

**THE INTEGRATION OF HANDS-ON GAMES IN THE LEARNING OF
PROBABILITY: A CASE OF GRADE 12 LEARNERS IN THE
OSHAKATI CLUSTER OF OSHANA REGION**

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ABSTRACT

Although research and classroom experience have produced more publications based on teaching and learning of probability, there are still significant challenges regarding probability content and need for proper instructions to build learners' existing notions and intuition of probability in order to foster formal probabilistic understanding (Dollard, 2011; Xiayan, 2015). Beside mathematics being a compulsory subject in the Namibian School curriculum since 2012, it is one of the requirements for admission to science and science related fields of study at institutions of higher education. Furthermore, the Ministry of Education's reports (2013, 2014) on the Grade 12 examination indicate that learners studying mathematics at extended level find it difficult to answer questions on probability in Paper 4.

This study sought to investigate the effects of integrating hands-on games in the learning and their effects on the performance of Grade 12 extended mathematics learners in probability in Oshakati Cluster of Oshana region. The study used a quasi- experimental design. Fifty seven extended mathematics learners of Oshakati Cluster schools consented to and successfully participated in this study. The learners were randomly divided into an experimental and control group. Twenty seven learners formed the experimental group and 30 formed the control group. The interventions varied between the groups, with the experimental group experiencing the traditional teaching methods with the integration of hands-on games while the control group encountered the traditional teaching approach only.

Hands-on games on probability were developed to investigate the difference between the two groups that were given a pre-test and a post-test to measure their performance in

mathematics. The experimental group means scores (average performance) on pre-test and post-test were 7.85 and 17.1 respectively while the control group had 8.20 and 13.1. This indicated significant differences in the performance of the experimental group on probability at the 0.05 significant level. Results of this study provide evidence that the integration of hands-on games in teaching and learning probability benefits students and enhances their performance on probability. This study might also enable mathematics educators and other education stakeholders to gain a better understanding of the need to use games in the teaching and learning of school subjects as a means of enhancing learners' performance. Mathematics teachers are therefore encouraged to develop and correctly integrate hands-on games in their teaching in order to improve their learners' performance in probability.

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LIST OF ACRONYMS

HOG	Hands-on Games
MOE	Ministry of Education
NIED	National Institute for Educational Development
NSSCO	Namibian Secondary School Certificate (Ordinary Level)
UNAM	University of Namibia
NCTM	National Council of Teachers of Mathematics

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May God bless you all!

DEDICATION

This thesis is dedicated to my parents: Killian Shafodhino Abisai and Penehafo Sheehama. My son, Setson Pombili Alushe-Indila Abisai, the mother of my son Feni Sheenda, and my brothers and sisters for the major role they have played in my study. I thank them for their patience, love, courage and unconditional support that they have offered me during the process of carrying out this study.

DECLARATION

I, Setson Tangeni Abisai, hereby declare that the thesis: *“The integration of hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners’ performance in probability in Oshakati Cluster of Oshana Region”* 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.

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Setson Tangeni Abisai



Name of Student

Signature

Date

CHAPTER 1

ORIENTATION OF THE STUDY

This chapter outlines the background of the study. The chapter discusses the study's statement of the problem, the research hypothesis as well as the importance of carrying out this research. The chapter continues to discuss the limitations, delimitations of the study as well as the definitions of the terms used in this study based on the study context.

1.1 Background of the study

Probability is one of the topics in Namibia's secondary school mathematics curriculum (Ministry of Education, 2010b). It is a branch of mathematics that, together with statistics influences the decisions we make both as individuals and as a society (Nicolson, 2005). Even though, the concept of probability is not new in research (Dollard, 2011; Xiayan, 2015; Nicolson, 2005) there are various definitions of probability based on classic, frequentists and subjective perspectives.

According to Xiayan (2015), understanding probability stems from statistics as the frequency of random events fluctuating around a certain constant. Furthermore, Xiayan indicates that probability contains significant mathematical terminologies with specific meanings such as random phenomenon, fundamental events and equal possibility. These concepts are specific to understanding probability.

Dollard (2011) notes that probability can be interpreted in three ways, namely; classic interpretation (equal possibilities based on physical symmetry), the frequentists' interpretation (observed frequencies of events), and the subjective interpretation (degree of subjective certainty or belief). It is therefore crucial for learners to develop a

meaningful understanding of probability from all three perspectives. They should acknowledge these interpretations and explore connections between them and the different contexts in which one or the other may be useful (Dollard, 2011). All definitions seem to imply that probability involves a study of rules of random phenomenon or chance or likelihood of an event to occur (Wall, & Pimentel, 1997; Xiayan, 2015).

Literature (e.g. Jones, 1996; Xiayan 2015), notes that probability is an important part of secondary school mathematics that provides methods of problem solving and a thinking model for people to know the objective world. It also offers the foundational theory for the development of statistics. Thus probability provides secondary school learners with a good platform for knowing the applicability of mathematics and lays the foundation for their future study.

According to Dollard (2011), probability seems to be a difficult topic in mathematics. Jones (1996) therefore emphasised the need for instruction to build on learners' existing notions of probability, emphasising that teachers need to produce probabilistic tasks that are linked to the teaching objectives. Xiayan (2015) and Nicolson (2005) outline the significance of using games in improving understanding of probability. The use of games could be an effective tool for facilitating learners' learning because games motivate, challenge, increase curiosity and promote fantasy in children (Ferguson, 2014).

Jones (1996) and Nicolson (2005) note that games are important tools in supporting instruction as they create realistic simulations as well as enable teachers and learners to

deal with real life probability problems. In addition, involving learners in a series of games on probability such as tossing coins, drawing from candy bags, rolling dice, spinning spinners and many more may help learners to develop ideas about randomness and chance. This will enable learners to make sense of probability, which may in turn improve their results.

1.2 Statement of the problem

Although research and classroom experience had produced more publications based on teaching and learning of probability, there are still significant challenges regarding probability content and a need for proper instructions to build on learners' existing notions and intuition of probability in order to foster more formal probabilistic understanding (Jones, 1996).

Xiayan (2015) notes that, teaching the concept of probability is difficult due to a low degree of abstractness and generality as well as teachers' insufficient theoretical studies and inexperience with probability. Dollard (2011) notes that, most of the teachers have little or no experience hence tend to be less comfortable when teaching probability. Dollard asserts that many teachers believe that teaching probability is difficult, and they do not view hands-on activities and games as something that may induce learners' understanding.

Most studies have focused only on teachers' understanding of the meaning of probability while others have focused on misunderstanding of basic concepts related to probability (Dollard, 2011). However, only few studies have focused on learners' understanding of probability such as Nicolson (2005).

Mathematics has been one of the compulsory subjects in the Namibian school curriculum since 2012 (Ministry of Education, 2010b). In addition, mathematics is also one of the requirements for admission to science and science related fields at institutions of higher education (University of Namibia, 2013). Furthermore, the Ministry of Education's (2013, 2014) reports on the Grade 12 examination indicates that learners studying mathematics on extended level find it difficult to answer questions on probability in Paper 4. If unaddressed, this situation could compromise the performance of learners hence a need for an intervention. This study was therefore carried out to determine the effects of integrating hands-on games in the learning of probability and their effects on the performance of Grade 12 mathematics extended level learners in the Oshana region on probability.

1.3 Research Hypotheses

In this study, the following hypotheses were tested at the significant level of $\alpha = 0.05$:

H₀: There is no significant difference in the Grade 12 mathematics learners' mean scores of performance on probability between those who were taught using hands-on games and those taught using the traditional method only ($\mu_1 = \mu_2$).

H₁: There is a significant difference in the Grade 12 mathematics learners' mean scores performance on probability between those who were taught using hands-on games and those taught using the traditional method only ($\mu_1 \neq \mu_2$).

1.4 Significance of the study

The findings of this study may provide evidence and information on the effects of integrating hands-on games in the learning of probability and on the performance of

Grade 12 mathematics learners on probability. This may contribute to the enhancement of the teaching and learning of mathematics in Namibian schools. The use of hands-on games might increase learners' interest in studying mathematics, which might result in improved learners' performance, especially on probability, which is often regarded as a difficult topic in mathematics. This study might also enable mathematics educators and other education stakeholders to gain a better understanding of the need to use games in the teaching and learning of school subjects as a means of enhancing learners' performance. The findings of this study also narrowed the gap in the research literature on probability as well as provided mathematics educators and learners especially educators in the Oshakati Cluster with information on the best ways to teach and learn probability.

1.5 Limitations of the study

Firstly, the ability of the learners to successfully play and finish hands-on games in the given time and repeat it as well as the time taken for learners to master hands-on games and use these to solve given problems was a challenge. Some learners could not master the hands-on games; hence, they were unable to correctly apply them in solving mathematical problems given. Secondly, the interest of learners in playing hands-on games such as play cards, tossing coins, rolling dice and drawing balls and number cards from bags or bowl and familiarity with them was also another limitation to this study.

1.6 Delimitations of the study

Firstly, this study was based in Oshakati Cluster in the Oshana region. Therefore, the results may not be generalised across the whole country (Namibia). Secondly, this study was restricted to Grade 12 extended level mathematics learners from the Oshakati Cluster schools in the Oshana Education region in 2017. Furthermore, the results are

only to be generalised to the teaching and learning of probability in mathematics in these schools. However, other schools may learn a few examples from the study, and apply in their teaching of probability.

1.7 Definition of terms

To avoid any ambiguities that may arise in the research, the following key terms are defined based on the context of this study:

Effects refer to a change which is a result or a consequence of an action (Steinmayr, Meibner & Wirthwein, 2014). In the context of this study, the term effect refers to the action which can be the instructional method or the changes hands-on games had on Grade 12 learners' performance in extended level mathematics.

Equal possibility refers to the chance of every event to be the same (Xiayan, 2015). In this study the term "equal possibility" refers to the situation whereby an object is selected from the remaining available units at the time of selection the unit, the probability is equal.

Hands-on games refer to structured activities and learning tools where students are physically involved that have cognitive objectives based on mathematics and directly related to understanding of mathematics (Al-Mashaqbel, & Al Dweri, 2014; Rowe, 2007; Ferguson, 2014). In this study, hands-on games refer to physical learning tools that learners use in order to do mathematics activities and enable learners to understand mathematics concepts and its application in real life.

Learning refers to the transformation process of acquisition and creating knowledge and skills leading to the permanent change in a person's knowledge or behaviour due to

experience over a period of time. The acquired knowledge and skills can be used and applied in life situations (Al-Mashaqbel, & Al Dweri, 2014, Brown, Roediger, & McDaniel, 2014). In this study, the term “learning” refers to the ability of learners to correctly solve mathematical problems and apply skills in real life situations because of teaching.

Manipulatives refers to physical objects that are used as teaching tools to engage learners in a hand-on learning mathematics. They can be purchased from stores, brought from home, or can be made by teachers and learners (Ruzic & O’Connell, 2001). In this study “manipulatives” can be interchangeably with hands-on games as they are all teaching tools learners use in order to do mathematics activities and understand mathematics concepts and its application in real life.

Performance refers to an extent to which a student has accomplished specific learning objectives that were the focus of activities in an instructional environment specifically schools (Steinmayr, Meibner & Wirthwein, 2014). In this study, performance refers to the scores of the Grade 12 learners in extended level mathematics test: pre-test and post-test.

Probability refers to a study of rule of random phenomenon or chance or likelihood of an event to occur (Taylor, 2011; D’Emiljo, 2006). In this study probability refers to the branch of mathematics that deals with calculating the likelihood of given events to happen or not happen.

Random events refer to the unpredictable likelihood of one or more outcomes to be or not to be under a certain condition (Xiayan, 2015). In this study random events refer to the probability of an event either to happen or not to happen at given trail.

Traditional instruction refers to common teacher-centred instruction such as numerical drill, worksheets, textbook driven and teacher-centred instruction (Al-Mashaqbel, & Al Dweri, 2014; Rowe, 2007). In this study traditional instruction refers to the ordinary way of teaching whereby the teacher explain, demonstrate and discuss without using tools that give learners a chance to explore, interact and construct knowledge themselves.

CHAPTER 2

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This chapter presents the overview of the theoretical framework and the literature that underpins the study. The chapter commences by presenting the theoretical framework, the history of manipulatives or use of hands-on games, the hands-on games activities in probability as well as the benefits of using manipulatives such as hands-on games and ends with the summary of the chapter.

2.1 THEORETICAL FRAMEWORK OF THIS STUDY

According to Taylor (2011), probability is the branch of mathematics that describes randomness. The conflict between probability theory and learners' view of the world is due to learners' limited contact with randomness. Thus, learners need to be provided with instructions that promote the study of chance to provide them with experience on the random behaviour in the mathematics classroom (see Figure 1 below).

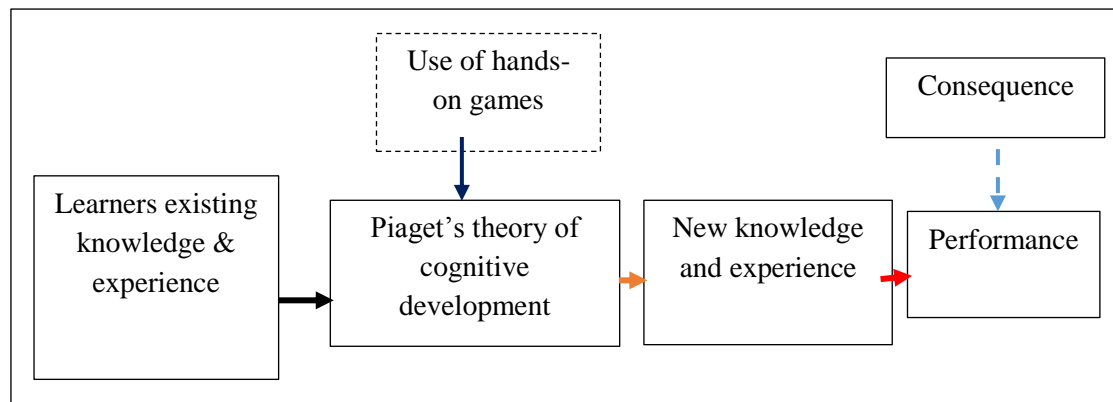


Figure 1: Diagrammatic presentation of the framework for the study (Adopted from Ojose's application of Piaget's cognitive development theory in mathematics learning).

