ICT-driven pedagogy makes me comfortable learning Geometry.	48	66.7	20	27.8	**68**	**94.4**	2	2.8	1	1.4	**3**	**4.2**	1	1.4	72	100
ICT-driven pedagogy would help me improve my performance in Geometry.	45	62.5	23	31.9	**68**	**94.4**	1	1.4	1	1.4	**2**	**2.8**	2	2.8	72	100
ICT-driven pedagogy would make it easier for me to do my home works and study for my tests and examinations.	36	50	31	43.1	**67**	**93.1**	4	5.6	0	0	**4**	**5.6**	1	1.4	72	100
I think ICT-driven pedagogy should be part of each and every subject in schools.	36	51.4	27	38.6	**63**	**90**	4	5.7	3	4.3	**7**	**10**	0	0	70	100

(F = frequency)

Table 16 indicates that on the overall scale more than half of the Experimental group agreed on all PU statements. Less than 15% of learners disagreed on the PU statements. On all the PU statements, less than 4.5% of the learners were undecided. A highest percentage (94.4%) agreed that ICT-driven pedagogy helped them in understanding Geometry topic better. An equal percentage of 94.4% of learners expressed that ICT-driven pedagogy made them comfortable learning Geometry and ICT-driven pedagogy had helped them improve their performance in Geometry. Furthermore, 80.5% of learners indicated that ICT-driven pedagogy helped them to visualize, whilst 93.1% indicated that ICT-driven pedagogy would make it easier for them to do their homework and study for tests and examinations. Ninety percent (90%) indicated that ICT-driven pedagogy should be made part of every subject in schools.

It was clear from these analyses that learners, perceived ICT-driven pedagogy to be useful.

The following table (Table 17) presents the frequency and percentages of learners' responses on ATU.

Table 17: Attitude toward use of ICT-driven pedagogy (ATU)

TAM constructs	Strongly agree		Agree		Total (SA+A)		Dis-agree		Strongly Disagree		Total(D+SD)		Un-decided		Total Learners	
	F	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*
I believe it is a good idea to use ICT-driven pedagogy in teaching and learning.	35	66.1	18	33.9	**53**	**100**	0	0	0	0	**0**	**0**	0	0	53	100
I think fully ICT-driven pedagogy when introduced would improve teaching and learning Geometry.	27	49.1	24	43.6	**51**	**92.7**	2	3.6	1	1.8	**3**	**5.4**	1	1.8	55	100
I think fully ICT-driven pedagogy when introduced would improve learners' performance Geometry.	29	52.7	23	41.8	**52**	**94.5**	1	1.8	0	0	**1**	**1.8**	2	3.6	55	100

(F = frequency)

Table 17 shows that all the learners (100%) felt that it was a good idea to use ICT-driven pedagogy in teaching and learning; whilst 92.7% felt that when ICT-driven pedagogy was to be fully introduced it would improve teaching-learning Geometry. Meanwhile, 94.5% of the learners indicated that it would improve performance in Geometry. It is evident from Table 17 that on all ATU statements a maximum of 3.6% learners were undecided, and this was noted on the statement '*... ICT-driven pedagogy would improve learners' performance in Geometry when introduced'*. It can be deduced that most of the learners were sure ICT-driven pedagogy would improve their performance in Geometry. Consequently, based on the findings in Table 17, the researcher concludes that the majority of the learners had positive attitudes toward using ICT-driven pedagogy.

The next table (Table 18) presents the frequency and percentages of learners' responses on BI.

Table 18: Behaviour Intentions (BI)

TAM constructs	Strongly agree		Agree		Total (SA+A)		Dis-agree		Strongly Disagree		Total (D+SD)		Un-decided		Total	
	F	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***	***F***	***%***
I intend to tell and show others about ICT-driven pedagogy.	13	23.6	32	58.2	**45**	**81.8**	5	9.1	1	1.8	**6**	**10.9**	4	7.3	55	100
I will prefer full use of ICT-driven pedagogy over traditional modes of teaching.	15	27.3	23	41.8	**38**	**69.1**	9	16.4	2	3.6	**11**	**20**	6	10.9	55	100
I will prefer teaching and learning through a combination of ICT-driven pedagogy and traditional modes of teaching.	18	33.3	26	48.1	**44**	**81.4**	6	11.1	2	3.7	**8**	**14.8**	2	3.7	54	100
I think schools should teach only using ICT-driven pedagogy.	17	31.5	15	27.8	**32**	**59.3**	15	27.8	4	7.4	**19**	**35.2**	3	5.6	54	100

(F = frequency)

On Behaviour Intentions, Table 18 shows that, more than 59% of learners agreed on all BI statements. The highest percentage of learners (81.8%) expressed that they would tell and show others about ICT-driven pedagogy. Meanwhile, 69.1% of learners would prefer full use of ICT-driven pedagogy over traditional modes of teaching. Above 80% (81.4%) of learners preferred teaching and learning through a combination of ICT-driven pedagogy and traditional modes of teaching. However, highest percentage (35.2%) of learners to disagree on BI construct, disagreed on the statement '*I think schools should teach only using ICT-driven pedagogy*', which was less than half of the learners. It is evident from Table 18 that learners, vouch for ICT-driven pedagogy to be adopted in schools.

Based on the TAM constructs analysis, it was evident that learners possessed positive attitudes toward use (ATU) of ICT-driven pedagogy, since they perceived ICT-driven pedagogy as easy to use (PEOU) and useful (PU). They also displayed positive behaviour intentions (BI) toward the adoption of ICT-driven pedagogy. The findings of this study core similar to those of Venter et al.'s (2012) in that perceived usefulness (PU) and perceived ease of use (PEOU) contribute to positive attitudes toward usage (ATU). This study's findings also support Al-Adam et al. (2013), in that PEOU and PU both seem to have an influence on individual's BI towards technology usage.

Positive behaviour intentions might arise because most (91.7%) (Table15) of the learners indicated that their interaction with ICT-driven pedagogy were clear and understandable, and the majority (90.3%) (Table 15) pointed out that the process of teaching and learning using ICT driven pedagogy was clear, understandable and straightforward. Many believed that their performance in Geometry would improve; hence, 69.1% (Table 18) preferred full use of ICT-driven pedagogy over traditional modes of teaching. Therefore, this study concludes that learners possess positive perception toward ICT-driven pedagogy which can be attributed to their perceiving of

ICT-driven pedagogy as useful and easy to use, which in turn enhanced their performance.

4.2.3.2 Learners' perception levels

This sub-section presents an analysis of the Experimental group's perception level towards ICT-driven pedagogy in the teaching of Geometry to Grade 12 learners. As indicated earlier (Section 4.2.3) a total of 72 learners (82%) answered 19 Likert-type items. The outcomes are presented in Table 19.

Table 19: Crosstab of Gender versus Perception level

Gender of Learners		Perception levels of learners			Total
		Positive (mean score ≥ 3.5)	*Negative (mean score <2.5)*	*Neutral (2.5≤ mean score <3.5)*	
Female	Count	31	1	7	39
	Perception levels of learners% within Gender of learners	79.5%	2.6%	17.9%	100.0%
	% within	60.8%	25.0%	41.2%	54.2%
	% of Total	43.1%	1.4%	9.7%	54.2%
Male	Count	20	3	10	33
	levels of learners% within Gender of learners	60.6%	9.1%	30.3%	100.0 %
	% within Perception	39.2%	75.0%	58.8%	45.8%
	% of Total	43.1%	4.2%	13.9%	45.8%
Total	Count	51	4	17	72
	% within Gender of learners	70.8%	5.6%	23.6%	100.0 %
	% within Perception levels of learners	100.0%	100.0%	100.0%	100.0 %
	% of Total	70.8%	5.6%	23.6%	100.0 %

Table 19 indicates that 79.5% of the females had a mean score of 3.5, which was categorised as a positive perception level. Less than 3% (2.6%) of the females had a negative perception level (mean score less than 2.5), while, 17.9% of the females were neutral (mean score less than 3.5 and less than or equal to 2.5). Further, Table 19 shows that above 60% (60.6%) of the male respondents had a positive perception level. Only 9.1% and 30.3% had a negative perception level and neutral respectively. Three times more males (4.2%) than females (1.4%) had a negative perception level and 4.2% more males (13.9%) than females (9.7%) had neutral perceptions toward ICT-driven pedagogy.

The findings of this study coincide with the research findings by Wasike et al. (2013), who found more female learners to have had a positive perception and perform well in Mathematics. This was because more females perceived an ICT-driven approach as useful. Although, Wasike et al. (2013) focus was not on a specific branch of Mathematics and did involve ICT, this study is similar to theirs since it partly looked at perceptions and performance in Mathematics. However, this study's findings do not support those of Barkatsas et al. (2009) and Omollo et al. (2009) which found more males to have positive perceptions compared to females which were attributed to a higher number of male learners in the study.