In addition, Xiayan (2011) and Dollard (2015) indicate that learning probability needs inductive thoughts and probability uses induction as the basic research method.

Probability features an opportunity of gaming that provides learning process (Xiayan, 2011). Furthermore, Ojose (2008) notes that, learners' cognitive development in mathematics instruction is based on the application of Piaget's theory, and depends on hands-on experience and multiple ways of representing a mathematical solution. All these imply that hands-on game activities are of great importance in providing learners an avenue to make abstract ideas concrete, allowing learners to get their hands on mathematical ideas and concepts as useful tools for solving problems as indicated in Figure 1.

Ojose (2008) further added that due to the need of concrete experience in learning, teachers need to use manipulatives such as dice, spinners, cubes and coins in their instruction to allow their learners to explore concepts. Once learners are physically involved in playing hands-on games they acquire experience that lays the foundation for more advanced mathematical thinking and builds their mathematical confidence (Ojose, 2008).

Ojose (2008) points out that, learners find it difficult to automatically link probability to its activities. Hence it is important for teachers to provide various mathematical presentations that will help learners make connections and facilitate learning, taking into consideration the uniqueness of learners (Ojose, 2008). Furthermore, knowledge of Piaget's stages can help teachers understand the cognitive development of learners as teachers plan cognitive stage-appropriate activities to keep learners active and fully engaged in learning. Therefore this study was informed by Piaget's theory of cognitive development informs this study.

2.2 LITERATURE REVIEW

2.2.1 Teaching and learning of probability

Grinstead and Snell (2012) indicate that, probability theory began in the seventeenth century with French mathematicians based on games of chance. Probability continued to influence early research until it was a well-established branch of mathematics that has applications in every area of scholarly activity in daily experience. Dollard (2011) explains that high school probability were teachers are likely to use random chance devices like dice and spinners is described in terms of equally likely outcomes and defines probability as the ratio of desired outcome to total possibility outcome.

Nicolson (2005) and Taylor (2011) indicate that, the development of learners' mathematical reasoning through the study of probability is essential in daily life as probability offers the fundamental theory for the development of statistics and problem solving in science and mathematics related fields. Probability presents real-life mathematics and connects main areas of mathematics such as counting, statistics and geometry. Probability is also used in medicine such as in predicting the risk of new medical treatments (Grinstead, & Snell, 2012). This indicates that educators need effective ways of teaching probability, thus need of this study.

The understanding of probability is essential in understanding politics, weather reports, genetics, sports and insurance policies. Thus probability enhances learners' problem solving skills (Taylor, 2011). Taylor further emphasises that learning probability can contribute to learners' conceptual knowledge of working with data and chance which can help learners in making correct decisions as they go through life issues such as fairness, questioning and searching for relationships when solving real-world problems.

Studies by Nicolson (2005) and Taylor (2011) emphasise the importance of teaching and learning probability. They note that probability theory plays a major role in modern society both in the daily lives of the public at large and in the professionals' activities within the society. Thus, probability theory calls upon many mathematical ideas and skills developed in other school subjects such as set, mapping, numbers, counting, graphs and enables learners to work in branches of mathematics, which are relevant to current life situations.

2.2.2 History of manipulative or use of hands-on games.

Ruzic and O'Connell (2001) indicate that hands-on games as part of manipulative objects began ancient times when people of several different civilizations used physical objects to help them solve every day mathematical problems. South West Asians used counting boards (wooden or clay covered in thin layer of sand). In the late 1800's, mathematicians invented manipulative-maneuverable objects that were specifically designed to teach mathematical concepts. Around 1837, the German educator Friedrich Froebel designed and introduced the educational play material "Froebel Gifts or Frobelgaben" which includes geometric building blocks. Manipulatives then became more popular and considered essential in the teaching of mathematics, several educational researchers have shown the significant difference they make once integrated in teaching of mathematical concepts in comparison to other methods since 1900's (Ruzic & O'Connell, 2001).

2.2.3 Use of hands-on games and activities in probability

Taylor (2011) indicates that many high school learners find it difficult to understand probability. He points out inadequate pre-requisite mathematical skills and abstract reasoning as well as lack of instruction that enables learners to be actively engaged in

learning in which they can discover and construct their own understanding of probability concepts as some of the factors that contribute to the perceived difficulty of probability.

According to Xiayan (2011), teachers need to use multimedia and provide rich real life situations and games to facilitate learners' understanding of probability. Xiayan notes that lack of learners' interest to learn probability is due to lack of understanding the historical background and practical application of probability. Hence introducing situations such as games in the mathematics classroom can arouse learners' interest in learning and thus deepen their understanding of probability.

Ojose (2008) and Budimir (2016) emphasise that implementing random phenomenon, such as games of chance like tossing coins, rolling dice and drawing candy from a bag, is a good way to acquire understanding of mathematical principles in probability learning. This approach is important for learners to gain basic knowledge, develop logical thinking, and acquire skills of recognising, describing and solving real life problems by probability methods.

Nicolson (2005) describes some instructional hands-on games that can be used to understand randomness and chances of events such as tossing coins, rolling dice, drawing from candy bags and spinning spinners. These are quick and basic experiments to do in probability lessons. Even though learners may have a potential to be bored, as they may have been exposed to this games, offering small variations to the standard experiments create learners' interest to think again and learn in the process.

Several studies (Nicolson, 2005; Dunn, 2005) explain that dice are used to determine and understand the probability of simple events, assuming equally likely outcomes.

Learners are allowed to roll dice several times, record the number of times each number (1 to 6) comes up and discuss the results. Tossing coins involves throwing a coin in the air; the coin will turn a number of times in the air and land randomly “heads or tails”. This is done to seek and find explanation and interpretation of equally likely outcomes. Drawing candy from the candy bags is used to demonstrate the chances of pulling out candy depending on numbers of their particular types in the bag compared to other candy types. These help learners to understand the probability of independent and dependent events.

They further describe spinning spinners as a common tool for exploring and understanding classic probability. For each spinner, learners use a circle divided into six equal parts and a paper clip twirled around the point of a pencil. They repeatedly spin and shade the area where it stops. These enable learners to predict the next possible outcomes. Those hands-on games can be used to create random, equally likely outcome for experiments in probability, thus help learners to understand probability and form the connection between mathematics and real life situations. These hands-on games are used to create random and equally likely outcomes for experiments in probability.

Xiayan (2011) indicates that underachievement in mathematics is an ongoing worldwide concern. He points out that learners begin elementary mathematics lacking motivation which continues to secondary school level which yields poor performance. Part of the reason may be due to poor attitudes toward mathematics and poor teaching strategies in mathematics. Therefore, to remedy poor motivation and increase learner achievement, teachers need to be aware of and implement best teaching practices by incorporating games in mathematics instruction.

2.2.4 The benefits of using manipulatives such as hands-on games

Naresh (2014) indicates that there are difficulties related to topics such as randomness, sample space, conditional and independent probability. Naresh further emphasise that mathematics curricula denote a set of ideas that learners are taught and expected to learn. Therefore, teachers need to develop a strong, coherent, and intuitive pedagogical knowledge as well as simulation tools that will enable them to teach successfully and make learners to understand probability concepts.

Nareh's study used games such as the Game of Plinko (a game of chance) and the Game of Pachisi (originated in India involve two dice and four players) that shows significant difference. Hence, emphasising the importance of tools or game activities set in everyday context or cultural context as they help learners to establish connections between probability content, context, and culture. This creates an in depth exploration of probability concepts, allow learners to discover the importance of studying mathematics and its application which enhance learners interest, learning and improve learners' performance.

Boggan, Harper and Whitmire (2010) indicate that even though National Council of Teachers of Mathematics (NCTM) has encouraged schools to use manipulative in mathematical instruction, teachers are reluctant to plan, construct and use them in their lessons. This is despites the fact that the same study educational researches indicated that the most valuable learning occurs when learners actively construct their own mathematical understanding which is often accomplished through the use of manipulatives. It is therefore important for learners to engage with a variety of material

to manipulate and have opportunity to sort, classify, weigh, stack and explore if they are to construct mathematical knowledge.

Research from both learning and classroom studies indicated that if manipulatives such as hands-on games are carefully designed, selected, planned and fit the mathematical ability of the learners at level used they can help to teach mathematics and can positively affect learners' learning at all levels of ability (Arnold, 2015; Ruzic & O'Connell, 2001). This implies that mathematics teachers need to carefully plan their lessons and use hand-on games appropriately in order to enhance their learners' knowledge and understanding of mathematical concepts.

Using various hands-on provide an exciting classroom environment, promotes learner positive attitude toward mathematics learning and greatly reduce anxiety (Ruzic & O'Connell, 2001). Arnold (2015) and Ruzic and O'Connell (2001) emphasise that apart from enhancing mathematical learning, learners are also given a chance to reflect on their past experience. Further, emphasise that hands-on games can be successfully used in introducing mathematics lessons, practice or remediate mathematical concepts in mathematics instruction. This will only be possible if the games are appropriate for the learners and have been chosen to meet specific goals in order to increase learners' mathematical thinking and understanding instead of learners simply moving the manipulative objects around.

2.3 Summary

The reviewed literature indicates that the use of manipulative objects began ancient times (Ruzic and O'connell, 2011). Literatures support the use of hands-on games in the mathematics instruction. Valuable learning occurs when learners actively construct their own mathematical understanding which is accomplished through the use of manipulatives (Boggan, Harper & Whitmire, 2010). Literature also revealed that simply integrating hands-on games in mathematics lessons is not enough; teachers need to correctly plan and develop hands-on games based on lesson objectives in order to teach successfully and make learners to understand probability and other mathematical concepts.

In Namibia context, few researches have been done on the use of manipulative objects in mathematics beside probability being a challenging topic (Ministry of education, 2013, and 2014). Therefore, this study sort to determine the effects of integrating Hands-on games in the learning and their effect on the performance of learners in extended level mathematics. The next chapter discusses the methodology used in this study.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter outlines the methodology used in this study. It discusses the quasi-experimental design, how the research site and study participants were selected. The chapter also explains the instruments and methods used in collecting the data for the research. The data analysis procedures that were followed and research ethics taken into consideration are also discussed in this chapter.

3.1 Research design

This study utilised the quantitative approach to data collection and analysis. In quantitative research design, experimental design typically involves a comparison of two variables as well as testing the hypothesis to establish cause-effect relationship between variables (Cohen, Manion, & Morrison, 2011; Gay, Mills, & Airasian, 2011). Experimental design involves the random assignment of participants in order to ensure that every element of the population has an equal chance of being selected. This is done to produce comparison groups that are similar on all possible factors at the beginning of the experiment. In addition, random assignment allows the researcher to make a strong claim about the cause and effect and to generalise the findings to a known population (Johnson & Christensen, 2012). The researcher manipulates independent variables, controls the other variables and then observes the effects on the dependent variables (Creswell, 2014; Gay, Mills & Airasian, 2009). This study followed the quasi-experimental, pre-test-post-test control group design which require at least two groups, the experimental and control group which are formed by random assignment of participants in order to avoid a perception of unfairness toward learners in the treatment and those in the control group. The quasi-experimental pre-test-post-test control design

was selected to determine the effects of integrating hands-on games (HOG) in the learning and their effects on the performance of Grade 12 Extended Level Mathematics learners in Oshakati cluster of Oshana region on the learning probability by these learners.

The two groups were given a pre-test followed by different treatments and then a post-test using the same test in order to measure the effect of hand-on games (an independent variable) on the learners' performance in probability (dependent variable) (Borg, Gall, & Gall, 1999).

The two groups were taught by the researcher himself, given same teaching materials, examples and activities. The two groups varied with the teaching approaches. The experimental group was taught using traditional method (talk and chalk) plus hands-on games while the control group was taught using traditional (talk and chalk) approach only. Figure 2 below represents the pre-test-post-control design.

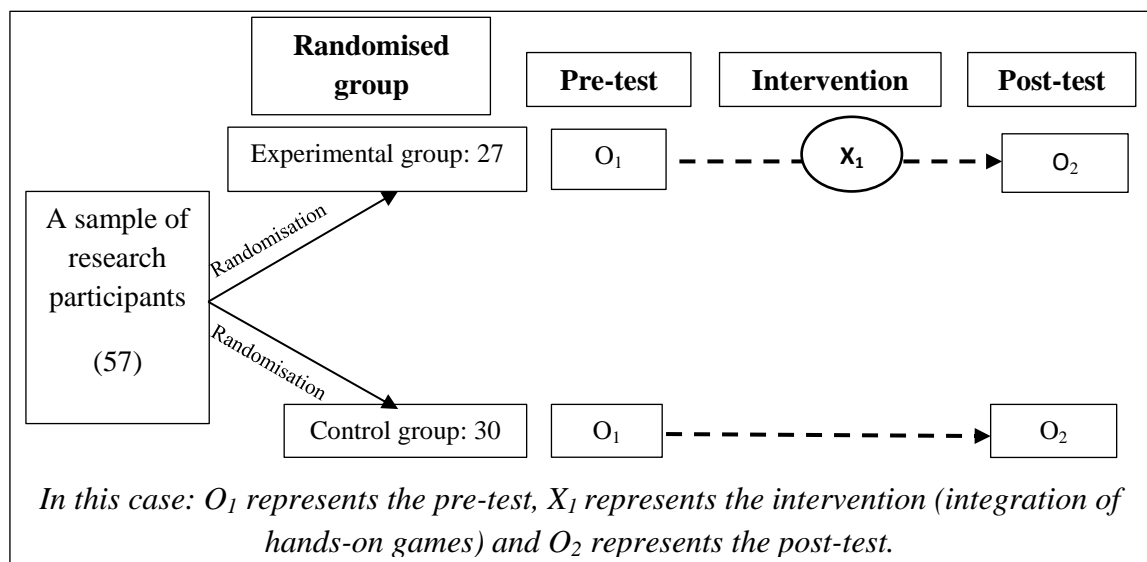


Figure 2: The diagrammatic representation of the pre-test-post-test control group design

3.2 Population

A population is a large group from which a sample is selected and to which the researcher generalises the results (Creswell, 2014; Gay, Mills, & Airasian, 2011). The population of this study comprised of all the Grade 12 learners doing Mathematics extended level in Oshakati Cluster, Oshana Education region in 2017. There are three secondary schools in Oshakati Cluster but only two of those secondary schools had learners registered for extended level in 2017.

3.3 Sample and sampling procedures

The sample refers to a subset of or number of individuals selected from a population that represents that specific population, while the sampling procedure is the process of selecting the sample (Gay, Mills & Airasian, 2011). In an experimental research at least 15 individuals per group are needed (Cohen, Manion, & Morrison, 2011; Charles, & Mertler, 2002; Creswell, 2014). This study focused on Oshakati Cluster in Oshana Education Region which only consists of three secondary schools, the sample comprised 60 Grade 12 mathematics extended level learners from three Secondary Schools in the Oshakati Cluster.

The three schools were assigned pseudonyms (schools A, B and C). School B only had 2 learners registered for extended, and did not interest in the study, School C did not have learners registered for extended and School A had 58 learners registered for extended. Because school B learners did not show interest and school C could not participate because there was no learners doing extended, only the 58 learners from school A participated in the study. Learners were randomly assigned into two groups: 28 formed an experimental group and 30 formed a control group. Learners were assigned

pseudonyms A1 up to A58. All participants were selected from schools of Oshakati Cluster, Oshana Region with almost similar characteristics in terms of the location, school situations and all learners were doing mathematics extended level. The study was conducted at school A and most of the learners were residing in the school hostel which made it easier to come for classes on Saturdays and Sundays morning's time. The study pre-test started with 57 learners because one learner withdrew from the study: the experimental group with 27 and the control group with 30 learners. Some learners withdrew after the pre-test, during the study which reduced the experimental group to 23 learners and the control to 23 learners. Hence in total, only 46 learners participated in the study.

3.4 Research instruments

The instruments used in this study were the pre- and post-tests. Reed and Bergemann (1991) describe a test as a benchmark to assess learning and determine how the learners perform. The scores of the tests are used by the researcher to compare the mathematical performance of the experimental and control groups (Cohen, Manion, & Morrison, 2011). The instruments used in this study were the two tests, pre-test and post-test. The researcher developed the mathematics test based on the syllabus' specific learning objectives on probability which were part of lesson presentation. The tests were based on the content of probability, but questions that were reshuffled in the post-test to minimise learners' memorisation. Marks or scores gathered allowed the researcher to calculate the averages, perform t-tests and compare them to determine the effects of the intervention. Each test was out of 35 marks and lasted for 1 hour.

3.4.1 Validity and Reliability

Gay, Mills and Airasian (2011) define experimental validity as the degree to which results obtained are due to only the manipulated independent variable and whether results are generalizable to individuals or contexts beyond the experimental setting. Reliability of the study can be referred to as the consistency of the scores obtained from one administration of an instrument to the other and from one set of items to another (Fraenkel, Wallen & Hyum, 2012).

This study was conducted based on extended level mathematics learners and results produced are applicable to other NSSCO extended level mathematics learners in Oshana region since the syllabus used is the same and learners are of the same characteristics. Therefore the study yielded recommendation of further research in other regions.

Learners in the control and experimental group were of mixed ability as they were not taught mathematics by the same teacher at their specific school and randomly assigned into groups. So the groups were of similar characteristics. The pre-test results, the average performance also indicated that the groups were equivalent before the study. The same test: test-retest was administered to both experimental and control group. This means that same test was given to both groups during the pre-test and the post-test.

3.5 Data collection procedures

After obtaining permission from the Permanent Secretary of the Ministry of Education and the Director of Oshana Education region as well as from the school principal at the school where the study was conducted, the researcher obtained the names of the learners doing Mathematics on extended level at Oshakati cluster secondary schools. School B only had 2 extended learners which did not show interest in the study while school C did

not have any learner registered for extended therefore the study was comprised of students from school A only. The researcher then randomly assigned participants to the experimental and control groups. The participants were given pseudonyms to protect their identity and use the codes during the study. The pre-test was administered and the results of the individuals were recorded. After this, the experimental group was given an eight-hour teaching using manipulatives. Finally, the post-test was administered and the results of the individuals were recorded again. The results from both tests were analysed using inferential statistics.

3.5.1 Mathematics Pre-test and Post-test

As indicated by Gay, Mills, and Airasian (2011) and Reed and Bergemann (1991) data was gathered using the pre-test and post-test. Pre-testing both groups was administered to establish equivalence of the groups before intervention. The mathematics' same test, test-retest score were used to determine whether a significant difference existed between the scores of the experimental group and control group. The researcher developed the mathematics test based on the syllabus' extended level specific learning objectives on probability. This topic was selected because learners tend to perform below average in it (Ministry of Education's, 2013 & 2014). In addition, it was selected because it is independent or does not require a lot of prerequisite knowledge from other topics in the syllabus, which enabled the researcher controlled for maturation as a threat to the validity of this study. The researcher requested the head of department from the specific school to moderate the test in order to ensure its validity.

3.5.2 Lessons or Interventions

The experimental group and control group participants were differentiated and taught in their respective groups using different approaches. The lessons were planned and taught based on the objectives in the mathematics NSSC (O) syllabus. The lessons were conducted during the weekends for four weeks amounting to 8 hours. This was done in a short period of time in order to minimise the history threat to validity. Subsequently, with a help of two invigilators the post-test was administered in separate classrooms at same time for the same duration the same way participants were pre-tested.

3.5.3 Experimental group

Interventions in the experimental group were done using the traditional (talk and chalk) approach plus the integration of hands-on games to explain probability concepts in certain activities. This allowed learners to interact and be engaged which enhance learning. This is an induction approach where gaming provides learning process (Xiayan, 2011). Ojose (2008) argue that the learners' cognitive development and construction of knowledge and understanding in mathematics based on Piaget's theory, depends on hands-on games experience and multiple ways of representing a mathematical solution. The researcher explained that general rules to be followed during the intervention including the necessity of attending lessons, participation in all the learning activities constructively and collaborating with others as well as asking questions. The researcher clearly explained to the participants the objectives from the syllabus to be addressed during the study and then began teaching learners starting with the general introduction of the topic especially basic knowledge, which falls under core level. Participants were given copies of the notes to be used during the study.

Each lessons lasted for one hour. The first and the second Saturday and Sunday were based on the theoretical teaching parts and explanation. The researcher used the traditional approach first with ordinary explanatory, demonstration, discussion with the researcher as a teacher and questions and answer method. After that, leaners were grouped in groups of seven to solve the activities using hands-on games. These Hands-on games were cards with letter of word mathematics followed by questions on probability of letters in that specific word. The play cards allowed them to draw tree diagrams of independent and dependent probability, and to solve specific questions. Rolling of an individual dice as well as rolling two dices allowed learners to draw up the probability spaces. The last hand-on game was done using marbles. In this game, participants had to randomly choose, replace, or not replace balls of different colour from the bag and draw up tree diagrams. The researcher distributed worksheets to be completed during every game played. After participants had answered questions in their respective groups, one of the group members had to present and demonstrate clearly how they arrived at each specific answer. The errors and misconceptions made by groups as well as questions were noted by the researcher and thereafter discussed by the whole class for corrections. Participants were given copies of the notes to be used during the study.

3.5.4 Control group

Lessons for the control group were done using the traditional approach only with ordinary explanatory, demonstration, discussion with the researcher who is the teacher at same time and questions and answer method for participants to learn and understand probability concepts. Participants were also allowed to group themselves where necessary in order for them to interact and be actively engaged which enhanced learning.

This is a deductive approach where participants are given full theoretical knowledge and asked to apply it to solve mathematical problems. As it was done to the experimental participants, the researcher explained general rules to be followed during the intervention, which included the necessity of attending lessons, participating in learning activities constructively and collaborating with others as well as asking questions. The researcher clearly explained to the participants the objectives from the syllabus to be addressed during the study and then began teaching with a general introduction of the topic especially basic knowledge which falls under core level. Participants were given copies of the notes to be used during the study.

Each lessons lasted for one hour. The researcher used the traditional approach only with ordinary explanatory, demonstration, discussion with the researcher as a teacher and questions and answer method throughout. Participants were given activities similar to those given the experimental group where they solve probability problems individually or in group. Errors and misconceptions made by individual participants or groups as well as questions were noted by the researcher and thereafter discussed by the whole class for corrections.

3.5.5 Mathematics Post-test

After the four weeks of intervention, the experimental and the control groups wrote the post-test at the same time, for the same duration (one hour) in two separate rooms monitored by the invigilators. This post-test consists of the same number of questions and marks, and it assess the same content and difficulty level as the pre-test. The only difference between the pre-test and the post-test of the study lies in the fact that

questions were shifted in order to avoid memorisation from learners as they were exposed to the same questions during the pre-test.

3.6 Data analysis

In experimental research such as this study, the researcher has to determine whether the treatment (the use of traditional method and integrating hands-on games) made a significant difference in the performance of learners in probability as compared to learners using the traditional method alone. To test the hypothesis and make valid conclusions, the researcher made use of inferential statistics (Creswell, 2014; Gay, Mills, & Airasian, 2011). This study used a t-test to determine whether a significant difference existed between the two groups at a selected probability level $\alpha = 0.05$ which is mostly used in education research (Creswell, 2014; Gay, Mills, & Airasian, 2011). Figure 3 shows the rejection and acceptance regions of two tailed curve at $\alpha = 0.05$.

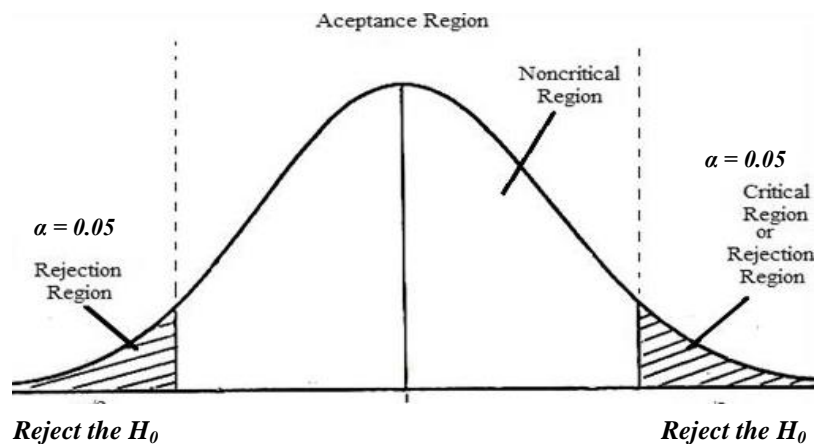


Figure 3: The standard normal curve showing the rejection and acceptance regions

A series of t-test calculations were carried out to test for significance in the mathematics pre-test results of the control and the experimental group to determine whether the groups were equivalent prior to the study. Calculations were done using the following

formulae: Calculations were done using the following formulae: $Mean = \bar{X} = \frac{\sum X}{N}$,

$S_1^2 =$ variance of an experimental group, $S_2^2 =$ variance of the control group,

$Variance = S^2 = \frac{N (\sum X^2) - (\sum X)^2}{N (N - 1)}$, $S_1 = SD_1 = \sqrt{S_1^2} =$ standard deviation of an

experimental group, $S_2 = SD_2 = \sqrt{S_2^2} =$ standard deviation of the control group, degree

of freedom (df) = $N_1 + N_2 - 2$ and the

$t_{calculated} = \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}}$, $S_1^2 =$ variance of an experimental

group, $S_2^2 =$ variance of the control group, $Variance = S^2 = \frac{N (\sum X^2) - (\sum X)^2}{N (N - 1)}$,

$S_1 = SD_1 = \sqrt{S_1^2} =$ standard deviation of an experimental group, $S_2 = SD_2 = \sqrt{S_2^2} =$

standard deviation of the control group, degree of freedom (df) = $N_1 + N_2 - 2$ and the

$t_{calculated} = \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}}$. Intra-group comparisons were then

made in each group to compare the pre-test results to post-test results. Finally the t-test was calculated to determine whether there was a significant difference in the post-test mean scores of the experimental and control groups. This provided statistical evidence that allowed the researcher to accept or reject the null hypothesis. The degree of freedom (d) and the significant value ($\alpha = 0.05$) allowed the researcher to obtain the t-critical

value from the t-table. Getting the t-calculated value greater than the t-critical value at $\alpha = 0.05$, the researcher then reject the H_0 and accepts the H_1 , meaning that there is a statistically significant difference in the pre-test and post-test mean scores of the experimental and the control groups on probability.

3.7 Ethical considerations

Upon receiving the ethical clearance from the Centre for Research and Publications Office of the University of Namibia, the researcher obtained permissions to conduct the research from the Permanent Secretary of the Ministry of Basic Education, Arts and Culture, the Director of the Oshana Educational Region and principals of the selected secondary schools. The researcher started with the study in the Oshakati Cluster schools after permission from the Permanent Secretary and the Director of Oshana Education region was granted (see Appendix A to F).

Pseudonyms were used to refer to the schools and students such as School A, B and C or learners A1, B1, etc. to safeguard their identities. The researcher clearly explained the purpose and procedure of the research to participants and participants then signed the consent form. Prior to the data collection process, parents received and signed parental consent for the learners who were 16 years or younger. Participants above the age of 16 voluntarily participated. The participants were guaranteed confidentiality and anonymity as well as given the right to refuse to participate or to withdraw at any stage of the study without penalty. Pre-test and post-test papers were safely stored and all marks and calculation were typed and stored in the memory stick to be disposed (test papers burned) some months after the completion on the study.

3.8 Summary

This chapter discussed the research methodology in terms of the research design, specifying the population of the study and the methods used to select the sample from the population. The chapter also discussed the research instruments, the pre-test and post-test used to gather data from the learners. The chapter concluded with the data collection procedure, data analysis as well as the ethical considerations.