On an overall scale, this study found a total of 70.8% (Table 19) learners (males and females) had positive perception level of ICT-driven pedagogy, with 5.6% of learners possessing a negative perception level and 23.6% a neutral one. The findings of this study support research findings by Omollo et al. (2013), that learners have a positive attitude ($\bar{x} = 3.6110$) towards the use of ICT implementation in a Biology curriculum since the use of ICT with videos boost their interest. This study's findings also similar to those of Idris (2009), in that most of the learners showed positive perceptions towards the use of GSP compared to those with negative perceptions. Idris (2009) analysed learners' perceptions toward technology adoption at $\propto = 0.05$ and found a minimum mean ($\bar{x}$) of 4.01. This study found most (70.8%) of the learners showed positive perceptions towards the use of GSP compared to those with negative perception toward UbD at $\alpha = 0.05$.

Figure 8 clearly shows that the modal class were females with a positive perception level, with a mean score of greater than 3.5. More males had negative perceptions than females.

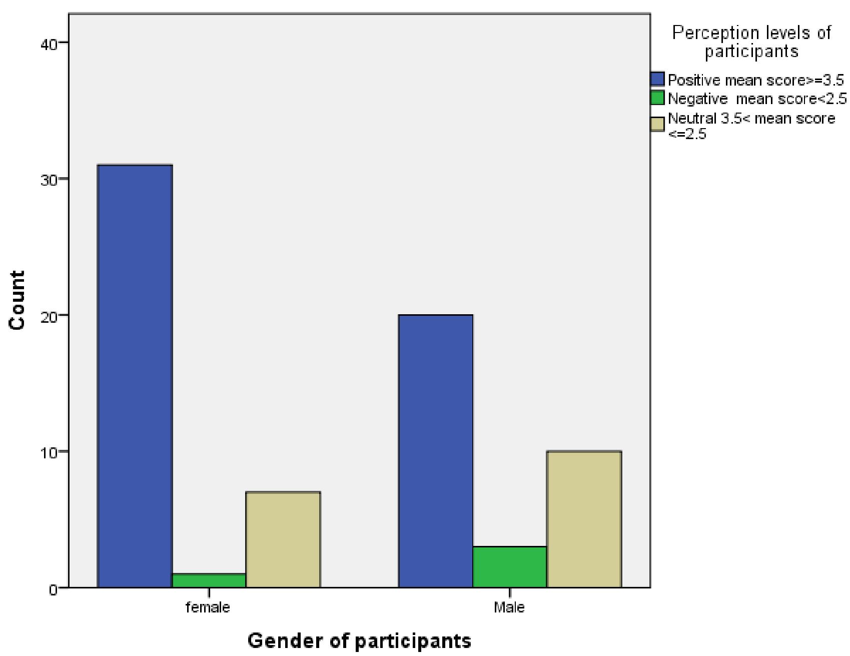

Figure 8: *Frequency counts of Gender versus perception levels*

The next section looks at the relationship between gender and learners' perception levels.

4.2.3.3 Relationship between gender and perception levels

This sub-section presents a Chi-square test on the relationship between males and females of the Experimental group and their perception level.

Table 20: Chi-Square Test of gender vs perception level

Null Hypothesis: *There is no association between gender and perception level*			
Test statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.426	2	.180

Table 20 shows Chi-square (x^2) = 3.426 and ρ = 0.180. Since $\rho = 0.180 > \alpha = 0.05$, it implies that the null hypothesis of Chi-square can be rejected at 95% level of significance, which means that there was a very weak association between gender and perception level. Therefore, both males and females can have either a positive, negative or neutral perception level toward ICT-driven pedagogy.

However, the findings of this study (with reference to Table 20) do not support research findings obtained by Omollo et al. (2013), who found no significant difference ($t = -1.138,$ with the association $\rho - \text{value} = 0.0001)$ between gender and attitude, which was due to PEOU and PU of ICT in Biology.

4.2.3.4 Relationship between performance and perception levels

This subsection presents Chi-square calculation and a cross-tabulation in order to determine whether there was an association between the performance and perception level of learners. This was done in order to determine whether the Experimental learners that have passed or failed the post-test had a negative ($\bar{x} < 2.5$), positive ($\bar{x} \geq 3.5$) or neutral perception ($2.5 \leq \bar{x} < 3.5$) towards ICT-driven pedagogy. It should be noted that due to lack of the National standard Grade descriptors, a regional level Grade descriptor was used to determine the assessment categories (pass and/ fail). Table 21 shows the cross tabulation of perception levels against performance ruling of learners on the post-test.

Table 21: Perception levels of learners versus Performance ruling on the post- test Cross-tabulation

Perception levels of learners		**Performance Ruling on the post test**		**Total**
		Pass	*Fail*	
Positive (mean score ≥ 3.5)	Count	31	20	51
	% within Perception levels of learners	60.8%	39.2%	100.0%
	% within Performance Ruling on the post test	67.4	76.9%	70.8%
	% of Total	43.1%	27.8%	70.8%
Negative (mean score < 2.5)	Count	3	1	4
	% within Perception levels of learners	75.0%	25.0%	100.0%
	% within Performance Ruling on the post test	6.5%	3.8%	5.6%
	% of Total	4.2%	1.4%	5.6%
Neutral (2.5 ≤ mean score <3.5)	Count	12	5	17
	% within Perception levels of learners	70.6%	29.4%	100.0%
	% within Performance Ruling on the post test	26.1%	19.2%	23.6%
	% of Total	16.7%	6.9%	23.6%
Total	Count	46	26	72
	% within Perception levels of learners	63.9%	36.1%	100.0%
	% within Performance Ruling on the post test	100.0%	100.0 %	100.0%
	% of Total	63.9%	36.1%	100.0%

Table 21 indicates a total of 63.9% of the learners passed the post-test and 36.1% failed. Of the total, 70.8% of learners had a positive perception of ICT-driven pedagogy. About 43.1% of learners had a positive perception and performed well on the post-test. However, 27.8% of the learners possessed a positive perception but failed the post-test. In addition, 4.2% of the learners had a negative perception but passed the post-test, and 1.4% of the learners had negative perception and failed the post-test. Furthermore, of those with neutral perception, 16.7% and 6.9% of the learners passed and failed the post-test respectively.

In addition, Table 21 indicates the modal category is ‘pass’ with a positive perception level (43.1 %) and the lowest category is ‘fail’ with negative perception (1.4 %). Generally, most of the respondents had a positive perception toward ICT-driven pedagogy. Figure 9 clearly shows a graphical presentation of the frequency counts of perception against performance ruling (pass or fail).

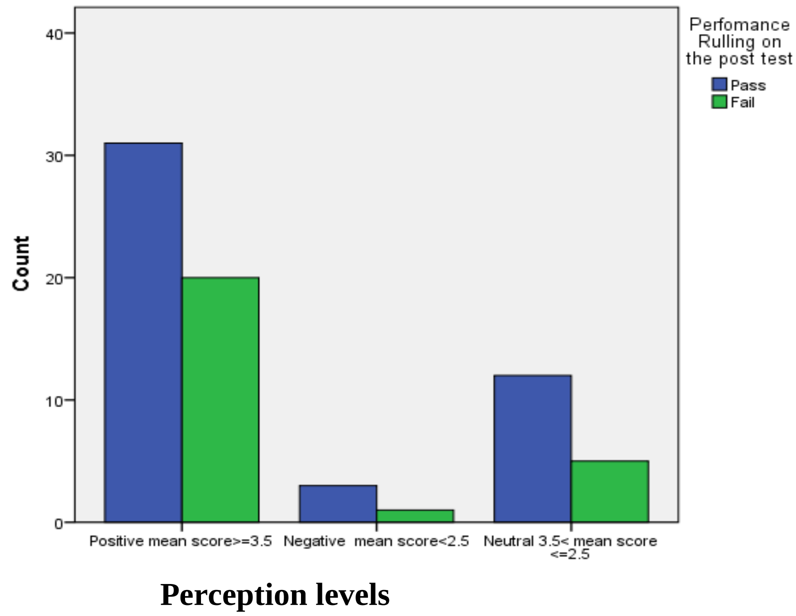

Figure 9: *Frequency counts of performance ruling against perception level*.

In addition, a Chi-square test (Table 22) was carried out in order to determine whether there was a relationship between performance ruling of the experimental group and their perception level.

Table 22: Chi-Square Test of performance versus perception level

Null Hypothesis: *There is no association between performance and perception level*			
Test statistic	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.758	2	0.685

Table 22, shows that Chi-square = 0.758, ρ = 0.685. This implies that there was an association between the performance level and perception level at 95% level of significance. Meaning that, those learners who passed the post-test had a positive perception and those who failed had negative perception level toward ICT-driven pedagogy.

A strong association between performance and perception level could imply that there was a relationship between achievement in Geometry topics and each of the five components of TAM. In general, the majority (70.8%, see Table 19 or 21) of the Experimental group in this study showed a positive perception level towards ICT-driven pedagogy even though only 63.9% passed the post-test.