CHAPTER 4

PRESENTATION AND DISCUSSION OF RESULTS

4.1. Introduction

In this chapter, the data collected from the pre-test and post-test are presented and discussed. The study sought to determine the effects of integrating hands-on games in the learning of probability and their effects on the performance of Grade 12 extended mathematics learners' understanding of probability in Oshakati Cluster schools of Oshana region.

4.2 Biographical information of the participants

Fifty seven Grade 12 learners registered for extended level at Oshakati Cluster schools in the Oshana region participated in the study. The experimental group comprised 27 learners and the control group comprised 30 learners (see Table 1).

Table 1: Shows the biographic information of the participants

Gender	Groups		Total
	Experimental	Control	
Male	19	13	32
Female	8	17	25
Total	27	30	57

The experimental group comprised 19 male learners and 8 female learners while the control group had 13 male learners and 17 female learners totaling 57 learners. This indicated that many male learners registered for extended level mathematics compared

to females as reflected in Table 1. All 57 learners were pre-tested. Eleven learners withdrew because they were non-border and had transport problem to come for lesson on Saturdays and Sundays. Hence only 46 learners were post-tested, 23 learners from each group.

4.3 The effects of hands-on games on the performance of Grade 12 learners in extended level Mathematics on probability

To measure learners' performance, a pre-test and a post-test were administered. The pre-test was administered before the intervention and a post-test after the intervention. The scores of the pre-test and post-test for the experimental and control groups are given in Appendix N. The following main hypothesis was tested at $\alpha = 0.05$ to find out whether a significant difference existed between the scores of the experimental group and the control group.

H₀: There is no significant difference in the performance of the experimental and the control group.

H₁: There is a significant difference in the performance of the experimental and the control group.

These hypotheses were followed by other four sub-hypotheses that are presented in Tables 2 to 5. These sub-hypotheses were formulated as shown in Figure 4.

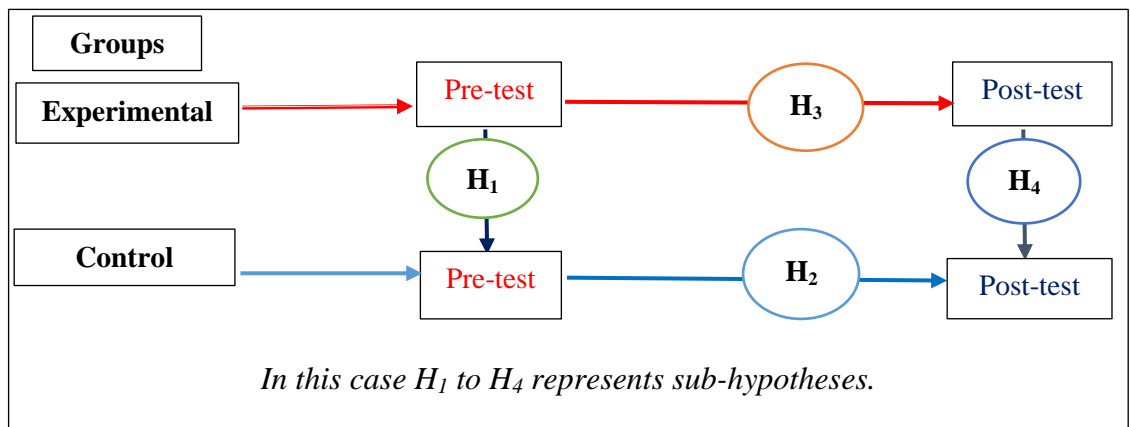


Figure 4: The diagrammatic representation of how hypotheses were formulated and data was analysed

To determine the effects of integrating hands-on games in the learning and performance of Grade 12 Extended Level Mathematics learners on probability, the following sub-hypotheses were tested:

H_0 : There is no significant difference in the pre-test mean scores of the control and the experimental groups.

H_1 : There is a significant difference in the pre-test mean scores of the control and the experimental groups.

Table 2 gives the performance of the two groups on the pre-test.

Table 2: Comparison of experimental and control pre-test results

Statistical value	Experimental group	Control group
Mean	7.85	8.20
Standard Deviation (SD)	1.99	2.04
Variance	4.0	4.2
t-critical		2.021
t-calculated		-0.6532

The t-test of the mathematics pre-test results with independent groups with degrees of freedom (df) = 55, using the level of significance for two tailed test, the statistical table value ($t_{critical}$) at $\alpha = 0.05$ level of significance was 2.021. The $t_{calculated}$ absolute value $|-0.6532|$ is less than the $t_{critical} = 2.021$. In addition, the pre-test of the experimental group scored the mean of 7.85 which is the closely similar that of the control group which scored 8.20, (see Table 2). Therefore the study fails to reject the H_0 and concludes that there is no statistically significant difference in the mean scores of the control and experimental groups at the beginning of the study. This means that the control and experimental groups were equivalent before the intervention.

Control group

After the mathematics probability pre-test, the control group was taught probability as stipulated by the learning outcome in the extended level mathematics syllabus of NSSCO using the traditional method (PowerPoint or chalk and talk) including explanatory, demonstrations and question and answer method. Learners were involved in individual and group work as well as encouraged to do extra activities and homework. Activities given were of the same type as the experimental group. The intervention

lasted four weekends and the post-test was administered thereafter. The t-test was calculated and the pre-test and post-test mean scores of the control group were compared as shown in Table 3, based on the following hypothesis:

H₀: There is no significant difference in the pre-test and post-test mean scores of the control group.

H₁: There is a significant difference in the pre-test and post-test mean scores of the control group.

Table 3 gives the results to test of the above hypothesis.

Table 3: The comparison of the control group’s pre-test and post-test results

Control group	Pre-test	Post-test
Mean	8.2	13.1
Standard Deviation (SD)	2.04	3.64
Variance	4.16	13.2
t- calculated		6.209
t- critical		2.021

Table 3 shows that at $\alpha = 0.05$ and degree of freedom (df) = 51, the t calculated = 6.209 and using the level of significance for two traileed test, the statistical table value $t_{critical}$ is 2.021. The $t_{calculated}$ is greater than the $t_{critical}$ value which shows that there is a statistical significant difference between the control group’s pre-test and post-test scores.

Experimental group

After the mathematics probability pre-test, the experimental group was taught the same probability content using traditional instruction approach supplemented with the integration of hands-on games. Same types of activities were given to the experimental group during the intervention, only that the experimental group used hands-on games: play cards, rolling dice, and drawing marbles (balls) from a bag. The intervention lasted four weekends and the post-test was administered thereafter. The t-test was calculated and compared to the pre-test as shown in Table 4, based on the following hypothesis:

H₀: There is no significant difference in the pre-test and post-test mean scores of the experimental group.

H₁: There is a significant difference in the pre-test and post-test mean scores of the control experimental group.

Table 4: The comparison of the results of the experimental group pre-test and post-test

Experimental group	Pre-test	Post-test
Mean	7.85	17.1
Standard Deviation (SD)	1.99	4.62
Variance	4.0	21.53
t-critical		2.021
t-calculated		10.036

With the degree of freedom ($df = 48$) and $\alpha = 0.05$ the critical value of the $t_{critical}$ is 2.021. Table 4 shows the t-test result of 10.036. The $t_{calculated}$ is greater than $t_{critical}$, therefore, the H_0 is rejected and concludes that there is a statistically significant

difference in the experimental group's pre-test mean scores compared to the post-test mean scores.

4.4 Comparison of Experimental and control groups performance on the post test

Based on the following hypothesis:

H₀: There is no significant difference in the post-test mean scores of the control and the experimental group.

H₁: There is a significant difference in the post-test mean scores of the control and the experimental group.

Table 5: Comparison of the post-test results of the experimental and control groups

Statistical value	Experimental group	Control group
Mean	17.1	13.1
Standard Deviation (SD)	4.62	3.64
Variance	21.53	13.2
t-critical		2.042
t-calculated		3.745

Table 5 shows that the calculated t-test value was 3.745 which is greater than $t_{critical} = 2.042$ at $\alpha = 0.05$ with $df = 44$. Therefore, the H_0 is rejected and the researcher concluded that there is a statistically significant difference in the post-test mean scores of the experimental and the control groups on the probability topic.

4.5 DISCUSSION OF THE RESULTS

The comparison of the experimental and control groups' performance (i.e., the mean scores on probability pre-test in Table 2) indicates that the mean scores of the control group of 8.20 and experimental groups of 7.85 are closer to each other. This shows that there were no significant difference between the experimental and control groups before the intervention. Therefore the two groups could be said to be equivalent at the beginning of the intervention.

Table 3 shows that the control group pre-test and post-test mean scores were 8.2 and 13.1 respectively. The $t_{\text{calculated}} = 6.209$ is greater than the $t_{\text{critical}} = 2.021$. This result indicates that there was a significant difference between the pre-test and post-test mean scores of the control group at 0.05 level of significance, with $df = 51$, after instruction on probability. This shows that the control group benefitted from extra teaching on the topic. Nonetheless, the significant difference between the pre-test and post-test may be due to the fact that as learners the pre-test may have inspired the control group to work harder which resulted in the higher performance on the post-test. Secondly, it is not possible to isolate the participants completely as two groups attended the same school, which made it possible for learners to mix during week days and share ideas resulting in the improved post-test results.

The results in Table 4 shows that the pre-test and post-test mean scores of the experimental group on probability of 7.85 and 17.1 respectively showed a significant difference at the 0.05 level of significance with $df = 48$ with the $t_{\text{calculated}} = 10.036$ greater than $t_{\text{critical}} = 2.021$. The 17.1 mean score of the experimental group's post-test achievement on the test was higher compared to the pre-test mean score of 7.85. The

better mean score on the post-test seems to suggest that the intervention resulted in significantly better performance on probability for the experimental group.

In Table 5 the results on the post-test of the experiment and control groups, with mean scores of 17.1 and 13.1 respectively, indicated that the $t_{\text{calculated}} = 3.745$ was greater than $t_{\text{critical}} = 2.042$. This shows that the post-test mean scores of the experimental and control groups were statistically different at 0.05, level of significance. Table 2 and Table 3 showed no significant difference in the mean pre-test scores of the control and experimental group as well as in the pre-test and post-test mean scores of the control group. Table 4 and Table 5, showed the significant difference in the mean scores of the pre-test and post-test of the experimental group as well as in the pre-test and post-test mean scores of the experimental group. This indicates that the experimental group performed significantly better than the control group on the post-test. The difference in the experimental pre-test and post-test mean scores as well as the mean scores of the post-test of the control and experimental group show that the difference may be attributed only to the intervention (the use of hands-on games) that was given to the experimental group. Thus the null hypothesis: “there is no significant difference in the Grade 12 mathematics learners’ performance on probability between those taught using hands-on games and those taught using the traditional method only” was rejected.

This means that the intervention administered on the experimental group, the use of traditional method with integration of hands-on games improved learners’ performance as compared to the traditional method which was administered to the control group. It is therefore important that the traditional method be supplemented by hands-on games in teaching mathematics in order to enhance learners’ understanding of the concepts.

4.6 CONCLUSION

The findings of this study indicate that there were no statically significant differences in the pre-test mean scores of the experimental and control groups before the intervention. This seems to suggest that the two groups were equivalent at the beginning of the intervention. The post-test results indicate a higher mean score for the experimental group compared to the control group. This shows that the integration of hands-on games in teaching probability at extended level had improved the learner's learning and performance on the topic, hence it could be concluded that use of hands-on activity improved students' grasp of the probability content in this study.

4.7 SUMMARY

This chapter logically presented the data collected from the pre-test and post-test of the study. The average performance (mean scores) of groups, standard deviation, degree of freedom, and t-calculated value were calculated. Calculated values were summarised and presented in tables, compared and discussed. This allowed the researcher to determine the significance of the difference between the experimental and the control group.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENTATIONS

This chapter summarises the study in terms of the statement of the problem, the research methodology and the major findings of the study. The chapter also includes conclusion, recommendations and suggestions for further research.

5.1 SUMMARY

This study investigated the integration of hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners' performance in the Oshakati Cluster of Oshana region.

The following hypotheses were tested:

H₀: There is no significant difference in the Grade 12 mathematics learners' performance on probability between those taught using traditional method with hands-on games and those taught using the traditional method only.

H₁: There is a significant difference in the Grade 12 mathematics learners' performance on probability between those taught using traditional method with hands-on games and those taught using the traditional method only.

The study comprised 57 extended level Grade 12 mathematics learners from three secondary schools in Oshakati Cluster in the Oshana educational region. Twenty seven learners were assigned randomly to the experimental and 30 to the control group.

All 57 learners were pre-tested on probability on the first day. Eleven learners withdrew after the pre-test, during the intervention, and only 46 learners were post-tested. The

experimental and control groups had 23 learners each. The mathematics pre-test and post-test on probability were used to test the effect of traditional method with the integration of hands-on games on the learners' performance.

The experimental and control groups were separately taught the same content on probability, using the same notes and activities by the researcher for four weekends (on Saturdays and Sundays). Each lesson lasted for one hour. The control group was taught using the traditional (chalk and talk) method only while the experimental group was taught using the traditional method with the integration of hands-on games.

The experimental group's post-test mean score was higher than the pre-test mean score, which indicates a significant difference in the use of traditional method with the integration of hands-on games on learners' performance in mathematics. The control group post-test mean score was 13.1 compared to 17.7 mean score of the experimental group after the intervention. This indicates a high mean score difference in the experimental group compared to the control group which can be attributed to the integration of hands-on games in the experimental group.

5.2 CONCLUSION

Based on literature, research and instructional experiences over years have resulted in a concerted effort to develop mathematics tools in addressing the challenges of mathematics teaching for improved performance. This study investigated the integration of hands-on games in the learning and performance of Grade 12 extended level mathematics learners on probability in the Oshakati Cluster schools, Oshana educational region. The mean score of the experimental group on the pre-test was 7.85 and that of the control group was 8.20 compared to the post-test mean score of 17.7 for the

experimental group and 13.1 for the control group. The integration of hands-on games in mathematics seems to have improved the performance of the extended level mathematics learners' performance in the Oshakati Cluster schools, Oshana Educational region. These findings provide strong evidence of the effectiveness of the use of hands-on games in improving learning and performance. The use of hands-on games in probability has a possibility of providing teachers with an effective method in facilitating teaching and learning of mathematics concepts.