The findings of this study support those by Slouti and Barton (2007) that the use of ICT in teaching and learning had a positive impact on learners' perceptions and it accounts for better performance in Mathematics. Learners' positive perception in this study could be attributed to the comfort learners felt when learning Geometry topics that were taught using ICT-driven pedagogy. It might also be attributed to the process of teaching and learning using ICT driven pedagogy being understandable and straightforward. Thus, learners believed that ICT-driven pedagogy would help them in understanding the topic better and improve their performance in Geometry.

4.2.3.5 Relationship between Gender, Performance and Perception levels

The relationship between gender, performance and perception levels were analysed under this sub-section. Spearman's rho was used since it measures correlation when the data for at least one variable is expressed as rank or ordinal (Gay et al., 2009). In this study, Spearman rho was used to determine the relationship between gender, performance and perception levels (Table 23).

Table 23: Bi-variance correlation analysis between gender, performance and perception level

		Statistics	**Perception level of learners**	**Performance Ruling on the post test**	**Gender of learners**
Spearman's rho	*Perception level of learners*	Correlation Coefficient	1.000	0.560	-0.034
		Sig. (2-tailed)	0.000	0.001	0.120
		N	72	72	72
	Performance Ruling on the post test	Correlation Coefficient	0.560	1.000	-0.122
		Sig. (2-tailed)	0.001	0.000	0.052
		N	72	72	72
	Gender of learners	Correlation Coefficient	-0.034	-0.122	1.000
		Sig. (2-tailed)	0.120	0.052	0.000
		N	72	72	72

Table 23 shows a correlation between performance on the post-test and perception levels toward UbD (r = 0.560, ρ = 0.001 < 0.05). This implies that perception toward ICT-driven pedagogy is positively associated with learners' performance on post-test. This statistics complement the findings under Section 4.2.3.4.

This study also found a very weak negative correlation between gender and performance (r = -0.122; $\rho = 0.052 > 0.05$), and between gender and perception level (r = -0.034; $\rho = 0.120 > 0.05$); which implies that there was a minimal association between gender and perception level and performance. The findings of this study support that of Mubeen et al. (2013) that there was a weak significant relationship between gender and academic performance ($t = 0.85$; $\propto = 0.05$). This was because in principle both females and males will produce exactly the same scientific knowledge (Mubeen et al., 2013). However, the research findings of this study do not agree with the findings by Ondiek (2010) who found a significant relationship between learners' gender and attitude towards Mathematics content which included Geometry topics.

4.3 Conclusion

The results of this study revealed that using ICT-driven pedagogy in teaching geometrical terms, relationships, angle properties and symmetry (Geometry topics) to Grade 12 learners has a positive effect on their performance.

The findings indicated at $\propto = 0.05$ that there was no statistical significant difference ($t = -3.837$; $\rho = 0.854$) between the Control groups' pre-test and post-test scores but there was a significant difference ($t = -3.837; \rho = 0.00$) on the pre-test and post-test of the experimental group. Prior to the intervention, there was no significant difference ($\rho = 0.904$) in the mean performance of the Experimental group pre-test ($\bar{x} = 13.78$) and Control group pre-test ($\bar{x} = 13.73$).

After the intervention, this study found a significant difference ($\rho = 0.004$; $Mann - Whitney\ U\ test = 2\,914.500$) in the Geometry post-test performance of the Experimental and Control groups. Thus the null hypothesis that '*There is no significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods'* was rejected. Significant difference in performance between Experimental group and Control group might be attributed to the use of ICT-driven pedagogy which has the potential of enhancing understanding of Geometry and this account for better performance. A higher percentage of Experimental group learners were found to agree on all TAM constructs. Therefore, this study found that these learners' perceived ICT-driven pedagogy as easy to use and useful, and this positively influenced their behaviour intentions for technology adoption.

Females were found to hold more positive perceptions toward ICT-driven pedagogy compared to males. In addition, this study also found a weak negative association (r = -

0.034; $\rho = 0.120 > 0.05$) between gender and perception toward ICT-driven pedagogy. Furthermore, there was an association (r = 0.758, ρ = 0.685 < 0.05) between the performance ruling and perception at 95% level of significance; and a very weak negative correlation (r = -0.122; $\rho = 0.052 > 0.05$) between gender and performance on the post-test.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the study; beginning with the research processes and followed by the summary of research findings. It also presents reflections on the study and conclusions drawn from the findings. Finally, based on the research findings this chapter presents recommendations.

5.2 Summary of the research process

This study was sequential explanatory in nature, using non-equivalent pre-test-post-test quasi experimental design and a survey. It aimed at finding answers to these questions: 1) What is the effect of using UbD teaching approach on Geometry performance of Grade 12 learners at the NSSC Ordinary level in the Omusati Education region? and, 2) What are the perceptions (*levels)* of the Experimental group on the use of UbD teaching approach using GSP? 3) What is the association between perception levels, performance and gender of learners?

This study tested the following hypothesis: H_o: There is no significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods. H_1: There is a significant difference between the performance of learners who were taught Geometry using UbD and those taught using traditional methods.

The sample consisted of 176 Mathematics NSSCO Grade 12 learners from two secondary schools out of 17 secondary schools in the Omusati Education Region. The two schools (School A and School B) were purposively selected because one school had a Geometers' Sketchpad software while the other school did not. School A served as an Experimental group on the basis that it had GSP software while School B was a Control group. Cluster random sampling was used to select the sample of participating classes. At each school, two Grade 12 Mathematics NSSC Ordinary level classes were randomly selected to form a cluster, each consisting of 88 learners.

The pre-test and post-test on Geometry topics were used to test for the effect of ICT-driven pedagogy on learners' performance. After the pre-test, the Control and Experimental groups were taught separately, by the researcher, the same topics of Geometry, namely: Geometrical terms and relationships, angle properties, and symmetry. The Experimental group at School A was taught using Understanding by Design (UbD) as a teaching approach using GSP. In addition, *Khan Academy* and *YouTube* videos were used minimally (less than 5 minutes). Meanwhile, the Control group at School B was taught using traditional modes of teaching, i.e. explanation methods, demonstrations on the chalkboard, discussions with researcher, and a textbook. The perception levels of the Experimental group toward the use of ICT-driven pedagogy were determined using a questionnaire which was administered immediately after the post-test.

The data was analysed using the Statistical Package for Social Sciences (SPSS) software. First, the normality of the test scores was assessed using the Shapiro-Wilk test. Intra-group comparisons were made in each group using a paired sample t-test in order to compare the Mathematics pre-test results with the post-test results. Furthermore, Levene's t-test was carried out at a significance level $\propto = 0.05$ in order to determine if the Control and Experimental groups had the same or different amounts of variability. Since the variance between the Control and Experimental post-test scores was assumed to be unequal, a Mann-Whitney U (non-parametric) test was used to test for significant difference. Likert-type items were used to determine learners' perception levels toward ICT-driven pedagogy by calculating the mean scores on the attitudinal scale. Numerical scores were assigned to five response options given to each item on the attitude scale in the questionnaire. Chi-square was used to determine whether there was an association between males and females in the Experimental group and their perception levels, and between learners' performance versus their perception levels. In addition, the mean score was used to perform cross tabulation between gender versus perception levels and learners' performance, in order to determine whether those who had passed the post-test had a negative or positive perception towards ICT-driven pedagogy, and whether they were male or female. Later, bi-variance cross-tabulation was carried out in order to establish the link between gender, perceptions and performance.

5.3 Summary of the research findings

This section presents the key research findings of the study. The findings are presented with reference to the research questions. Literature findings are also discussed to boost the value of the discussion.

5.3.1 Effects of ICT-driven pedagogy on learners' Geometry performance

The results of this study suggested positive effects of ICT-driven pedagogy on the learners' performance compared to the performance of those taught using traditional methods of teaching. The Experimental and Control groups had contiguous mean scores in the pre-test prior to the intervention. Further, no significant difference ($t = 0.120$; ρ (sig. (2 tailed)) = 0.904 >0.05) (Table 10) was found between Experimental and Control group. This indication suggests that the two groups were equivalent before the intervention. After the intervention, the Experimental group had outdone the Control group (see Fig.5) in the post-test. Mann-Whitney U (non-parametric) test that was used to test for significance difference in performance between the two groups, found a significant difference (ρ -value $=0.004 < 0.05$) (Table 11) in the Geometry post-test performance of the Experimental and Control group at 95% confidence level.

The findings of this study support Idris (2009) and Myers (2009) that the use of GSP as teaching tool results in better performance of learners in Geometry, since GSP was a visual teaching aid that assisted with simplifying the explanation of non-figurative geometrical concepts and proofs of geometrical properties. The findings also concur with Wellingsky (1998), that the use of UbD approach and technology lead to better performance as it simplifies the teaching and heightens understanding of Geometry. In addition, the findings of this study supports Bruner's (1960) Constructivist Theory that teaching that involves the use of three modes of representation, i.e., concrete, pictorial and symbolic, leads to more effective learning and good performance in subjects. It also supports Perry (2013), Adams (2010) and Kay, Kletskin (2012) and Pearson and Litchfield (2011), who found that the use of visual media can strengthen understanding since it simplifies abstract concepts and in turn improves learners' academic achievement. However, the findings of this study do not support the study conducted by Gönül and Solano (2013), which found that *Khan Academy* videos had no significant change in learners' scores because, according to Gönül and Solano (2013), they are supplements that do not immediately help learners understand the content and it might not have an impact on learners' academic performance.

5.3.2 Summary on learners' perception levels

TAM constructs were analysed in order to establish the Experimental group's technology acceptance before determining their perception levels. This study found that above 80% of learners agreed on all TAM constructs. More learners (70.8%) had a positive perception level toward ICT-driven pedagogy, of which a higher percentage was females (43.1%). Thus, learners possessed positive perception level toward ICT-driven pedagogy which might lead to behaviour intentions (BI) to suggest for the adoption of ICT tools. In addition, this study found a weak association ($x^2 = 3.426$; $\rho = 0.180 > \alpha = 0.05$ [Table 20] and r $= -0.034$; $\rho = 0.120$ [Table 23]) between gender and perception levels; an association between performance and perception level ($x^2 = 0.560$; $\rho = 0.001 < \alpha = 0.05$), thus perception toward ICT-driven pedagogy might have an influence on the Experimental groups performance and vice versa. Furthermore, a very weak negative correlation between gender and performance on the post-test (r = -0.122; $\rho = 0.052 > 0.05$) was found.

The findings of this study support those of Venter et al. (2012) and Al-Adam et al. (2013) that perceived usefulness (PU) and perceived ease of use (PEOU) contribute positively to Behaviour Intentions (BI) and Attitudes Towards Use (ATU). This implies that learners perceived ICT-driven pedagogy useful and easy to use and this positively influenced their perceptions on its use. In terms of gender and perception, the findings of this study confirm those of Wasike et al. (2013) and Slouti and Barton (2007) that female learners have positive perceptions towards the use of ICT-driven pedagogy and it accounts for better achievement in mathematics compared to male; and that there was a weak significant relationship between gender and academic performance ($t = 0.85$) (Mubeen et al., 2013).

In summary, the present study has contributed to the research about effects of GSP using UbD as an approach to teach geometrical terms, relationships, angle properties and symmetry. The findings of this research have proven that GSP and UbD could be used in teaching to enhance the understanding of Geometry and improve performance in this branch of Mathematics. Thus, the study has contributed to the existing body of knowledge on using ICT-driven pedagogy to enhance learning and performance in Mathematics.

5.4 Reflections

The sample used in this study was small and the findings cannot be generalised to represent the whole country. The schools were selected on the basis that they both had a computer laboratory and one had GSP software. More schools could have participated, but this was not possible since only one in the whole Omusati region had the GSP software and an equal number of learners in each cluster were necessary in this study.

The study adopted Bruner’s Constructivist Theory, Technology Acceptance Model (TAM) as well as the Theory of flow Cognitive Absorption (CA) which is a concept of TAM. Bruner’s Constructivist Theory was used to explain the effects of UbD approach on the performance of learners in learning Geometry topics, while TAM and the Theory of flow was used to explain learners’ perceptions toward UbD teaching approach and GSP. The findings of this study were in line with Bruner’s Constructivist Theory and TAM in that using pictorials in Geometry would enhance learners’ understanding and consequently improve performance. It was evident from the study that the use of ICT-driven pedagogy might lead to better performance in Geometry topics. It emerged that PEOU and PU influenced behaviour positively toward Technology Adoption (ATU). It also emerged that females possessed more positive perception compared to males. It also merged that there was a weak association between gender and perception levels and a weak negative association between performance and gender, thus perception toward ICT-driven pedagogy and performance could not be linked to gender and vice versa.

5.5 Conclusion

This study investigated the effects of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners in the Omusati Education region. It aimed at finding alternative ways to improve learners’ performance in Geometry since the Examiners’ report (DNEA, 2011, 2012, 2013, 2014) on NSSC Ordinary level Mathematics highlighted that “*questions on Geometry are the worst answered questions every year* *and much effort should be put into teaching of Geometry*”. The following are the most significant conclusions drawn from this study:

5.5.1 The use of ICT-driven pedagogy might improve learners’ performance in Geometry.

5.5.2 More than 70% of the learners had a positive perception toward ICT-driven pedagogy.

5.5.3 There was a weak association between gender and perception; and between performance and gender.

5.5.4 There was a strong association between performance and perception.

5.6 Recommendations for practice

The following recommendations are made, based on the findings of this study.

1. Mathematics teachers should be encouraged to use ICT-driven pedagogy when teaching Geometry topics i.e. geometrical terms, relationships, angle properties and symmetry, in order to improve the academic achievement of their learners.
2. Teachers should be encouraged to use visual media in teaching since visual media strengthens understanding by simplifying abstract concepts.
3. Teachers should be encouraged to use Understanding by Design (UbD) lesson plans formats.

4. Schools that are equipped with ICT facilities should be encouraged to secure GSP software in order to enhance teaching and understanding of geometrical terms, relationships, angle properties and symmetry.

5.7 Recommendations for further research

The researcher makes the following recommendations for further research:

1. Further studies should be conducted to investigate the effectiveness of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners in other education regions.
2. A more detailed study should be conducted on the relationship between ICT-driven pedagogy versus gender, perceptions and performance in Geometry; mainly focusing on why females perform better in Geometry topics when taught with ICT-driven pedagogy.

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APPENDICES

Appendix A: Letter to the Regional Director of Education

P. O. Box 2567, Oshakati

Cell: 081 3301043

10 February 2015

Att: The Director of Education: Omusati Education Region

Private Bag 529 Outapi

Dear Sir

Re: Request for permission to conduct research at selected schools in Omusati region

I am Leena N. Kanandjebo, a Master of Education (Mathematics) student at the University of Namibia. In partial fulfilment to qualify for my Master's degree, I am required to conduct a research. I am planning to carry out a study in the Omusati region around March and April 2015. Omusati region is selected because it's one of the region characterised with poor performance in Mathematics.

My research topic is **'Effects of ICT-driven pedagogy on performance of grade 12 Geometry ordinary level learners, in the Omusati education region'**. The study attempts to investigate effects of Understanding by design (UbD) as an ICT-driven pedagogy incorporated with Geometer's sketchpad on performances of learners in geometry. It will also investigate perception levels of learners toward ICT-driven pedagogy. In addition, the study will be supervised by Dr. E. Ngololo

The study will use two schools with computer laboratory. The data will be collected using questionnaires and learners' pretest and posttest. The lessons will be based on geometry topic in the NSSCO Mathematics syllabus and the lessons will be videotaped. The school and learners will be assured of confidentiality and anonymity in the final research report. A time table for class sessions with dates and times of visits will be provided, and will not disrupt the normal class teaching time at the school.

I therefore kindly request your good office to allow me to conduct this vital research in Omusati region as my research site. I shall send a summary of the findings to the school that have participated in the study. Furthermore, these findings will also be available at the University of Namibia library for public use.

Attached please find research permission letter and ethical clearance certificate from the University of Namibia.

Thanking you in advance for the anticipated favourable response.

Yours Faithfully,

Leena N. Kanandjebo

Appendix B: Letter to the School Principal

P.O.Box 2567

Oshakati

09 March 2015

The Principal

………………..Secondary School

Dear Sir/Madam

Re: Request to conduct Research at ……………………….Secondary School

I am Leena N. Kanandjebo, a Master of Mathematics Education student at the University of Namibia. In partial fulfilment to qualify for my Master's degree, I am required to conduct a research. I have chosen to investigate the **'Effects of ICT-driven pedagogy on performance of grade 12 Geometry ordinary level learners, in the Omusati education region'.**

I therefore kindly, request your good office to allow me to carry out my research at your school. I will conduct the study with four classes doing Mathematics NSSCO. The data will be collected using a pre-test & post-test and a questionnaire. The lessons will be based on Geometry, a topic in the Mathematics NSSCO syllabus. Classes will be conducted in the afternoon between 15h00- 16h00. Furthermore lessons will be videotaped. The learners will be assured of confidentiality and anonymity in the final report. A time table for class sessions with dates and times of visits will be provided, and will not interrupt the normal class teaching time.

Attached please find the proof of permission to conduct the research in the Omusati Education Region, granted by the Office of the Omusati Regional Director of Education.

Yours in Education,

Leena N. Kanandjebo

Appendix C: Permission to conduct research from the University of Namibia

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Inspiring minds & shaping the future

RESEARCH PERMISSION LETTER

Date: 30 October 2014

TO WHOM IT MAY CONCERN

RE: RESEARCH PERMISSION LETTER

1. This letter serves to inform that student: **LEENA VILMA KANANDJEMBO** (Student number: 200709020) is a registered student in the Department of SCIENCE, MATHEMATICS AND SPORT EDUCATION at the University of Namibia. His/her research proposal was reviewed and successfully met the University of Namibia requirements.
2. The purpose of this letter is to kindly notify you that the student has been granted permission to carry out postgraduate studies research. The School of Post-graduate Studies has approved the research to be carried out by the student for purposes of fulfilling the requirements of the degree being pursued.
3. The proposal adheres to ethical principles.