5.3 RECOMMENDATIONS

Based on the findings of this study, the following are recommended:

5.3.1 Mathematics teachers should integrate hands-on games in their lessons on probability should they aim to improve their learners' mathematics learning and performance; because traditional methods alone are deemed to be too deductive, thus learners learn and perform more when they are actively involved with a variety of manipulatives.

5.3.2 Schools should purchase a variety of manipulatives such as marbles, dice and play cards for effective teaching of probability that teachers and learners can use in mathematics lessons to enhance learners understanding of probability and allow learners to link mathematics content to real life situations.

5.3.3 Mathematics teachers should also use different teaching approaches in teaching different mathematics topics. Teachers should be creative to develop attractive and educative hands-on games based on specific topics' competencies to facilitate learning and understanding of mathematical concepts.

5.3.4 Teachers' workshops on the integration of hands-on games in teaching mathematics are also recommended. Workshops can activate teachers' interests on the use of hands-on games, and enable teachers to incorporate hands-on games comfortably in their lessons, which will in turn to foster learning and enhance learners' performance.

5.3.5 Schools are recommended to have active Mathematics clubs equipped with useful manipulatives. These clubs can act as tools to stimulate learners' interests in learning mathematics. Additionally, they can provide a free environment where learners can apply classroom knowledge to solve mathematics problems. Through this, learners will gain more knowledge that they will be able to apply correctly when solving mathematics problems in assessments. Mathematics clubs may also provide a way of enjoyment for social and emotional development of learners. As a result, this may minimize the individual learner's stereotyping perception of perceiving mathematics as a difficult and boring subject.

5.3.6 Learners should be given opportunities to design hands-on materials. This will not only allow learners to demonstrate their understanding of subject content, but it may also enable learners to apply learnt knowledge in solving mathematical problems while enhancing their cognition for improved performance.

5.4 SUGGESTIONS FOR FURTHER RESEARCH

Based on the findings of this study, the following are suggested as areas for further research:

1. The population in this study was fairly small and based on one Cluster of one region. Thus the findings based on these participants may or may not be generalised to the population of learners in the region or country as whole. There is a need for research with large sample to determine the effect of hands-on games in the general population (whole region or country).
2. This study only focused specifically to Grade 12 extended level Mathematics learners in probability. Further research should be conducted to examine the effect of the integrating hands-on games in mathematics or other subjects at all levels using other challenging topics or concepts.
3. There are various manipulatives that can be used in mathematics depending on the topic. Research should be conducted on specific hands-on games or other manipulative materials on other topics of mathematics.

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Appendix A: Ethical clearance from University of Namibia Research Ethics Committee (UREC)



ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: FOE/179/2017

Date: 24 April, 2017

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: The Integration Of Hands-On Games In The Learning And Performance Of Grade 12 Extended Level Mathematics Students On Probability In The Oshakati Cluster, Oshana Educational Region, Namibia

Nature/Level of Project: Masters

Researcher: Setson Tangeni Abisai

Student Number: 200647849

Faculty: Faculty of Education

Supervisors: Prof. C D Kasanda (Main) Dr. S T Naukushu (Co)

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. P. Odonkor: UREC Chairperson

A handwritten signature in black ink, appearing to be "P. Odonkor", written over a horizontal line.

Ms. P. Claassen: UREC Secretary

A handwritten signature in black ink, appearing to be "P. Claassen", written over a horizontal line.

Appendix B: Letter to the Permanent secretary

Setson T Abisai

P O Box 11885

Oshakati

02 May 2017

The Permanent Secretary

Ministry of Education

Windhoek

**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT OSHANA
EDUCATIONAL REGION SCHOOLS**

Dear Madam Senat. I. Steenkamp

I, Setson T Abisai (200647849), an M. Ed. (Mathematics Education) student at the University of Namibia. I am requesting the Ministry's permission to conduct research in the Oshana Educational Region, Oshakati Cluster Secondary Schools in Namibia. The title of research is: *The integration of hands-on games in the learning of grade 12 Extended Level Mathematics and their effects on learners' performance learners' in probability in the Oshakati Cluster of Oshana Region.*, Professor C. D. Kasanda and Dr. S. T. Naukushu are my supervisors.

Information collected through the tests will be held in strictest confidence and will only be used for the purpose of this research. There will be no physical risks involved for those who will be participating in this study.

I would like to assure you that no class lessons will be interrupted during data collection process. Upon completing the study, I undertake to provide the Ministry with a final copy of the research study.

Attached on this letter is my ethical clearance from the University of Namibia Research Ethics Committee (UREC).

I am confident that my request will be viewed favorably and I look forward to your positive response.

Yours Sincerely

A handwritten signature in black ink, appearing to be 'Setson T Abisai', written in a cursive style.

Setson T Abisai (Student No: 200647849) (email: abisaist@gmail.com)

University of Namibia

Appendix C: Permission from the Permanent secretary



REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION, ARTS AND CULTURE

Tel: +264 61 -2933200
Fax: +264 61- 2933922
Enquiries: C. Muchila/ G. Munene
Email: Cavin.Muchila@moe.gov.na/gml2munene

Luther Street, Govt. Office Park
Private Bag 13186
Windhoek
Namibia

File no: 11/1/1

Mr. Setson T. Abisai
P O Box 11885
Oshakati
Email: abisaist@gmial.com

Dear Mr. Abisai


SUBJECT: PERMISSION TO CONDUCT RESEARCH IN OSHANA REGION


Kindly be informed that permission to conduct research for your Master's Degree in "*The Investigation of Hands-on Games in the Learning and Performance of Grade 12 extended Level Mathematics students on Probability in the Oshakati Cluster, Oshana Region*" in Oshana region is herewith granted. You are further requested to present the letter of approval to the Regional Director to ensure that research ethics are adhered to and disruption of curriculum delivery is avoided.

Furthermore, we humbly request you to share your research findings with the ministry. You may contact Mr C. Muchila/ Mr. G. Munene at the Directorate: Programmes and Quality Assurance (PQA) for provision of summary of your research findings.

I wish you the best in conducting your research and I look forward to hearing from you soon.

Sincerely yours


SANET L. STEENKAMP
PERMANENT SECRETARY


2017 -05- 0 5
Private Bag 13186
Windhoek, Namibia

5/5/17
Date

All official correspondences must be addressed to the Permanent Secretary

Appendix D: Letter to the regional director of education

Setson T Abisai

P O Box 11885

Oshakati

08 May 2017

The Director of Education

Oshana Educational Region

Private Bag 5518

Oshakati

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Mrs. H. Amukana (Director)/ Mr. G. Ndafenongo (Deputy Director)

I Setson T Abisai (ID: 87092200326), presently on the staff of Rev. Juuso Shikongo Secondary School and an M. Ed. student under the supervision of Prof. C. D. Kasanda (061 2063726) and Dr. S. T. Naukushu (065 232 3000). My research topic is: *The integration of hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners' performance in probability in the Oshakati cluster of Oshana Region.*

I am hereby seeking your consent to conduct the above educational research for my thesis in order to fulfil the M. Ed. requirements, to take place in Oshakati Cluster Secondary Schools during the course of June 2017. Sixty (60) participants representing Grade 12 mathematics extended level students will be part of this study. Every effort

will be made not to disrupt the daily functions of the schools as the research will be done after school hours or during weekends (Saturdays). Confidentiality and anonymity of participants will be maintained during and after this research.

I have attached a copy the Ethical Clearance Certificate from the University of Namibia Research Ethics Committee (UREC) as well as the permission to conduct research from the Permanent secretary, Ministry of Education.

Upon completing the study, I undertake to provide the Directorate with a bound copy of the full research report finding of the study.

If you require any further information, please do not hesitate to contact me on (cell: 081 3506568, email: abisaist@gmail.com).

I am confident that my request will be viewed favorably.

Yours sincerely

A handwritten signature in black ink, appearing to be 'Setson T Abisai', written in a cursive style.

Setson T Abisai (Student number: 200647849)

Appendix E: permission from regional director of education



REPUBLIC OF NAMIBIA



**OSHANA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE**
Aspiring to excellence in Education for All

Tel: 065 229800

Fax: 065 229833

Enquiries: Gerhard S. Ndafenongo

e-mail: ndafenongogs@gmail.com

Refno: 11/1/1

906 Sam Nuyoma Road

Private Bag 5518

Oshakati, Namibia

MR SETSON T. ABISAI

P.O. BOX 11885

OSHAKATI

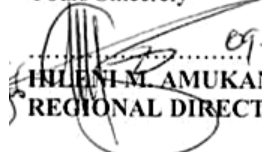
Cell: 0813506568, e-mail: abisaist@gmail.com

Attention: *Mr Abisai*

RE: PERMISSION TO CONDUCT RESEARCH IN OSHAKATI CLUSTER IN OSHANA REGION

1. I acknowledge receipt of your letter dated 08th May 2017 and therefore it bears reference;
2. Kindly be informed that permission is hereby granted to conduct the study entitled: **The integration of hands-on games in the learning and performance of Grade 12 extended level Mathematics students on probability in Oshakati Cluster**, within selected schools in Oshana Region. You are hereby requested to present this letter of approval to the principal of the selected schools to ensure that the research is authorised, authentic and procedures are adhered to.
3. This permission is subject to the following strict conditions; (i) There should be minimal or no interruption on normal teaching and learning, during a class or scheduled afternoon session, and (ii) Ethical issues of confidentiality and anonymity should be respected and retained throughout this activity i.e. voluntary participation, and consent from participants..
4. Both parties should understand that this permission could be revoked without explanation at any time.
5. Furthermore, we humbly request you to share with us your research findings with the Directorate of Education, Arts and Culture_ Oshana Region. You may contact Mr GS Ndafenongo, the Deputy Director: Programs and Quality Assurance (PQA) for the provision of summary of your research findings.
6. I wish you the best in conducting your study.

Yours Sincerely


HILENI M. AMUKANA
REGIONAL DIRECTOR



All correspondence should be addressed to the Director of Education, Arts & Culture

Appendix F: Letter to the school principal

Setson T Abisai

P O Box 11885

Oshakati

29 May 2017

To: The Principals of Oshakati Cluster Secondary Schools

RE: CONDUCTING A RESEARCH IN OSHAKATI CLUSTER SECONDARY SCHOOLS

Dear Sir/Madam

I Setson T Abisai (ID: 87092200326), presently on the staff of Rev. Juuso Shikongo Secondary School and an M. Ed. student under the supervision of Prof. C. D. Kasanda (061 2063726) and Dr. S. T. Naukushu (065 232 3000). My research topic is: *The integration of hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners' performance on probability in the Oshakati cluster of Oshana region.*

Upon given Ethical Clearance Certificate from the University of Namibia Research Ethics Committee (UREC) and permission from the Permanent secretary, Ministry of Education as well as permission from the Director of Education, Oshana Region, I am glad to inform you that I will be conducting the above educational research for my thesis in order to fulfil the M. Ed. requirements, to take place in Oshakati Cluster Secondary Schools during the course of June 2017.

Sixty (60) participants representing Grade 12 mathematics extended level students will be part of this study. I will be in close conduct with Mathematics educators so that I will be able to select 20 mathematics extended learners from each of the above schools. Learners will form two groups (experimental and control): Quasi- experimental design based on Probability. Every effort will be done not to disrupt the daily functions of the schools as the research will be conducted after school hours or during weekends (Saturdays) at Oshakati SS. Confidentiality and anonymity of participants will be maintained during and after this research.

I have attached the permission from the Permanent secretary, Ministry of Education as well as the one from the Director of Education, Oshana Region. Upon completing the study, I undertake to provide the Directorate with a bound copy of the full research report finding of the study.

If you require any further information, please do not hesitate to contact me on (cell: 081 3506568 or 081 1800027), email: abisaist@gmail.com).

I am confident that my request will be viewed favorably.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Setson T Abisai', written over a light grey rectangular background.

Setson T Abisai (Student number: 200647849).

Appendix G: Consent form for learners' parents

The integration of hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners' performance in probability in Oshakati Cluster of Oshana region

Researcher: Setson T Abisai

I have read this consent form and discussed it with my child. I had time to consider whether my child will take part in this study. I understand that his/her participation is voluntary and that we are free to withdraw from the research at any time without disadvantage.

If I have concerns or complain regarding the way the research is or has been conducted I can conduct the Research Ethics Committee, University of Namibia on 061 206 3111.

By signing below, I am consenting for my child to: participate in a series of lessons, and write tests before and after these lessons.

I agree and I give permission for my child to participate in this research.

Parent/ Guardian Signature: Date:
...../...../.....

Parent/Guardian Name:

Appendix H: Consent form for learners

**The integration of hands-on games in the learning of Grade 12 Extended Level
Mathematics and their effects on learners' performance in probability in Oshakati
Cluster of Oshana region, Namibia.**

Researcher: Setson T Abisai

I have been given information about the study and discussed the research study with Mr. Abisai who is conducting this research as part of his M. Ed. (Mathematics Education) degree supervised by Prof. C. D. Kasanda and Dr. S. T. Naukushu in the Department of Mathematics, Science and Sport Education at the University of Namibia.

I have been advised of the potential risks associated with this research and have had an opportunity to ask Mr. Abisai any questions I may have had about the research and my participation. I understand that my participation in this research is voluntary, I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdraw of consent will not affect my treatment in anyway or relationship with the University of Namibia.

If I have any enquiries about this research, I can contact (Mr. Abisai at 081 3506568 and/ or Prof. Kasanda (061 2063726) or if I have any concern or complaints regarding the way the research is or has been conducted, I can contact, the Research Ethics Committee, University of Namibia at 061 206 3111.

By signing below, I am indicating my consent to participate in the research. I understand that the data collected from my participation will be used primarily for a M. Ed. thesis, and I consent for it to be used in that manner.

Signed

Date

.....

...../...../.....

Full name

.....

Appendix I: Mathematics pre-test and post-test

TEST FOR PARTICIPANTS

Purpose: The purpose of this study is to investigate the effects of integrating hands-on games in the learning of Grade 12 Extended Level Mathematics and their effects on learners' performance in Oshakati cluster of Oshana region on Probability.

Direction: Please answer all the questions. Information provided and all research material collected will be in strictest confidence and will be used for research purpose only. Your response to this test is highly appreciated.

Instructions:

- Write your pseudo name. **i.e. 1A** and school pseudo name. **i.e. School A** on the space provided.
- Answer all questions on the space provided in this question paper.
- Show all your working clearly as this would earn you marks.
- It is preferable to give your answer in fraction where possible.
- This question paper consists of **6** pages including this page (information page)

Participant name (i.e. 1A):

Participant School's name (i.e. School A):

Topic Tested: Probability [Extended level] Marks: 35 Duration: 1 Hour

Test questions

1. In a class of 30 male learners, 15 play soccer, 7 play cricket, 5 play tennis and 3 do not play any sport.

If a learner is selected at random from the class, what is that probability will?

a) Play soccer

Answer (a): [1]

b) Do not play any sport,

Answer (b): [1]

c) Not play tennis,

Answer (c): [1]

d) Be female?

Answer (d): [1]

2. A normal die is thrown 60 times.



The result of the 60 throws is shown in the table below.

1	2	5	3	2	6	5	2	6	4
2	3	4	5	6	2	3	1	1	2
2	1	2	6	1	3	5	6	2	4
6	3	5	4	2	6	1	4	6	5
4	2	6	5	2	1	3	4	5	1
5	6	1	2	5	6	2	3	4	6

a) Use the results above to complete the frequency table below [3]

Number	Frequency
1	9
2	
3	7
4	
5	10
6	

b) Using the **table in (a)**, Find the probability that

(i) an even number

Answer (b)(i): [2]

(ii) an odd number

Answer (b)(ii): [2]

(iii) 2 or 3

Answer (b)(iii): [2]

3. Mr. Angula keeps his small stock in two different kraals A and B.

In kraal A there are 4 sheep and 8 goats.

In kraal B there are 4 sheep and 10 goats

Kraal A



Kraal B



(a) One animal is chosen at random from each kraal. Find the probability that

(i) both animals are goats

Answer (a)(i): [2]

(ii) at least one of the two animal is a sheep

Answer (a)(ii): [2]

(b) These two animals are not returned to the kraal.

A second animal is chosen at random from each kraal.

Find the probability that

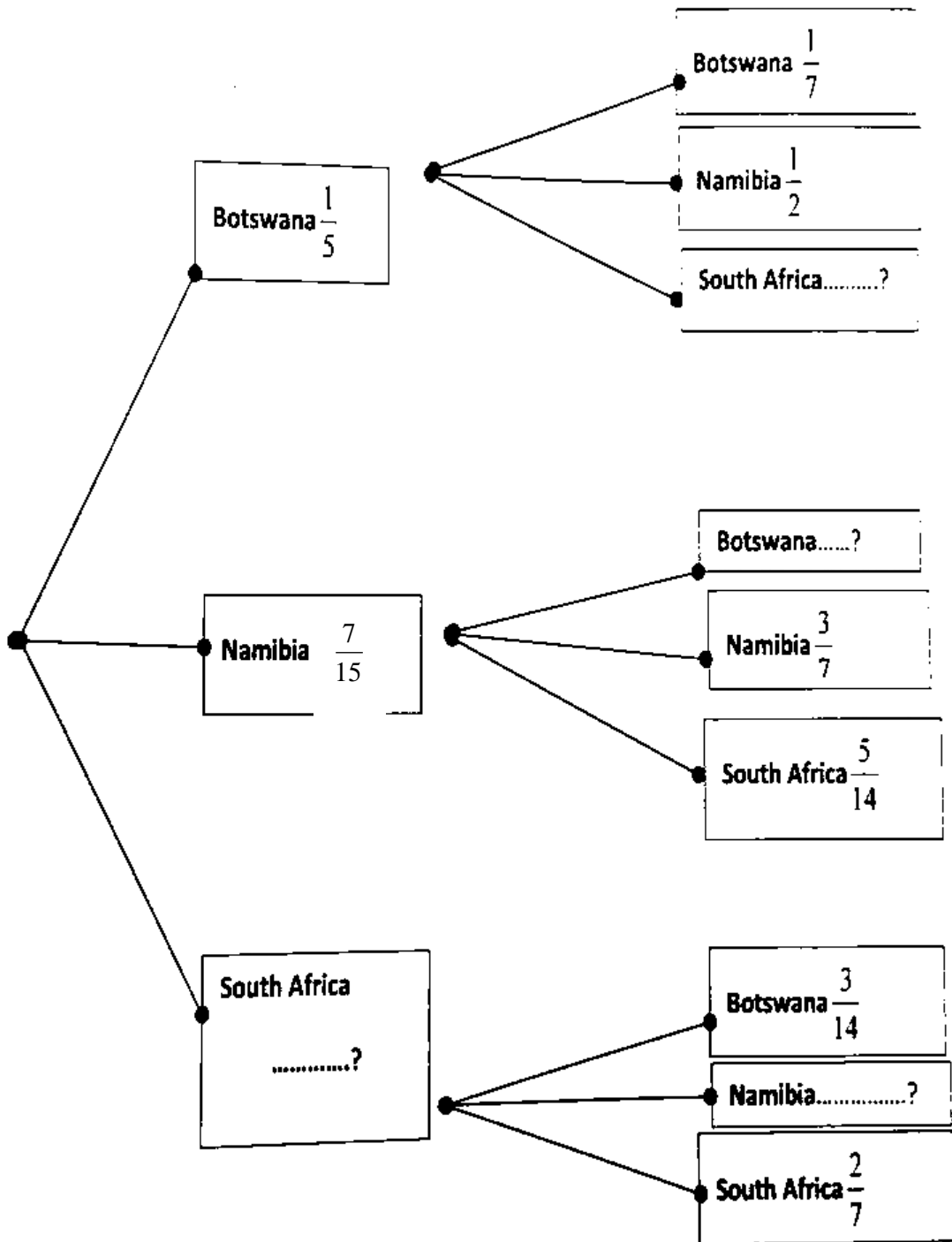
(i) all four animals are sheep

Answer (b)(i): [3]

(ii) the four animals include both sheep and goats

Answer (b)(ii): [3]

4. 15 students attend a mathematics quiz-competition.
 5 students are from South Africa, 3 are from Botswana and 7 from Namibia.



One of these students is chosen at random to write a report of the quiz-competition.
One of the remaining 14 is chosen at random to deliver the report.

(a) Complete the probability tree diagram below, showing the countries from which the students were chosen. [4]

(b) Calculate the probability that

(i) both the chosen students were from Namibia,

Answer (b)(i): [2]

(ii) that neither the chosen students were from South Africa,

Answer (b)(ii): [3]

(iii) that a student from Botswana would deliver the report.

Answer (b)(iii): [3]

TOTAL MARKS: 35

END

Thank you for taking time to write the test

Appendix J: Lesson Plan

LESSON PLAN

MATHEMATIC RESEARCH

SUBJECT: MATHEMATICS

GRADE: 12

TOPIC: PROBABILITY

DURATION: 4 WEEKS

PLAN

1. TEACHING RESOURCE AND MATERIAL USED:

- Mathematics $y = mx + c$ textbook by K. D', Presenter notes in PowerPoint, chalkboard, Worksheets, Hand-on materials for Experimental group: Play cards, dice, and Marbles, letters and number cards.

2. LESSONS OBJECTIVES: by the end of the lesson, learners should be able to:

- Understand probability in practice, e.g. relative frequency.
- Calculate the probability of simple combined events, using possibility diagrams and tree diagrams where appropriate (in possibility diagrams outcomes will be represented by points on a grid and in tree diagrams outcomes will be written at the end of branches and probabilities by the side of the branches).

3. LESSON PRESENTATION

INTRODUCTION

- State the topic (probability) and give the learners the focus of the lesson in terms of expectations: the learning objectives of the lesson.
- Motivate learners to realize the importance of listening and active participation, doing activities as well as questioning.

PRESENTATION OF SUBJECT MATTER AND LEARNING ACTIVITIES

First Presentation

- Define Probability as a measure of how likely the event to occur.
- Explain how to calculate the Probability: $P = \frac{\text{Number of successful outcomes}}{\text{Total number of possible outcomes}}$
- Recap the basic core content: Probability of independent events: single events, expected number from probability, exclusive events ("not" to occur) and addition of probabilities.

Second Presentation

- Explain the probability in practice such as using geometry Finding probability of (Shaded and unshaded area) for given geometric shapes.

Independent events:

- Explain how to draw a possibility space and tree diagram
- Explain how to calculate probability of simple combined events by using the possibility space and tree diagrams.

PRESENTATION OF SUBJECT MATTER AND LEARNING ACTIVITIES

Third Presentation

Dependent events:

- Explain how to draw a possibility space and tree diagram
- Explain how to calculate probability of simple combined events by using the possibility space and tree diagrams.

LEARNING ACTIVITIES DURING PRESENTATION

Control group: In all lessons

- Listen and take notes
- Do activities either individually or in groups
- Ask questions
- NB: same activities as the experimental but not practical (hand-on)
- Presenter facilitate and answer questions

Experimental group: In all lessons

- Listen and take notes
- Do activities individually and in group when using hand-on games
- Ask questions
- Presenter facilitate the activities and the application of manipulative materials such as play cards, dice, Marbles, number and letter cards to specific activities.

4. CONSOLIDATION

- Emphasize based on the objective at end of each presentations
- Conclude by summarizing the main parts to consider when answering questions i.e. formulae.

5. ASSESSMENT AS CLASS ACTIVITY, OR HOMEWORK

- Learners expose to various activities during lessons and homework (practice exercise question in $y = mx + c$). Activities used during lessons. See appendix

6. REFLECTIONS:

- After repeating some of the challenging parts such as tree diagram of dependent events and monitoring homework before each lesson, learners of each group seemed to have understood the topic well.

Presenter: Mr. Setson T Abisai

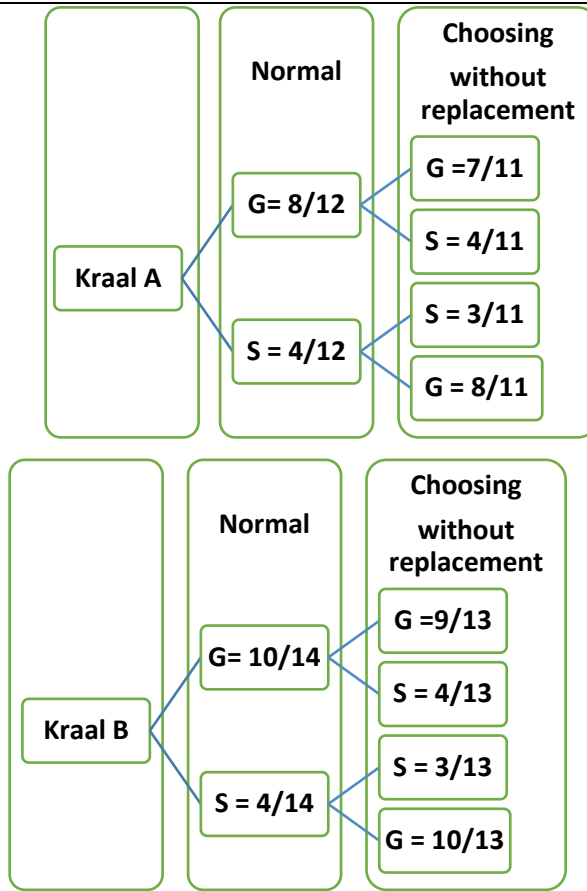
Signature:



Appendix K: Marking scheme of the mathematics Pre-test and post-test

Question	Answers	Marks	See Method															
1	a) $\frac{1}{2} \Rightarrow 0.5$	1	$15 + 7 + 5 + 3 = 30, \Rightarrow \frac{15}{30} = \frac{1}{2}$															
	b) $\frac{1}{10} \Rightarrow 0.1$	1	$\frac{3}{30} = \frac{1}{10}$															
	c) $\frac{5}{6} \Rightarrow 0.83$	1	$1 - \frac{5}{30} = \frac{25}{30}$															
	d) 0	1	$P(\text{female}) = P(\text{not male}) = 1 - \frac{30}{30} = 1 - 1$															
2	a)	3	<table border="1"> <tr> <td rowspan="7">Count and tally. Fill in the frequency</td> <th>Number</th> <th>Frequency</th> </tr> <tr> <td>1</td> <td>9</td> </tr> <tr> <td>2</td> <td>14</td> </tr> <tr> <td>3</td> <td>7</td> </tr> <tr> <td>4</td> <td>8</td> </tr> <tr> <td>5</td> <td>10</td> </tr> <tr> <td>6</td> <td>12</td> </tr> </table>	Count and tally. Fill in the frequency	Number	Frequency	1	9	2	14	3	7	4	8	5	10	6	12
Count and tally. Fill in the frequency	Number	Frequency																
	1	9																
	2	14																
	3	7																
	4	8																
	5	10																
	6	12																
	b) (i) $\frac{17}{30}$	2	$P(2) \text{ or } P(4) \text{ or } P(6) = \frac{14}{60} + \frac{8}{60} + \frac{12}{60} = \frac{34}{60}$															
	(ii) $\frac{13}{30}$	2	$P(1) \text{ or } P(3) \text{ or } P(5) = \frac{9}{60} + \frac{7}{60} + \frac{10}{60} = \frac{26}{60}$ Or $P(\text{not even}) = 1 - \frac{34}{60}, \text{ or } 1 - \frac{17}{30}$															
	(iii) $\frac{7}{20}$	2	$P(2 \text{ or } 3) = \frac{14}{60} + \frac{7}{60} = \frac{21}{60}$															

3.