Thank you so much in advance and many regards.

Yours truly,

Name of Main Supervisor: **Dr. Elizabeth N. Ngololo**

Signed:

Dr. C. N.S. Shaimemanya

Signed: ....

Director: School of Postgraduate Studies
Tel: 2063523
E-mail: cshaimemanya@unam.na

Appendix D: Ethical clearance certificate

UNIVERSITY OF NAMIBIA

ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: SEC/FOE/70/2014 **Date: 27 October, 2014**

This Ethical Clearance Certificate is issued by the University of Namibia Research Ethics Committee (UREC) in accordance with the University of Namibia's **Research Ethics Policy and Guidelines. Ethical approval is given in** respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the Faculty/Centre/Campus Research & Publications Committee sitting with the Postgraduate Studies Committee.

Title of Project: EFFECTS OF ICT-DRIVEN PEDAGOGY ON PERFORMANCE OF GRADE 12 GEOMETRY ORDINARY LEVEL LEARNERS IN THE OMUSATI EDUCATION REGION, NAMIBIA

Nature/Level of Project: MASTERS

Principal Researcher: Leena N. Kanandjebo (Student No: 200709020)

Host Department & Faculty: Department Mathematics, Science and Sports Education, Education

Supervisors : Dr E. Ngololo (Main) (Co) Dr H.C. Brunette

Take note of the following:

(a) Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the UREC. An application to make amendments may be necessary.

(b) Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the UREC.

(c) The Principal Researcher must report issues of ethical compliance to the UREC (through the Chairperson of the Faculty/Centre/Campus Research & Publications Committee) at the end of the Project or as may be requested by UREC.

(d) The UREC retains the right to:

(i). withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,

(ii). request for an ethical compliance report at any point during the course of the research.

UREC wishes you the best in your research.

Prof. I. Mapaure
UNAM Research Coordinator
ON BEHALF OF UREC

Appendix E: Permission to conduct research from the Directorate of Education

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-REPUBLIC OF NAMIBIA

OMUSATI REGIONAL COUNCIL

DIRECTORATE OF EDUCATION

Team Work and Dedication for Quality Education

Tel: +264 65 251700
Fax: +264 65 251722

Private Bag 529
OUTAPI

27 February 2015

Enq: Apollonia Hango

Leena N. Kanandjembo
P.O.Box 2567
Oshakati

Dear Madam

Re: Request for permission to conduct research at selected school in Omusati Region.

This letter serves to notify you that permission has been granted for you to conduct the above said research at the identified schools in the region. The Omusati Education Directorate is pleased to inform you that permission is granted and research to be undertaken at schools should by no means whatsoever disrupt teaching and learning.

We hope and trust this exercise will enhance quality education in the Region.

Yours faithfully

02/03/15

OMUSATI REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
2015 -03- 02
REPUBLIC OF NAMIBIA

Mr. Laban Shapange
Acting Director of Education

Teamwork and dedication for quality education

All official correspondence must be addressed to the Regional Director.

Appendix F: Consent form for the School Principal

Leena Ngonyofi Kanandjebo is hereby given permission to use …………………………………… School as the research site for the research study she is required to conduct in partial fulfilment for the Master's degree in Education of the University of Namibia.

I understand that:

- The data for analysis will be collected by means of employing the ICT-driven pedagogies in teaching the Grade 12 Mathematics learners, administering the Mathematics pre-test & post-test and the questionnaire.
- Classes will be conducted between 15h00 and 16h00, by the researcher on selected topics of geometry.
- The lessons will be videotaped.
- The information from these instruments may be used in the final report of this study.

I have been assured that the school and the learners will have anonymity in the final report and the information collected will be used for the sole purpose of the study.

____________________ **____/ _______/ 2015**

Principal's signature **Date**

__________________ **______/_______/2015**

Researcher's signature **Date**

Appendix G: Consent form for the learners

Instruction: Please fill out this consent form and return it.

I, ____, a Grade 12 learner at ……………………………………………….. hereby give consent to be a subject in the study entitled '**Effects of ICT-driven pedagogy on performance of Grade 12 Geometry Ordinary level learners, in the Omusati Education region'** by attending the sessions, sit for the tests and completing the questionnaire.

I understand that:

- I do not have an obligation to participate, and may withdraw from the study at any point prior to the publication or presentation of research results.
- Anonymity will be maintained through the use of pseudonyms. My name will not be mentioned in the final report
- The research will be used for academic and professional presentations and publications.
- The lessons will be videotaped.

______________________	**_________________**	**______/______/2015**
Name of Learners	**Signature**	**Date**
______________________	**_________________**	**______/______/2015**
Name of Researcher	**Signature**	**Date**

Appendix H: Data collection Calendar of events

DATE		OBJECTIVES TO BE COVERED
16/03/2015		Piloting the instruments
18/03/2015		Selection of learners at school B and pre-testing at School B
TEACHING at School B		
School B	**School A**	
19/03/2015	**26/03/2015**	• Use and interpret the geometrical terms: point, line, parallel, intersecting, bearing, right angle, acute, obtuse and reflex angles, perpendicular, similarity and congruence
20/03/2015	**27/03/2015**	• Use and interpret vocabulary of triangles, quadrilaterals, circles, polygons and simple solid figures, including nets.
23/03/2015	**28/03/2015**	• Recognise line and rotational symmetry (including order of rotational symmetry) in two dimensions • Use the following symmetry properties of circles: - equal chords are equidistant from the centre - the perpendicular bisector of a chord passes through the centre of a circle

		- tangents from an external point are equal in length • Recognise properties of triangles, quadrilaterals and circles directly related to their symmetries.
24/03/2015	**30/03/2015**	• Calculate unknown angles using the following geometrical properties(reason may be required but no formal proofs) such as angles: at a point, on a straight line and intersecting straight lines, formed within parallel lines, in a semi-circle, between tangent and radius.
25/03/2015	**31/03/2015**	• Angle properties of triangles, quadrilaterals and regular polygons.

Appendix I: Lesson plans

Day 1

Stage 1: Desired Results
Unit Title: Geometrical terms and relationships **Approximate Duration: 40 minutes** **Summary:** In this unit learners will begin to build the foundational vocabulary needed to be successful in Geometry. They will apply the vocabulary to algebraic situations. **Print Materials Needed:** Class Handouts **Teaching Resources:** **School B:** Chalkboard **School A:** UbD teaching approach plus Geometer's Sketchpad, Khan academy videos, Youtube videos
Established Goals: Use and interpret the geometrical terms: point, line, parallel, intersecting, bearing, right angle, acute, obtuse and reflex angles, perpendicular, similarity and congruence

<table>
<tr>
<td colspan="2">Understandings:

Learners will understand that:

1. Mathematical statements can be justified through deductive and inductive reasoning.
2. Congruence describes a special similarity relationship between objects and is a form of equivalence.</td>
<td>Essential Questions:

1. What are the building blocks of Geometry?
2. How can you describe the attributes of the geometric terms?
3. How can you describe angle pairs and their relationships?</td>
</tr>
<tr>
<td>Know</td>
<td>Understand</td>
<td>Do</td>
</tr>
<tr>
<td><u>Vocabulary/Terms</u>

<u>Terminology for lines:</u>

• point, line, line segment, ray diagonal, perpendicular, vertical, parallel

<u>Terminology for</u></td>
<td><u>Learners will understand:</u>

• The vocabulary related to Geometry
• The applications of</td>
<td><u>Learners will be able to:</u>

• Identify the vocabulary in geometric figures
• Properly name the vocabulary using the correct symbolization</td>
</tr>
</table>

<u>angles:</u> • Acute, right angle, obtuse, straight, reflex, revolution • Complementary, supplementary, vertically opposite **<u>Terminology for shapes</u>**: • Congruent and similar shapes **Other terminologies:** bearing, midpoint, bisector, vertex of an angle, measure of an angle, perpendicular bisector	this vocabulary to algebraic and geometric problems	• Set up and solve algebraic equations using this vocabulary
Stage 2: Assessment Evidence		

Performance Task: • Learners will observe geometrical figures around the school yard. They will then be required to answer the following questions: 1. Name the geometrical shape you observed 2. What is the value of the vertex angles 3. Name the angle. • Class exercise
Stage 3: Learning Plan
Learning Activities: (School A and B) • Show a video to the learners that explains geometrical terms • Explain to the learners what are the geometrical terms using Geometers' sketchpad • Give a handout with class exercise.

Day 2

<table>
<tr><td colspan="2">Stage 1: Desired Results</td></tr>
<tr><td colspan="2">Unit Title: Geometrical terms and relationships

Approximate Duration: 40 minutes

Summary: Learners will focus on presenting and proving relationships within a triangle that students can, in turn, use to prove relationships within other figures.