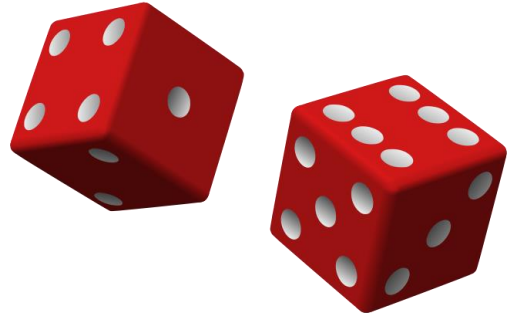
	a) (i) $\frac{10}{21}$	2	$P(GG) = \frac{8}{12} \times \frac{10}{14} = \frac{80}{168}$
	(ii) $\frac{11}{21}$	2	$1 - P(GG) = 1 - \frac{10}{21}, \text{ or,}$ $P(GS) + P(SG) + P(SS) = \left(\frac{8}{12} \times \frac{4}{14}\right) + \left(\frac{4}{12} \times \frac{10}{14}\right) + \left(\frac{4}{12} \times \frac{4}{14}\right)$ $= \frac{32}{168} + \frac{40}{168} + \frac{16}{168} = \frac{88}{168}$
	b) (i) $\frac{157}{1001}$	3	$P(SS) + P(SS) =$ $\left(\frac{4}{12} \times \frac{3}{11}\right) + \left(\frac{4}{14} \times \frac{3}{13}\right) = \frac{12}{132} + \frac{12}{182}$

	(ii) $\frac{1388}{3003}$	3	$[P(GS) + P(SG)], \text{ or, } [P(SG) + P(SG)]$ $= \left[\left(\frac{8}{12} \times \frac{4}{11} \right) + \left(\frac{10}{14} \times \frac{4}{13} \right) \right], \text{ or}$ $\left[\left(\frac{4}{12} \times \frac{8}{11} \right) + \left(\frac{4}{14} \times \frac{10}{13} \right) \right]$ $= \left(\frac{32}{132} + \frac{40}{182} \right)$
4	a) (i)	4	<p>Tree diagram:</p> <p style="text-align: center;">WRITTING</p> <p>REPORT</p> <div style="display: flex; align-items: center; margin-bottom: 20px;"> <div style="border: 1px solid black; padding: 5px; margin-right: 10px;">$N = \frac{7}{15}$</div> <div style="margin-left: 10px;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$B = \frac{3}{14} \rightarrow NB = \frac{7}{15} \times \frac{3}{14} = \frac{1}{10}$</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$N = \frac{6}{14} = \frac{3}{7} \rightarrow NN = \frac{7}{15} \times \frac{2}{7} = \frac{1}{5}$</div> <div style="border: 1px solid black; padding: 5px;">$SA = \frac{5}{14} \rightarrow NSA = \frac{7}{15} \times \frac{5}{14} = \frac{1}{6}$</div> </div> </div> <div style="display: flex; align-items: center; margin-bottom: 20px;"> <div style="border: 1px solid black; padding: 5px; margin-right: 10px;">$B = \frac{3}{15} = \frac{1}{5}$</div> <div style="margin-left: 10px;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$B = \frac{2}{14} = \frac{1}{7} \rightarrow BB = \frac{1}{5} \times \frac{1}{7} = \frac{1}{35}$</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$N = \frac{7}{14} = \frac{1}{2} \rightarrow BN = \frac{1}{5} \times \frac{1}{2} = \frac{1}{10}$</div> <div style="border: 1px solid black; padding: 5px;">$SA = \frac{5}{14} \rightarrow BSA = \frac{1}{5} \times \frac{5}{14} = \frac{1}{14}$</div> </div> </div> <div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-right: 10px;">$SA = \frac{5}{15} = \frac{1}{3}$</div> <div style="margin-left: 10px;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$B = \frac{3}{14} \rightarrow SAB = \frac{1}{3} \times \frac{3}{14} = \frac{1}{14}$</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">$N = \frac{7}{14} = \frac{1}{2} \rightarrow SAN = \frac{1}{3} \times \frac{1}{2} = \frac{1}{6}$</div> <div style="border: 1px solid black; padding: 5px;">$SA = \frac{4}{14} = \frac{2}{7} \rightarrow SASA = \frac{1}{3} \times \frac{2}{7} = \frac{2}{21}$</div> </div> </div>

	(ii) $\frac{1}{5}$	2	$P(NN) = \frac{7}{15} \times \frac{6}{14} = \frac{7}{15} \times \frac{3}{7} = \frac{21}{105} \text{ or } \frac{42}{210}$
	(ii) $\frac{3}{7}$	3	$[P(BB) + P(BN) + P(NB) + P(NN)]$ $= \left[\left(\frac{1}{5} \times \frac{1}{7} \right) + \left(\frac{1}{5} \times \frac{1}{2} \right) \right] + \left[\left(\frac{7}{15} \times \frac{3}{14} \right) + \left(\frac{7}{15} \times \frac{6}{14} \right) \right]$ $= \left(\frac{1}{35} + \frac{1}{10} + \frac{21}{210} + \frac{42}{210} \right)$
	(iii) $\frac{1}{5}$	3	$[P(BB) + P(NB) + P(SB)]$ $= \left[\left(\frac{1}{5} \times \frac{1}{7} \right) \right] + \left[\left(\frac{7}{15} \times \frac{3}{14} \right) + \left(\frac{1}{3} \times \frac{3}{14} \right) \right]$ $= \left(\frac{1}{35} + \frac{21}{210} + \frac{3}{42} \right)$

Probability Dice Play

Independent events: When two ordinary dice rolled.



Using Probability space

Given two dice: Dice 1 and Dice 2

Construct a probability space

	DICE 1						
DICE 2							

Construct a probability space of the sum

	DICE 1						
DICE 2							

Use those probability spaces to calculate the probability that you will get:

- a) The same number on both dice
- b) At least prime number on both
- c) Sum of two number is 7
- d) Sum of two number is less than 7
- e) Sum of two number is greater than 7
- f) Sum greater than 7 and even number
- g) Sum less than 7 and odd number

Play cards

Provided with a pack of cards

Arrange the cards and fill in the table below

Steps:

- ⊖ Total number of cards
- ⊖ Number of red and black cards
- ⊖ Total number of diamonds, Spiders, hearts, and Flowers



Total _____	Red _____	Spiders _____	Heart _____	Flowers _____	Total
	Diamonds (Red)	Spiders (Black)	Heart (Red)	Flowers (Black)	Total
Q					
K					
J					
A					
1					
2					
3					

4					
5					
6					
7					
8					
9					
10					
Total					

Use the table to calculate the probability that the card is:

Red

Black

Not red or black

Ace or king

Black or queen

Tree diagram using cards

1. WITH REPLACEMENT

Count the number of cards (Total)_____

Count the number of hearts _____

Pick out one card of a heart.

What is the probability of:

✓ Picking that cards (heart)_____

✓ Not picking a heart _____

Form up a tree diagram (1st pick):

1st pick

2nd pick

Put the card back and pick a heart again (2nd pick)

What is the probability of heart: _____, not a heart _____.

Continue the tree diagram (2nd pick)

Calculate the probability that:

• Both cards are heart _____

• At least a heart _____

- Neither a heart _____

Tree diagram using cards

2. WITHOUT REPLACEMENT

- ⊖ Count the number of cards (Total)_____
- ⊖ Count the number of hearts _____
- ⊖ Pick out one card of a heart.
- ⊖ What is the probability of:
 - ✓ Picking that cards (heart)_____
 - ✓ Not picking a heart _____
- ⊖ **Form up a tree diagram (1st pick):**

1st pick

2nd pick

- ⊖ Without replacing the heart card, pick another heart (2nd pick)
- ⊖ What is the probability of heart: _____, not a heart _____.
- ⊖ Continue the tree diagram (2nd pick)

Calculate the probability that:

- Both cards are heart _____
- At least a heart _____
- Neither a heart _____

Tree diagram using picking balls from a bag (Mable's)



- ⊖ You are provided with a bag with 12 balls.
 - Count the solid green balls _____
 - Count the rest of the balls (clear green) _____

1st draw:

- ⊖ Pick out a solid green ball; P (solid green) _____; P (Clear green): _____
- ⊖ Make a tree diagram (1st draw):

1st draw

2nd draw

2nd draw: (1)

- ⊖ Without replacing the solid green ball:
 - How many solid green balls remain _____ P(solid green) _____ and P (Clear green) _____
- ⊖ *Continue the tree diagram (2nd draw 1)*

2nd draw: (2)

- ⊖ Take the solid green back
- ⊖ Pick a clear green ball without replace
 - How many clear green left _____
 - P (clear green) _____
 - P (solid green) _____
- ⊖ *Continue the tree diagram (2nd draw 2)*

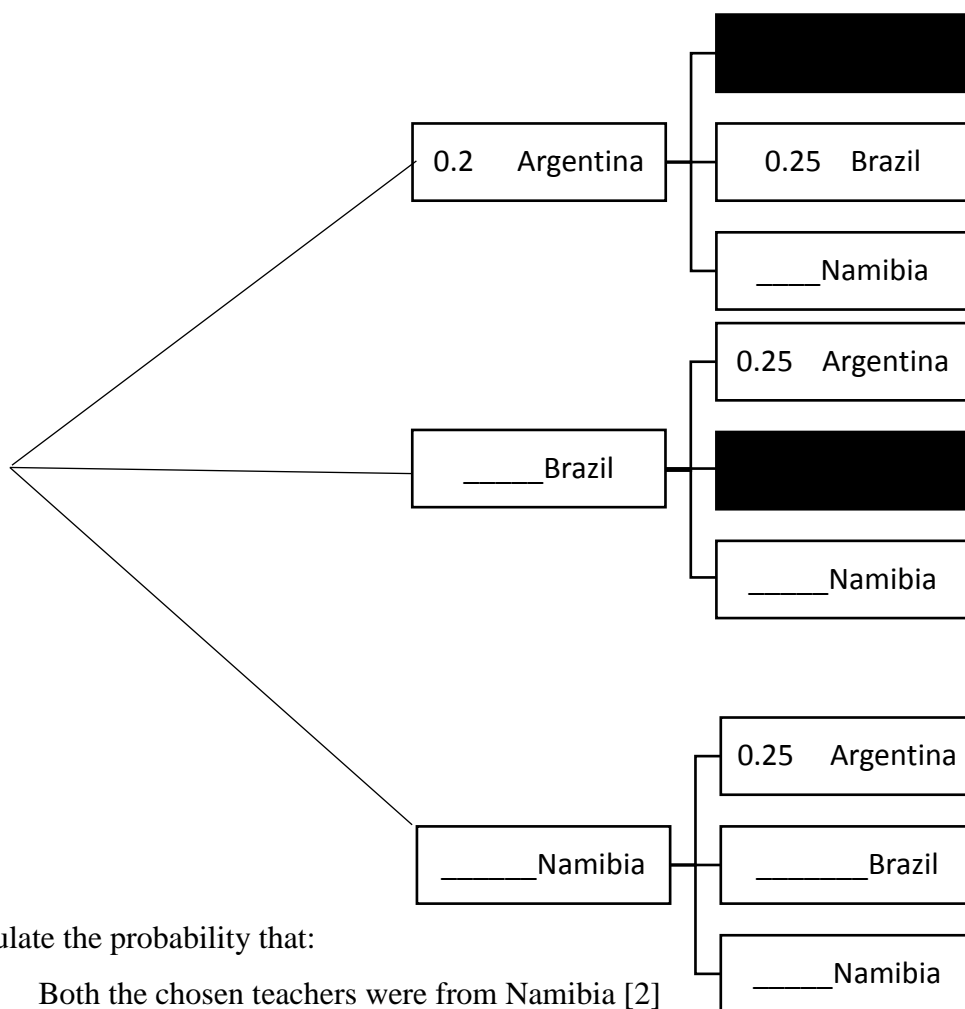
Use the tree diagram to calculate the probability of drawing:

- Both solid green
- One solid green and one clear green
- At least a solid green

Research mathematics Activity: Probability

One teacher from Argentina, one from Brazil and three from Namibia attended an international conference. One of these five teachers is chosen at random to make a speech, and one of the remaining four is chosen at random to write a report.

- (a) Copy and complete the probability tree diagram below, showing the countries from which the teachers were chosen. [4]



- (b) Calculate the probability that:
- Both the chosen teachers were from Namibia [2]
 - Neither of the chosen teachers was from Namibia [3]
 - The teacher from Brazil was not chosen [3]
- (c) One of the remaining three teachers is chosen at random to chair the conference. Calculate the probability that this is the teacher from Brazil. [2]

[Total: 14]

PROBABILITY

Experimental group: Use the given number cards 1 to 6, to answer the following questions on probability.

Experimental group: without number cards

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

Cards numbered from 1 to 16 are placed in a box and shaken.

A card is drawn at random from the box, the number is noted. Calculate, giving your answer in its simplest form (fraction), the probability of drawing a card with a number which is:

- a) Factor of 15 (1)
 - b) Odd number (1)
 - c) Even number (1)
 - d) A multiple of 2 (1)
 - e) A factor of 15 and an odd number (2)
 - f) A factor of 15 or odd number (2)
 - g) A multiple of 2 or an odd number (2)
 - h) A multiple of 2 and odd number (1)
-

PROBABILITY

Peter plant 12 rose trees. He knows that 4 trees will give red roses, 2 trees will give pink roses and 6 trees will give white roses.

a) What is the probability that the first rose tree to flower will give: (3)

- (i) Red roses
- (ii) Pink roses
- (iii) White roses

b) By **means of a tree diagram**, show the probability of how two rose's trees chosen at random will flower.

What is the probability for each color of rose on each branch? (5)

Tree diagram

c) What is the probability, that the first two rose trees to flower:

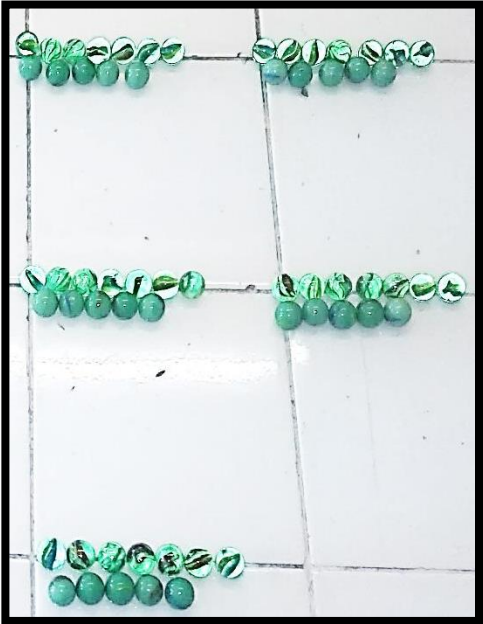
- (i) Both will give pink roses (1)
 - (ii) One will give white roses and other red roses? (2)
-

Appendix M: Hand-on materials or tools used by the experimental group participants

Play cards and dice

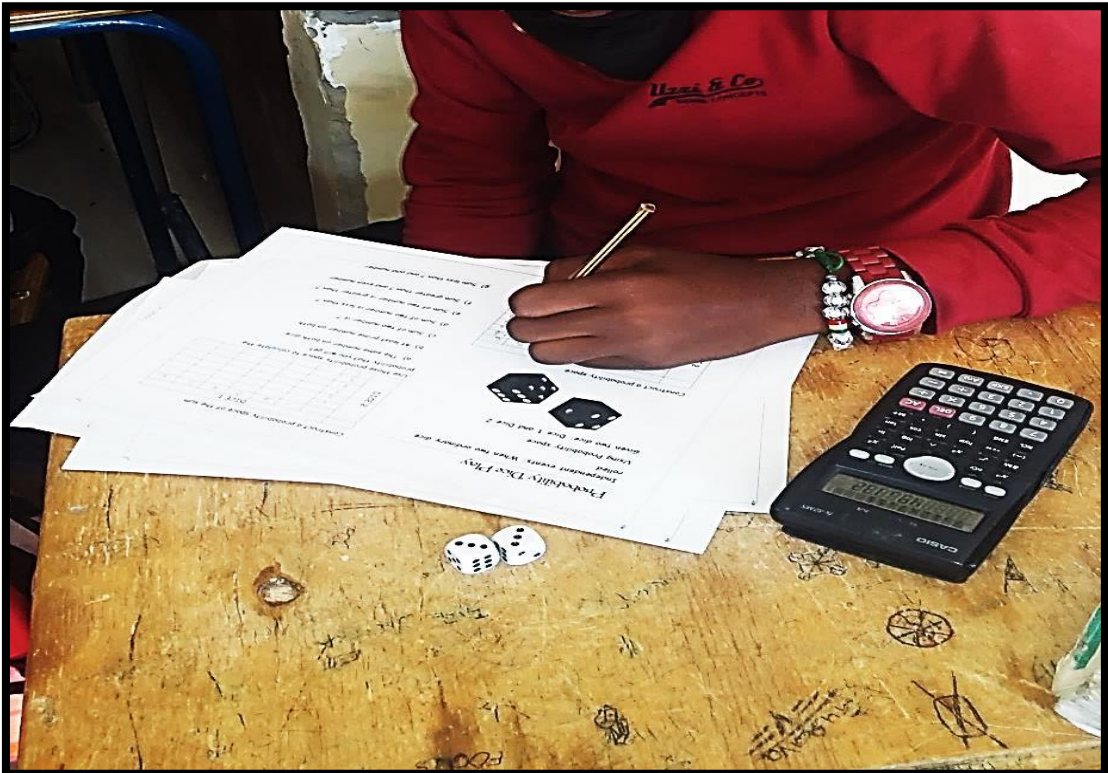


Marbles



Learners doing the activity during lesson: Experimental group playing hand-on games and answering questions





Appendix N: Calculations done during data analysis for mean scores, deviation, standard deviation, t – test yielded table 1, 2, 3 and 4.

Key of the symbols and formulae used

X_1 = experimental group scores, X_2 = control group scores

N_1 = number of participants in an experimental group, N_2 = number of participants in the control group

\bar{X}_1 = mean of experimental group scores, \bar{X}_2 = mean of Control group scores

$$Mean = \bar{X} = \frac{\sum X}{N}$$

S_1^2 = variance of an experimental group, S_2^2 = variance of the control group

$$Variance = S^2 = \frac{N (\sum X^2) - (\sum X)^2}{N (N - 1)}$$

$S_1 = SD_1 = \sqrt{S_1^2}$ = standard deviation of an experimental group

$S_2 = SD_2 = \sqrt{S_2^2}$ = standard deviation of the control group

$$t - test = t_{calculated} = \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}}$$

Degree of freedom (df) = $N_1 + N_2 - 2$

The pre-test

Experimental Group		Number of participants (N ₁): 27	
Participants	Pretest Score out of 35 (X ₁)	(X ₁) ²	
A1	14	196	
A3	7	49	
A5	6	36	
A6	5	25	
A7	9	81	
A9	7	49	
A10	9	81	
A12	9	81	
A15	11	121	
A17	9	81	
A23	4	16	
A27	6	36	
A28	9	81	
A29	9	81	
A30	9	81	
A33	7	49	
A35	8	64	
A38	8	64	
A41	7	49	
A42	6	36	
A43	6	36	
A44	8	64	
A46	10	100	

A53	8	64
A55	7	49
A56	7	49
A59	7	49
Number of participants (N₁)	27	
Total	$\sum X_1 = 212$	$\sum X_1^2 = 1768$
Mean	$\bar{X}_1 = 7.851851852$	

Experiment group: calculation of deviation and standard deviation of pre-test

$$S_1^2 = \frac{N_1(\sum X_1^2) - (\sum X_1)^2}{N_1(N_1 - 1)} = \frac{27(1768) - (212)^2}{27(27 - 1)} = \frac{2792}{702} = 3.977207977 = 3.98(3s.f)$$

$$SD = \sqrt{Variance} = \sqrt{S_1^2} = \sqrt{3.977207977} = 1.994293854 = 1.99(3s.f)$$

Control Group	Number of participants (N₂): 30	
Participants	Pretest Score out of 35 (X₂)	(X₂)²
A2	9	81
A4	10	100
A8	9	81
A11	9	81
A13	9	81
A14	4	16
A16	9	81
A16	9	81
A19	6	36
A20	6	36

A21	7	49
A22	8	64
A24	8	64
A25	8	64
A26	15	225
A31	7	49
A32	12	144
A34	8	64
A36	8	64
A37	6	36
A40	6	36
A45	8	64
A47	11	121
A48	8	64
A49	9	81
A50	8	64
A51	7	49
A52	7	49
A57	8	64
A58	7	49
Number of participants (N₂)	30	
Total	$\sum X_1 = 246$	$\sum X_2^2 = 2138$
Mean	$\bar{X}_2 = 8.2$	

Control group: calculation of deviation and standard deviation of pre-test

$$S_2^2 = \frac{N_2(\sum X_2^2) - (\sum X_2)^2}{N_2(N_2 - 1)} = \frac{30(2138) - (246)^2}{30(30 - 1)} = \frac{3624}{870} = 4.165517241 = 4.17(3s.f)$$

$$SD = \sqrt{Variance} = \sqrt{S_2^2} = \sqrt{4.165517241} = 2.040959882 = 2.40(3s.f)$$

The post-test

Experimental Group		Number of participants (N₁): 23	
Participants	Posttest Score out of 35 (X₁)	(X₁)²	
A1	26	676	
A3	19	361	
A5	19	361	
A6	17	289	
A7	24	576	
A9	15	225	
A10	17	289	
A12	19	361	
A15	13	169	
A17	29	841	
A27	12	144	
A28	19	361	
A29	13	169	
A30	22	484	
A33	22	484	
A35	17	289	
A38	13	169	
A42	11	121	
A44	13	169	

A46	20	400
A53	17	289
A55	15	225
A59	16	256
Number of participants (N₁)	23	
Total	$\sum X_1 = 408$	$\sum X_1^2 = 7708$
Mean	$\bar{X}_1 = 17.73913043$	

Experiment group: calculation of deviation and standard deviation of post-test

$$S_1^2 = \frac{N_1 (\sum X_1^2) - (\sum X_1)^2}{N_1 (N_1 - 1)} = \frac{23(7708) - (408)^2}{23(23 - 1)} = \frac{10820}{506} = 21.38339921 = 21.4(3s.f)$$

$$SD = \sqrt{\text{Variance}} = \sqrt{S_1^2} = \sqrt{21.38339921} = 4.624218767 = 4.62(3s.f)$$

Control Group		Number of participants (N₂): 23	
Participants	Posttest Score out of 35 (X₂)	(X₂)²	
A2	12	144	
A4	11	121	
A8	19	361	
A11	19	361	
A13	13	169	
A16	11	121	
A18	10	100	
A19	13	169	
A20	9	81	
A21	12	144	

A22	14	196
A24	13	169
A25	14	196
A26	12	144
A32	17	289
A34	15	225
A37	11	121
A40	13	169
A45	22	484
A48	12	144
A50	7	49
A51	15	225
A58	7	49
Number of participants (N₂)	23	
Total	$\sum X_1 = 301$	$\sum X_2^2 = 4231$
Mean	$\bar{X}_2 = 13.08695652$	

Control group: calculation of deviation and standard deviation of post-test

$$S_2^2 = \frac{N_2(\sum X_2^2) - (\sum X_2)^2}{N_2(N_2 - 1)} = \frac{23(4231) - (301)^2}{23(23 - 1)} = \frac{6712}{506} = 13.26482213 = 13.3(3s.f)$$

$$SD = \sqrt{\text{Variance}} = \sqrt{S_2^2} = \sqrt{13.26482213} = 3.642090352 = 3.64(3s.f)$$

Pre-test t-test calculation: Between the Experimental and control group yielded

table 4.2

$$\text{Control_Mean} : \bar{X}_2 = 8.2$$

$$\text{Experiment_Mean} : \bar{X}_1 = 7.85$$

$$\text{Variance_Control} : S_2^2 = 4.17$$

$$\text{Variance_Experiment} : S_1^2 = 3.98$$

$$\begin{aligned} \bullet t_{\text{calculated}} &= \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}} \\ &= \frac{7.85 - 8.2}{\sqrt{\left[\frac{(27 - 1)(3.98) + (30 - 1)(4.17)}{27 + 30 - 2} \right] \left[\frac{27 + 30}{(27)(30)} \right]}} = \frac{-0.35}{\sqrt{\left[\frac{224.41}{55} \right] \left[\frac{57}{810} \right]}} \\ &= \frac{-0.35}{\sqrt{0.287123905}} = \frac{-0.35}{0.53583944} = -0.653180736 = -0.6532 = |-0.6532|(3sf) \end{aligned}$$

$$\bullet df = N_1 + N_2 - 2 = 27 + 30 - 2 = 55$$

t- Test calculation: Between the Control group pre-test and post-test scores yielded

table 4.3

$$\text{Control : Pre - test (Mean) : } \overline{X}_2 = 8.2$$

$$\text{Control : Post - test (Mean) : } \overline{X}_1 = 13.1$$

$$\text{Variance _ Control (Pre - test) : } S_2^2 = 4.17$$

$$\text{Variance _ Control (post - test) : } S_1^2 = 13.3$$

$$\begin{aligned} \bullet t_{\text{calculated}} &= \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}} \\ &= \frac{13.1 - 8.2}{\sqrt{\left[\frac{(23 - 1)(13.3) + (30 - 1)(4.17)}{23 + 30 - 2} \right] \left[\frac{23 + 30}{(23)(30)} \right]}} = \frac{4.9}{\sqrt{\left[\frac{413.53}{51} \right] \left[\frac{53}{690} \right]}} \\ &= \frac{4.9}{\sqrt{0.62282154}} = \frac{4.9}{0.789190433} = 6.208894321 = 6.209(3sf) \end{aligned}$$

$$\bullet df = N_1 + N_2 - 2 = 23 + 30 - 2 = 51$$

t- Test calculation: Between the Experimental group pre-test and post-test scores yielded table 4.4

$$\text{Experimental : Pre - test (Mean) : } \overline{X}_2 = 7.85$$

$$\text{Experimental : Post - test (Mean) : } \overline{X}_1 = 17.7$$

$$\text{Variance _ Experimental (Pre - test) : } S_2^2 = 3.98$$

$$\text{Variance _ Experimental (post - test) : } S_1^2 = 21.4$$

$$\begin{aligned} \bullet t_{\text{calculated}} &= \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}} \\ &= \frac{17.7 - 7.85}{\sqrt{\left[\frac{(23 - 1)(21.4) + (27 - 1)(3.98)}{23 + 27 - 2} \right] \left[\frac{23 + 27}{(23)(27)} \right]}} = \frac{9.85}{\sqrt{\left[\frac{574.28}{48} \right] \left[\frac{50}{621} \right]}} \\ &= \frac{9.85}{\sqrt{0.963298443}} = \frac{9.85}{0.981477683} = 10.03588789 = 10.036(3sf) \end{aligned}$$

$$\bullet df = N_1 + N_2 - 2 = 23 + 27 - 2 = 48$$

Post-test t-test calculation: Between the Experimental and control group yielded table 4.5

$$\text{Control_Mean} : \bar{X}_2 = 13.1$$

$$\text{Experiment_Mean} : \bar{X}_1 = 17.7$$

$$\text{Variance_Control} : S_2^2 = 13.3$$

$$\text{Variance_Experiment} : S_1^2 = 21.4$$

$$\begin{aligned} \bullet t_{\text{calculated}} &= \frac{X_1 - X_2}{\sqrt{\left[\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 N_2} \right]}} \\ &= \frac{17.7 - 13.1}{\sqrt{\left[\frac{(23 - 1)(21.4) + (23 - 1)(13.3)}{23 + 23 - 2} \right] \left[\frac{22 + 23}{(23)(23)} \right]}} = \frac{4.6}{\sqrt{\left[\frac{763}{44} \right] \left[\frac{46}{529} \right]}} \\ &= \frac{4.6}{\sqrt{1.508695652}} = \frac{4.6}{1.228289726} = 3.745044757 = 3.745(3.sf) \end{aligned}$$

$$\bullet df = N_1 + N_2 - 2 = 27 + 30 - 2 = 55$$