Print Materials Needed: y = mx+ c textbook and Class Handouts

Teaching Resources:
School B: Chalkboard, textbook
School A: UbD teaching approach plus Geometer's Sketchpad, Khan academy videos, Youtube videos</td></tr>
<tr><td colspan="2">Established Goals:
Use and interpret vocabulary of triangles, quadrilaterals, circles, polygons and simple solid figures, including nets.
Recognise properties of triangles, quadrilaterals and circles directly related to their symmetries.</td></tr>
<tr><td>Understandings:</td><td>Essential Questions:</td></tr>
</table>

<table>
<tr><td colspan="2">Learners will understand that:
3. Mathematical statements can be justified through deductive and inductive reasoning.
4. Some geometric relationships can be described and explored as functional relationships</td><td>4. What is the relationship between the sides of a triangle and of any given polygon?
5. How do you use properties of triangles, quadrilaterals, circles, polygons simple solid figures, including nets to name shapes and solve problems involving geometric shapes.</td></tr>
<tr><td>Know</td><td>Understand</td><td>Do</td></tr>
<tr><td><u>Vocabulary/Terms</u>
• Isosceles, right angled triangle, equilateral,</td><td><u>Learners will understand:</u>
• The vocabulary related to</td><td><u>Learners will be able to:</u>
• Identify the vocabulary in geometric figures</td></tr>
</table>

scalene, semi-circle, radius, diameter, circumference, rectangles, squares, trapezium, kite, rhombus, parallelogram, penta-, hexa-, hepta-,octa-, nona- deca-, dodeca- • Regular and irregular shapes	geometrical shapes • The applications of this vocabulary to algebraic and geometric problems	• Properly name the vocabulary using the correct symbolization and spelling • Identify parallel sides • Find possible side lengths.
Stage 2: Assessment Evidence		
Performance Task: • Learners will observe geometrical figures around the school yard. They will then be required to answer the following questions:		

4. Name the geometrical shape you observed 5. Identify if the shape is regular or irregular 6. Name and identify whether the shape is a quadrilateral or triangle or any other polygon. And name the shape.
Stage 3: Learning Plan
Learning Activities: • Show a video to the learners that explains geometrical shapes **(School A and B)** • Explain to the learners what are the geometrical terms involving triangles, quadrilaterals and other polygons using Khan academy and chalkboard **(School B)**

Day 3

Stage 1: Desired Results
Unit Title: Geometrical terms and relationships **Approximate Duration: 40 minutes** **Summary:** Learners will draw and identify symmetries of figures. **Print Materials Needed:** y = mx+ c textbook and Class Handouts **Teaching Resources:** **School B:** Chalkboard **School A:** UbD teaching approach plus Geometer's Sketchpad, Khan academy videos, Youtube Videos
Established Goals: • Recognise line and rotational symmetry (including order of rotational symmetry) in two dimensions • Use the following symmetry properties of circles: - equal chords are equidistant from the centre - the perpendicular bisector of a chord passes through the centre of a circle - tangents from an external point are equal in length.

<table>
<tr><td colspan="3">

- Recognise properties of triangles, quadrilaterals and circles directly related to their symmetries

</td></tr>
<tr><td colspan="2">

Understandings:

Learners will understand that:

5. Mathematical statements can be justified through deductive and inductive reasoning.

6. Some geometric relationships can be described and explored as functional relationships

</td><td>

Essential Questions:

1. What does symmetry entails
2. How do we find the line of symmetry and rotational symmetry.
3. How do you use properties of triangles, quadrilaterals, circles, polygons simple solid figures, including nets to name shapes and solve problems involving geometric shapes.

</td></tr>
<tr><td>**Know**</td><td>**Understand**</td><td>**Do**</td></tr>
<tr><td>

<u>Vocabulary/Terms</u>

- Order of rotational

</td><td>

<u>Learners will understand:</u>

- The vocabulary

</td><td>

<u>Learners will be able to:</u>

- Identify the line of symmetry of figures as

</td></tr>
</table>

symmetry, line of symmetry, mirror line chords, perpendicular bisector, tangent, types of polygons	related to geometrical shapes • The applications of this vocabulary to algebraic and geometric problems	well as order of symmetry • Identify line of symmetry as well as order of symmetry of letters
Stage 2: Assessment Evidence		
Performance Task: • Learners will cut geometrical shapes They will then be required to: Describe the symmetry of the figure.		
Stage 3: Learning Plan		
Learning Activities: • Explain symmetries of figures using GSP. (School A)		

Day 4 and Day 5

Stage 1: Desired Results
Unit Title: Geometrical terms and relationships **Approximate Duration: 40 minutes** **Summary:** Learners will build on their knowledge of angles to prove and use properties of parallel lines, triangles, circles and quadrilaterals. **Print Materials Needed:** y = mx+ c textbook and Class Handouts **Teaching Resources:** **School B:** Chalkboard and textbook **School A:** UbD teaching approach plus Geometer's Sketchpad, Khan academy videos, Youtube videos
Established Goals: • Calculate unknown angles using the following geometrical properties (reason may be required but no formal proofs) such as angles: at a point, on a straight line and intersecting straight lines, formed within parallel lines, in a semi-circle, between tangent and radius. • Angle properties of triangles, quadrilaterals and regular polygons.

Understandings: see quadrilaterals parallel lines	Essential Questions:
Learners will understand that: **1.** Mathematical statements can be justified through deductive and inductive reasoning. **2.** Some geometric relationships can be described and explored as functional relationships **3.** Spatial reasoning and visualization are ways to orient thinking about the physical world. **4.** There are some mathematical relationships that are always true and these relationships are used as the rules of arithmetic and algebra and are useful for writing equivalent forms of expressions and solving equations**.**	1. What are the relationship of the angles in (a) parallel lines, (b) triangles, (c) circles, (d) quadrilaterals, polygons 2. What formulas do you use to find the sum of the interior and exterior angles of a regular polygon? 3. How do you use properties of triangles, quadrilaterals, circles, polygons simple solid

		figures, including nets to name shapes and solve problems involving geometric shapes?
Know	**Understand**	**Do**
<u>Vocabulary/Terms</u> • Alternate angles, corresponding angles, interior angles, exterior angles,	**<u>Learners will understand:</u>** • The vocabulary related to geometrical shapes • The applications of this vocabulary to algebraic and geometric problems	**<u>Learners will be able to:</u>** • Identify angles from a diagram • Find the sum of the interior and exterior angles of any polygon. • Apply the polygon exterior and interior angle-sum theorems • Use angle properties in a

		circle and polygons to solve angle problems**.**
Stage 2: Assessment Evidence		
Performance Task: • Learners will look at given geometrical shapes They will then be required to: 1. Calculate the values of unknown using the properties 2. Give reason for their answers.		
Stage 3: Learning Plan		
Learning Activities: **<u>School A</u>** • Explain angle properties of geometrical shapes using Khan Academy videos and give a summary afterwards. • Calculate angles using GSP **<u>School B</u>** • Use the chalkboard and textbook to explain and calculate angles.		

Appendix J: Pre-test

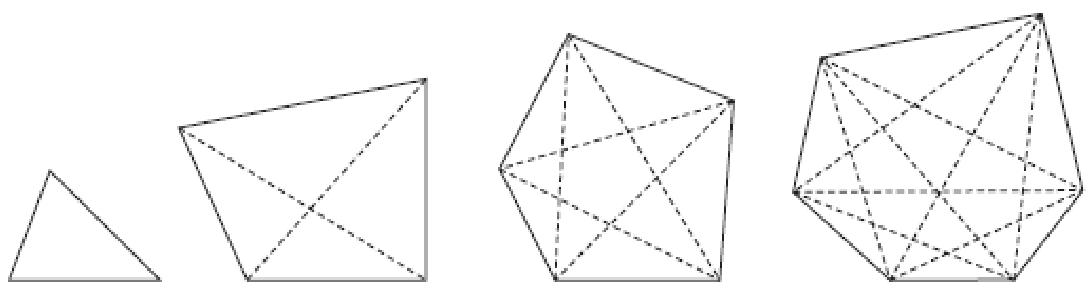
Participant code: …

Instructions:

- **Do NOT** write your name on this paper.
- Answer all questions and show your working.
- Write your answers in the spaces provided after each question or part question.

Theme: Geometrical Terms and relationships

1.



The diagrams above show some polygon and their diagonals. Complete the table.

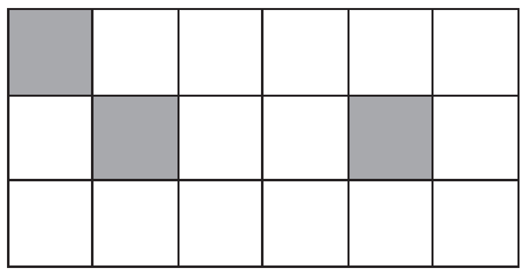
Number of sides	Name of polygon	Total number of diagonals
3	Triangle	0
4	Quadrilateral	2
5		5
6	Hexagon	9
7		14
8		
9		27

[5]

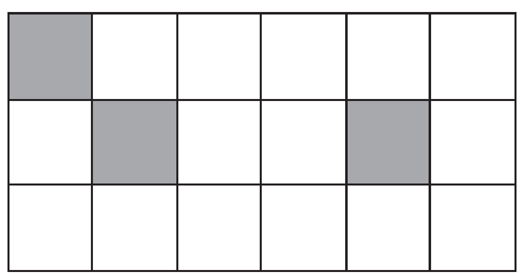
Theme: Symmetry

2. (a) Shade **one** square in each diagram so that there is

(i) One line of symmetry [1]

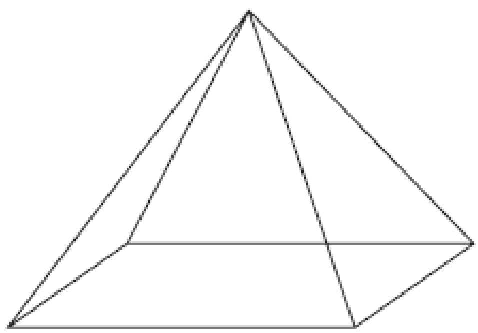


(ii) Rotational symmetry of order 2. [1]



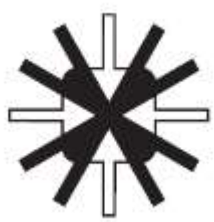
(b) the pryramid below has a rectangular base. The vertex of the pyramid is vertically above the centre of the base.

Write down the number of lines of symmetry for the pyramid.



Answer: …………………………..[1]

(c)



3. For the shape above, write down

   (i) The number of lines of symmetry,

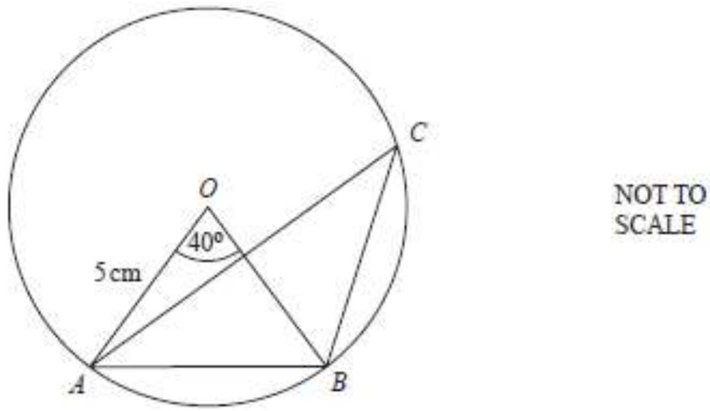
   Answer: ……………………………. [1]

   (ii) The order of rotational symmetry.

   Answer : ……………………………... [1]

Theme: Angle properties

4.



A, B and C are points on a circle, centre O. Angle AOB = 40°.

(a) Write down the size of angle ACB and reason

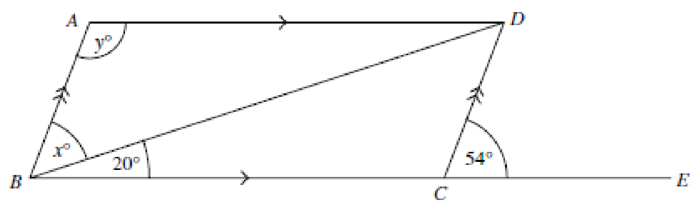
Answer : ……………………………………….[1]

Reason: ………………………………………………………………………… [1]

(b) Find the size of angle OAB.

Answer: (b) ……………………………….. [2]

5.



NOT TO SCALE

(a) ABCD is a quadrilateral and BCE is a straight line. Angle DCE $= 54°$and angle DBC $= 20°$. Calculate the value of x and y

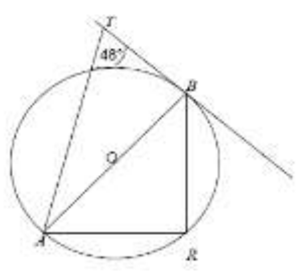
Answer: $x =$ ……………………[2]; $y =$ …………………….. [1]

(b) Write down the geometrical name for the quadrilateral ABCD.

Answer: ……………………………….. [1]

---

6. (a) BT is a tangent to the circle, centre O. AB is a diameter and angle ATB $= 48°$. R is another point on the circle.



(i) Find the size of angle TAB, giving a reason for your answer.

Answer (b) : Angle TAB…………………..

Reason……………………………………………………………………………

……………………………………………………………………………[2]

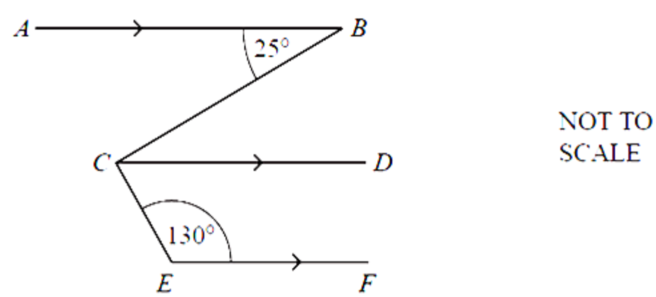
(ii) Write down the size of angle ARB,

Answer: ………………………………...[1]

(b)Find the size of each interior angle of a 6-sided polygon. Give answer to the nearest degree

Answer: ……………………………….. [3]

7.



In the diagram above, AB, CD and EF are parallel lines.

Angle ABC = 25° and angle CEF = 130°.

Calculate angle BCE.

Answer Angle BCE = ………………..… ° [2]

End **Total Marks: 25**

Appendix K: Post-test

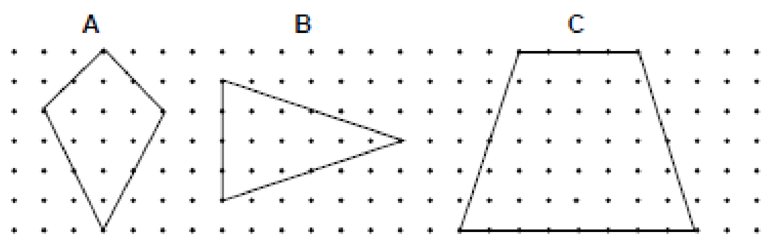
Participant code: …

Instructions:

- **Do NOT** write your name on this paper.
- Answer all questions and show your working.
- Write your answers in the spaces provided after each question or part question.

Theme: **Geometrical terms and relationship and Symmetry**

1. (a) In each of the shapes below draw one line which divides it into two congruent shapes.



[3]

b) What special name is given to shape,

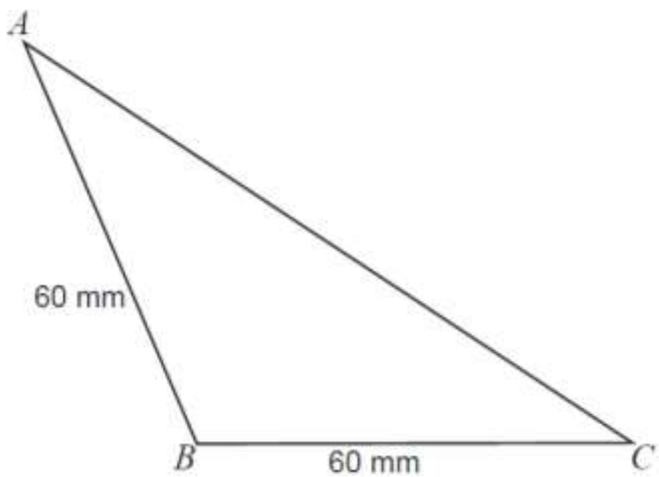
(i) A,

Answer: (b) (i) ………………….. ...…. [1]

(ii) C?

Answer: (b) (ii)………………..…….. [1]

2. In triangle ABC, AB $= 60\ mm$ and BC$= 60mm$



(a) Identify an acute angle and clearly indicate it on the triangle ABC. [1]

(b) How many order of rotational symmetry does triangle ABC have?

Answer: …………………[1]

Theme: Symmetry

3. **G E O M E T R I C A L**

From the word above, write down the letters that have

(a) No lines of symmetry

Answer (a): ……………………………[1]

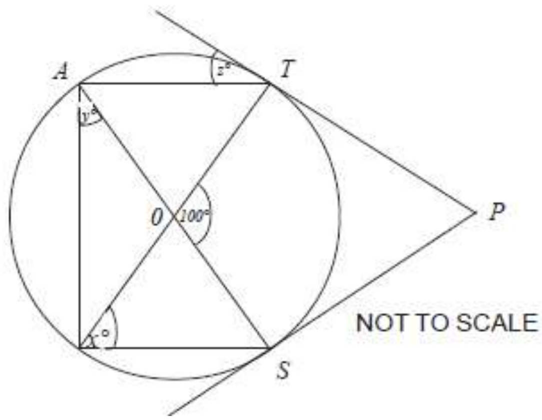
(b) Rotational symmetry of order 2.

Answer (b) : …………………………… [1]

Theme: Angle properties

4. PT and PS are tangents to the circle centre O.

   TOB and AOS are diameters and angle TOS $=100°$.



(a) Find the values of angle, x and y.

Answer :(a) $x =$………..$y =$ ………………[2]

(b) Give the special name of triangle AOT?

Answer: (b) ……………………………………. [1]

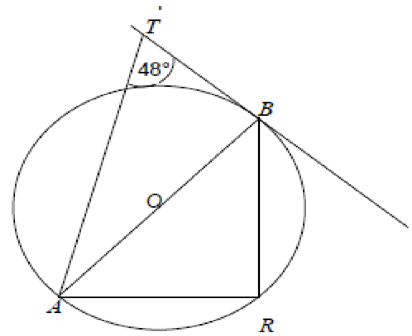
(c) Is AS parallel to TP? Give reason for your answer?

Answer:(c) ……………………………………………………… [1]

(d) Give a reason why angle ASP $= 90°$

Reason: ………………………………………………………………… [1]

5.



In the diagram above, BT is a tangent to the circle, centre O. AB is a diameter and angle ATB = 48° . R is another point on the circle.

(a) (i) Giving a reason, find the size of an angle TAB.

Answer (a)(i): angle TAB ……………………..

Reason: …………………………………………………………………………[2]

(ii)Write down the size of angle ARB

Answer: (a) (ii) Angle ………………………..… [1]

(b) Find the size of each interior angle of a regular 4 sided polygon.

Give your answer to the nearest degree.

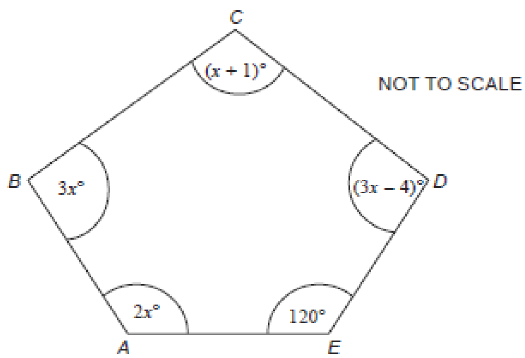
Answer: …………………….. [2]

6. (a) Give the special name of a regular six-sided polygon.

Answer: (a) ……………………………………….. [1]

(b)The diagram ABCDE below shows a pentagon. Angles A, B, C, D, and E are

$2x°, 3x°, (x+1)°, 3x° - 4$ and 120°.



(c) How many of lines of symmetry does the figure ABCDE have?

Answer: (c) ………….…………………..[1]

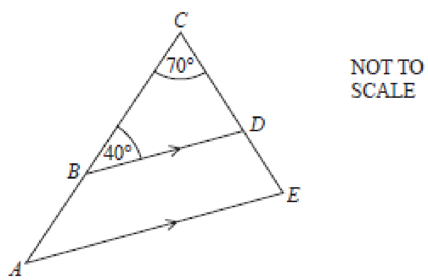
(d) State the sum of the interior angles of a pentagon.

Answer: (d) ……………………………..…. [1]

(e) Calculate the value of x.

Answer (e) ……………………………… [1]

7. In the diagram, ACE is a triangle. B is a point on AC and D is a point on CE. AE is parallel to BD, angle ACE= 70° and angle CBD= 40°.



(a) Write down the mathematical name of triangle BCD.

Answer (a): …………………………………… [1]

(b) Find the value of angle CAE, give a reason for your answer.

Answer (b) Angle CAE = ……………………

because ………………………………………………………………… [2]

End **Total marks: 25**

Appendix L: Learners mark scores

Participant's Code	Pre-test Scores	Post-test Scores
C01	13	16
C08	16	15
C09	10	13
C11	9	14
C12	12	11
C13	9	8
C14	14	17
C15	11	9
C16	9	12
C17	19	14
C18	16	14
C21	12	12
C22	11	17
C24	11	7
C25	16	10
C26	10	11
C27	15	4
C29	10	18
C30	12	22
C31	13	16
C32	10	12
C33	11	12
C34	10	14
C36	12	19
C41	14	16
C42	13	19
C43	13	7
C44	14	7
C45	15	11
C47	11	13
C51	10	14
C53	14	12
C57	14	11

C64	15	13
C67	12	14
C70	17	14
C72	15	9
C74	15	13
C75	15	19
C76	16	16
C78	16	17
C80	18	16
C81	12	15
C83	9	19
C84	15	16
C86	14	16
C87	17	19
C88	15	13
E19	17	19
E22	14	17
E38	11	16
E40	16	10
E45	10	12
E47	17	12
E56	16	16
E61	14	17
E64	19	12
E69	14	16
E70	14	13
E78	19	20
E79	17	15
E08	16	21
E55	11	17
E24	12	10
E80	19	20
E29	16	19
E42	15	13
E25	16	16
E82	16	17
E04	10	12
E28	7	11
E39	6	12
E13	14	18

E05	10	14
E52	10	19
E32	18	16
E88	15	17
E30	19	17
E58	12	10
E68	12	15
E21	5	13
E44	14	16
E60	11	19
E15	14	18
E03	13	14
E18	10	20
E49	18	16
E23	17	15
E65	15	14
E75	16	14
E84	14	18
E87	13	17
E33	14	10
E63	16	11
E66	11	14
E67	14	16
E73	18	12
E12	12	16
E74	17	15
C02	11	15
C03	15	15
C04	14	19
C05	16	13
C06	15	11
C07	16	12
C10	10	16
C19	16	17
C20	14	18
C23	18	16
C28	17	17
C35	13	11
C37	9	9
C38	22	23

C39	13	6
C40	11	14
C46	12	14
C48	16	14
C49	12	9
C50	7	13
C52	17	17
C54	16	10
C55	12	13
C56	14	12
C58	16	17
C59	13	12
C60	15	16
C61	13	7
C62	20	19
C63	18	13
C65	12	16
C66	11	9
C68	10	10
C69	11	13
C71	16	21
C73	17	11
C77	16	18
C79	17	16
C82	18	13
C85	19	14
E31	14	16
E53	16	17
E81	17	18
E85	14	16
E50	14	19
E54	3	13
E27	11	17
E17	12	14
E09	16	16
E16	11	19
E20	13	16
E57	10	16
E06	16	12
E41	17	20

E71	17	14
E11	16	13
E26	11	17
E14	9	15
E34	13	16
E43	10	14
E36	15	13
E37	14	16
E07	13	11
E46	15	16
E48	11	16
E62	19	13
E10	12	13
E35	16	18
E51	14	18
E77	14	14
E76	9	11
E72	7	12
E02	18	19
E59	15	17
E01	16	13
E83	15	19
E86	16	14

Appendix M: A questionnaire for learners

Participant code:................

Instructions:

1. Do **not** write your name on this paper.
2. Please indicate the extend of your agreement with each statement by ticking (√) in the column for: **strongly agree, agree, undecided, disagree and strongly disagree.**
3. Please, try to answer all the questions

Section A: Biographical information

1. Gender

Female	
Male	

2. **Section B:** Learners perceptions toward ICT driven pedagogy

TAM constructs	Strongly agree	Agree	Disagree	Strongly Disagree	Undeci ded
Perceived ease of use (PEOU)					
ICT-driven pedagogy is learner friendly.					
My interaction with GSP and other ICT tools (videos and internet) is clear and understandable.					
Learning to use GSP and other ICT tools would be easy for me.					
I think it would be easy to be become skilful at using GSP and other ICT tools.					
I find that the process of teaching and learning using ICT driven pedagogy was clear, understandable and straight					

forward.					
ICT tools are difficult to use					
Perceived usefulness (PU)					
ICT-driven pedagogy helped me in understanding the topic better.					
ICT-driven pedagogy helped me visualize.					
ICT-driven pedagogy makes me comfortable learning geometry.					
ICT-driven pedagogy would help me improve my performance in geometry.					
ICT-driven pedagogy would make it easier for me to do my home works and study for my tests and examinations.					
I think ICT-driven pedagogy should be part of each and every subject in schools.					
Attitude toward use (ATU)					
I believe it is a good idea to use ICT-driven pedagogies in teaching and learning.					
I think fully ICT-driven pedagogy when introduced would improve teaching and learning geometry.					
I think fully ICT-driven pedagogy when introduced would improve learners' performance geometry.					
Behaviour Intentions (BI)					
I intend to tell and show others about ICT-driven pedagogy.					
I will prefer full use of ICT-driven pedagogy over traditional modes of teaching.					
I will prefer teaching and learning through a combination of ICT-driven pedagogy and traditional modes of teaching.					
I think schools should teach only using ICT-driven pedagogy.					

Appendix N: Language Editing Certificate

Acknowledgment of Language Editing

Date: Tuesday, 17 May 2016

This is to certify that I have conducted Language Editing on the following:

EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)-DRIVEN PEDAGOGY ON PERFORMANCE OF GRADE 12 GEOMETRY ORDINARY LEVEL LEARNERS IN THE OMUSATI EDUCATIONAL REGION, NAMIBIA

by

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Algraham

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